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Indicated factors of physical development, physical readiness, functional condition and efficiency of female students in the process of adaptation to training

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Authors' Contribution:

A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: to determine indicated factors of physical development, physical readiness, functional condition and efficiency of female students in the process of adaptation to learning.

Material: it was examined female students at the beginning of the first and second year of training (n = 342, age 18-20 years). The investigation was conducted on 10 indicators of physical development, 9 indicators of physical preparedness and 13 indicators of functional status and performance.

Results: It is established that during the first year of study takes place changes in the factors of the physical development of students, such as: increase of body weight, mass-growth index, muscular strength of the right hand. From the factors of physical readiness: increase the time of the visibility on the crossbar and the number of push-ups from the floor; decreases the length of the jump from the place. From the factors of the functional state: the frequency of breathing and the Genci test increase; decrease the coefficient of circulatory efficiency, endurance factor and systolic blood pressure.

Conclusions: Indicated factors of female students' adaptation to learning is to be considered the strength of the hand (factor of physical development), long jump from the place (factor of physical preparedness), the Genci test (factor of the functional state), the coefficient of circulation efficiency and the endurance factor.

Keywords: physical development, physical readiness, functional state, adaptation, training, working capacity.

Introduction

There is a problem of determining indicated factors of physical development and the functional state of students. At the initial stage of training, the health of young people is deteriorating [1, 2]. This is due to a decrease in motor activity [3], a decrease in motivation to exercise, [4], excessive interest in the Internet and gadgets [5], unhealthy eating behavior [6, 7]. It is also associated with climatic [8], geographical [9] and environmental conditions [10, 11], adaptation to a new way of life [12, 13], the appearance of bad habits [14], deterioration in the socio-moral qualities of the person [15, 16]. Thus, the functional state of the circulatory system is estimated as "a tension of adaptation mechanisms" among 8% of students [17]. This is due to the period of adaptation to the new conditions. Long-term preservation of such conditions leads to depletion of the body's functional reserves, contributes to the development of diseases. The authors consider the process of studying at the university as a factor that negatively affects the health of young people [18].

In other studies [19] it is noted that 217 medical students develop chronic emotional stress during 1-3 training courses. The severity of this stress depends on the individual psychophysiological status of students. 60% of the students initially did not have sufficient adaptive capacity. This led to psychological problems and disorders of the autonomic nervous system. The authors show [20] that the processes of students' adaptation to learning can be assessed by the nature of the shifts in the parameters of heart rate variability. Positive trends were established in the first three courses. At the senior courses the tension

of mechanisms of regulation of a warm rhythm amplifies. Student survey [21] (1 course, Amur State University, Russia, 2000-2014) made it possible to reveal a number of statistically significant changes during the training: the speed decreased by 8,16%; total endurance – by 9,75%; strength muscle endurance – by 30%; speed-strength (dynamic force of the legs) – by 5,28%; agility – by 9,45%; The index of flexibility – by 43,6%.

Indicators of students' health can be improved through sports. It is important to optimize physical activity [22, 23], to form a positive attitude toward one's health [24], to take into account the didactic patterns of training [25], to select adequate tests [26], pedagogical control of motor activity [27]. In classes on the physical education of students, it is necessary to take into account the following: the initial parameters of health level [28]; parameters of the psychological state [29]; morphofunctional health parameters [30]; individual health parameters [31]; criteria for restoring health [32]; new technologies in physical education [33, 34]; standards of physical education [35, 36]; models of motor development and competence [37, 38]; the effect of physical training on academic performance [39]; features of sports pedagogy [40].

A topical issue remains the question of determining the criteria, procedures, methods for assessing indicated factors of students' adaptation to learning. Many of the indicators are ununified. Their combination is different in various studies. This makes it difficult to verify the results. The informativeness of the used factors is not studied in full and become the subject of discussion in the scientific community. Therefore, the question arose about the formation of a complex of indicated factors.

Indicated factors are important for the analysis of ontogenetic development and evaluation of the functional state of the leading systems of the body. They can be used to assess the adequacy of motor regimes [41, 42].

In the literature, it is proposed to use as indicator indices the following: long jump from the place [43], breath delay on the exhalation (the Genci test) and the Ruffier index [44], heart rate variability indices [20], maximum oxygen consumption [45], Martine-Kushelevsky test [41], the results of hand dynamometry [46, 47]. The literature data on the informativeness of the mass-growth index are contradictory [48]. In general, the presented data are fragmented, there is no systematic approach to determining indicated factor.

Hypothesis: one assumes that in order to successfully solve the issue it is necessary to identify informative indicator indices of adaptation to learning.

The purpose of the study is to determine the indicated factors of physical development, physical readiness, functional condition and efficiency of female students in the process of adaptation to learning.

Material and methods

Participants. The study involved students ($n=342$) of the first year of study (aged $18,35 \pm 0,04$ years) and the second year (aged $20,33 \pm 0,92$ years) of study. The research was conducted during the first and third semesters (September and October month). During the research no one complained of health problems. All the students gave voluntary consent to participate in the research.

Organization of the study. It was examined 32 indicators: 10 on physical development, 9 on physical fitness and 13 on functional condition and performance.

To measure physical development, the body length (cm), body weight (kg) and circumference of the chest (CC, cm) were measured [49].

The flexion muscle strength (kg) of the right and left hand was measured using the hand dynamometry method [50]. Then the power index was calculated: the percentage of muscle strength to body weight.

To assess the status of cardiovascular system (CVS) in rest conditions it is evaluated heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg) [51].

To assess the state of the respiratory system it was measured the vital capacity of the lungs (VCL, l), it was performed the Stange test and the Genci test. VCL was measured with a portable spirometer [52] and calculated the vital index (VI): the ratio of VCL to body weight (ml / kg). The Stange test (c) was performed as follows: the student in standing position breathes in; then the student makes a deep exhalation; then the student takes a breath that is 80-90% of the maximum; then the student holds his breath. There is a time delay in breathing. In the Genci test (c) after a normal exhalation, the student holds his breath as long as possible [53].

Physical efficiency was assessed by the maximum oxygen consumption (MOC, ml/min). Calculation of MOC was carried out according to the work power and

the heart rate recorded during the step test (climbing the bench at a height of 0,35 m for 4 minutes at a frequency of 20 cycles per minute). The working power N , in kg m/min, was found from the formula:

$$N = 1,2 \times P \times h \times n,$$

where P – is the body weight of the subject (kg); h – bench height (m); n – is the number of cycles (min); 1,2 – coefficient of ascent and descent.

The MOC was calculated using the Dobeln formula:

$$MOC = A \times [N / (H - h)]^{-1/2} \times K,$$

where A – is the empirical correction to the formula, depending on age and gender; N – power of work, in kg/min; H – heart rate (bpm) at a given work power; h – age-sexual correction to the pulse, K – age coefficient [53].

The Kredo index was calculated by the formula:

$$KI = (1 - D/P) \times 100,$$

where D – is the diastolic pressure (mmHg), P – is the pulse (heart rate), bpm [53].

The coefficient of efficiency of blood circulation (CEBC) was calculated by the formula:

$$CEBC = (SBP - DBP) \cdot HR,$$

where SBP - systolic blood pressure (mmHg), DBP - diastolic blood pressure (mmHg), HR - heart rate (bpm) [53].

The coefficient of endurance (CE) was determined by the Kvass formula:

$$CE = (10 \cdot HR) : PP,$$

where HR is the heart rate (bpm), PP is the pulse pressure (mmHg). The PP was calculated as the difference between SBP and DBP [53].

Adaptation to learning was assessed by the value of the adaptation potential (AP):

$$AP = 0,011 \cdot HR + 0,014 \cdot SBP + 0,008 \cdot DBP + 0,09 \cdot BM - 0,009 \cdot W + 0,014 \cdot A - 0,27,$$

where BM – body mass (kg), W – weight (cm), A – age in years [53].

To determine physical fitness, the level of development of the basic motor qualities was assessed in accordance with the “Model program of the discipline “Physical Culture” [54]. According to this program, the girls practiced physical culture 2 times a week for 2 hours. The annual load of 144 hours was evenly distributed over semesters. The program included such sections as: athletics (42 hours), volleyball (28 hours), athletic gymnastics (42 hours), swimming (28 hours), tests (4 hours). Classes were conducted according to a typical structure: the introductory part (15-20 min), the main part

(35-45 min), the final part (19-15 min). The introductory part consisted of a set of general development exercises. The main part consisted of the exercises of the relevant sections (see below). The final part consisted of a set of breathing exercises and exercises that developed flexibility. Here is an example of the content of the main part of the classes:

1) in the track and field athletics classes studied the technique of improving run, special exercises of the runner, running technique for long and short distances, technique of jumping in length from the place. Also prepared for the implementation of control standards for athletics (running 30 m, 100 m, 2000 m).

2) in the volleyball classes studied the basic rules of the game, overarm reception, attack blow, blocking the ball, group and team interactions.

3) in the swimming lessons, we studied feeding exercises, gliding on the chest and back, movements of the hands and feet in the rabbit on the back and chest.

4) athletic gymnastics classes developed strength qualities, power endurance. In the lesson, exercises with weights and exercises were used. Also prepared for the implementation of control standards for general physical training (flexion and extension of the arms in the supine position, the torso of the trunk from the supine position on the back, hanging on the crossbar).

During the training, group and individual game simulation methods were used.

At the end of each semester, the students passed the following tests: (in the conditions of sports hall and stadium): running at 30 and 100 m (speed); a long jump from the place (speed force); inclination from the standing position on the bench (flexibility); flexion and extension of the arms in the supine position; hanging on the crossbar; slopes from the supine position on the back (power endurance); running at 1000 m; running for 2000 m (total endurance).

Statistical analysis. The results of the investigation were processed in the Microsoft Excel Licensed Software

Package. The quantitative data were verified for the normal distribution in several ways (an estimate of the symmetry of the sample by the histogram and the Kolmogorov-Smirnov method). Further, the indicators of descriptive statistics were calculated: the arithmetic mean (M), the standard deviation (σ), and the error of the mean value (m).

In the text and tables are presented as $M \pm m$. The differences were estimated by the Student's criterion (t) for independent samples and the chi-square test: they were considered reliable at $p < 0.05$ (in the text is indicated as “*”).

Results

It is established that the data obeys the law of normal distribution, according to our study. This is confirmed by the estimation of the symmetry of the sample in the histogram. Figures 1-3 give examples of histograms for the parameters of physical development (body weight), physical readiness (long jump from the place) and functional state (the Genci test).

The study found statistically significant differences in 11 indicators (out of 32 indicators) (Table 1-3). From the indicators of physical development is increased: body weight, mass-growth index, muscular strength of the right hand. According to the mass-growth index, 12,83% of students had a body weight deficit, 16,37% had excess body weight.

From the indicators of physical preparedness, the time spent on the hanging on the crossbar and the number of push-ups from the floor increased. The length of the jump from the place decreased.

From the indicators of the functional state and working capacity, the frequency of breathing and the Genci test increased. The coefficient of efficiency of blood circulation, endurance factor, systolic blood pressure decreased.

The study established a number of statistically

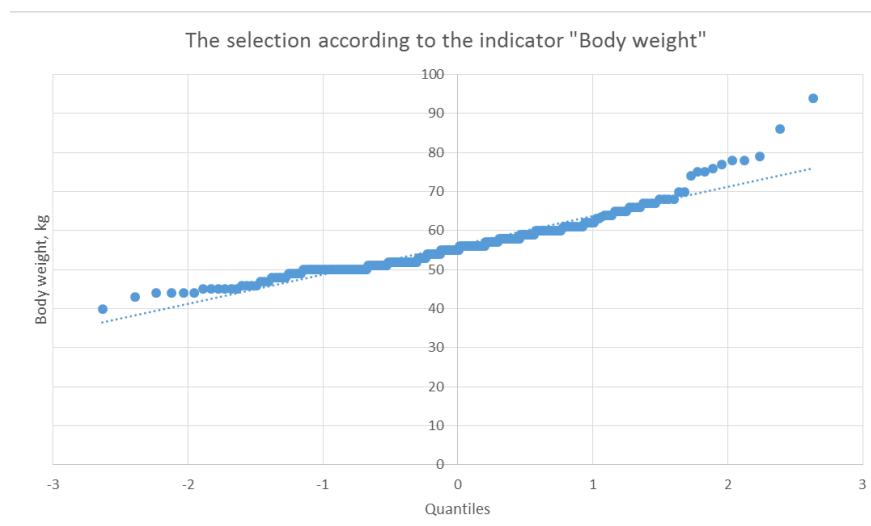


Fig. 1. Evaluation of the symmetry of the sample according to the histogram for the indicator “Body mass”

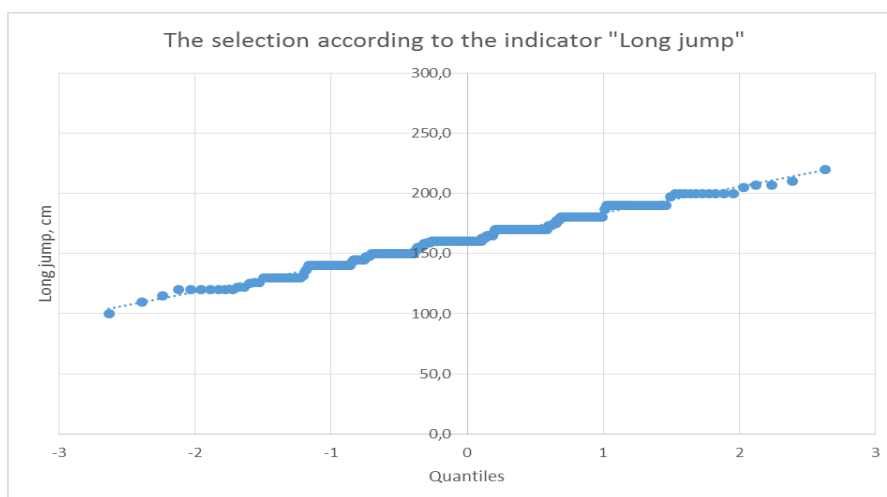


Fig. 2. Evaluation of the symmetry of the sample according to the histogram for the “Long jump”

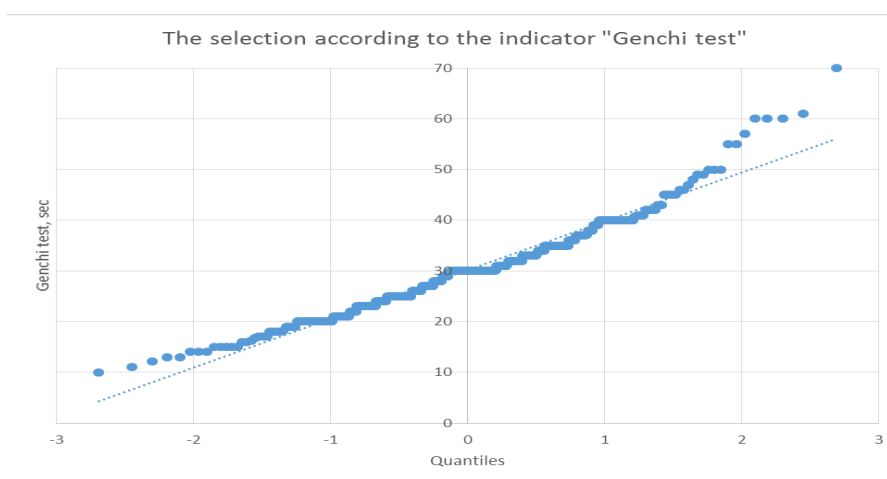


Fig. 3. Evaluation of the symmetry of the sample according to the histogram for the indicator of the “Genci Test”

Table 1. Physical development of female students

Parameters	Group 1			Group 2		
	n	M	m	n	M	m
Body length, cm	235	164,25	0,36	270	165,28	0,53
Body weight, kg	236	56,19	0,50	260	58,57*	0,99
Mass-growth index	226	341,32	3,21	258	351,36*	3,28
Muscular strength of the right hand, kg	334	22,61	0,26	241	23,85*	0,98
Muscular strength of the left hand, kg	333	20,64	0,25	241	22,23	1,00
Power index	218	40,74	0,63	235	40,65	1,17
Circumference of chest, in the rest, cm	342	85,04	0,30	269	85,99	0,78
Circumference of chest, breath, cm	342	89,60	0,30	269	90,61	0,76
Circumference of chest, exhalation, cm	342	83,24	0,29	269	83,61	0,79
Chest excursion	342	6,35	0,12	269	7,99	0,99

Note: * - the differences are reliable, $p > 0,05$

Table 2. Physical preparedness of female students

Parameters	Group 1			Group 2		
	n	M	m	n	M	m
1000 m, min	199	5,07	0,06	179	6,11	0,97
2000 m, min	34	11,94	0,28	29	11,73	0,28
100 m, sec	23	18,29	0,41	20	18,25	0,41
30 m, sec	213	5,43	0,04	200	6,38	0,97
Broad jump from the place, m	237	164,10	1,31	241	159,66*	1,30
Bending and extension of arms in support, times	249	9,91	0,46	220	12,58*	1,09
Body sit-up for 30 sec., times	233	22,77	0,71	242	23,06	0,95
Hanging on a crossbar, sec	241	8,66	0,64	200	11,40*	1,16
Inclination forward from standing position, cm	236	12,43	0,62	199	13,00	1,17

Note: * - the differences are reliable, $p > 0,05$

Table 3. Functional state and efficiency of female students

Parameters	Группа 1			Группа 2		
	n	M	m	n	M	m
Vital capacity of lungs, ml	333	2794,74	28,16	258	2872,81	42,74
Vital index, ml/kg	229	49,43	0,79	246	51,51	1,14
respiration rate, for 1 min	333	16,45	0,21	261	19,06*	1,27
The Stange test, c	283	47,81	0,81	255	48,26	1,24
The Genci test, c	279	30,18	0,58	255	32,84*	1,10
Maximum of oxygen consumption, ml/min	146	9,74	0,24	256	10,82	0,99
Kredo index	327	17,16	0,92	228	16,31	1,53
The coefficient of efficiency of blood circulation	327	3782,07	58,16	226	3460,18*	68,46
The coefficient of endurance	327	18,80	0,33	215	15,30*	0,97
The adaptation potential	327	2,24	0,03	218	2,99	0,99
Heart rate, bpm	336	81,89	0,64	264	81,22	1,02
SBP - systolic blood pressure (mmHg)	330	113,86	0,71	228	111,21*	0,95
DBP - diastolic blood pressure (mmHg)	330	66,78	0,52	228	68,42	0,95

Note: * - the differences are reliable, $p > 0,05$

significant differences in physical development, physical fitness, functional status of female students. It is increased the body weight, mass-growth index, muscular strength of the right hand, the time of hanging on the crossbar, the number of push-ups from the floor; breathing rate. Decreased the length of the jump from the place, the Genci test, the coefficient of efficiency of circulation, endurance factor, systolic blood pressure.

Discussion

The results of our study correspond to the physical development of school leavers [55] and female students [56] in Kirov (Russia), students from Nizhny Novgorod (Russia) [57], Cherepovets (Russia) [58] and Kazan (Russia) [59].

Physical development. The data obtained by us on the increase in body weight in first-year students confirm the literature data. According to [60], the girls added about 1 kg of weight during the first year of schooling at the university. The authors consider the first semester to be a critical period in the weight set [60]. They attribute this to significant changes in life [12] and unhealthy eating

behavior [61]. In another study of Belgian female students, weight and body mass index for the first 1,5 years at the university have not changed [62]. Thus, the literature data on the informativeness of the mass-growth index are contradictory [48]. The data obtained on the increase in the muscular strength of the right hand (increased by 1,85 kg) are consistent with the literature data [62].

Physical fitness. The data obtained by us agree with the literature data [58]. They testify to ambiguous dynamics of speed-strength and strength qualities of female students during the first year of study. In particular, about the improvement of power qualities (flexion and extension of the arms in the support lying hanging on the crossbar) and deterioration of the speed-strength qualities (long jump from the place). Other authors [63] is recognized jump in length from the place as the most informative indicator for the evaluation of muscle strength. In our opinion, the decrease in the "long jump" may be due to an increase in body weight and a general decrease in motor activity. According to [58], this is due to the selective activity of certain muscle groups and their ability to maximal power and speed. This ability, in the 17-18

years, is predominantly manifested by the muscles of the lower extremities involved in performing the jumping exercises (speed strength). In 20 years, this ability is mainly manifested by the muscles of the abdomen and back (power endurance). For the first time we have shown the increase in the process of adaptation to learning such indicators as: time of the hanging on the crossbar; amount of push-ups from the floor.

Functional state and efficiency. The data obtained by us on the state of the respiratory system testify to the multidirectional processes in the body of female students in adapting to training. An increase in the frequency of respiration at rest indicates disadaptation processes. Increased respiratory retention on exhalation (the Genci test) indicates adaptive processes. The Genci test is considered to be an informative indicator of the health of students [18]. There is a decrease in indicators: CEBC, systolic blood pressure; coefficient of endurance. In this case, the CEBC and the endurance coefficient tend to the physiological norm. We believe that supporting activities in physical culture played an important role in this. For the first time we showed a decrease in the process of adaptation to learning indicators: CEBC, systolic blood pressure; coefficient of endurance.

In our opinion, the indicator indices for the adaptation of female students to learning are characteristics with statistically significant differences. We suggest using those that are confirmed by consistent information in the literature.

We include such indicators: the results of hand dynamometry (an indicator of physical development), a long jump from the place (an indicator of physical readiness), the Genci test (an indicator of the functional state). We also propose to use CEBC and endurance factor as indicators of functional status. This choice is due to the fact that in the process of adaptation, their values tend to a physiological norm.

We do not agree with a number of authors [19] who consider the learning process at the university as a negative factor in reducing the health of students. In our opinion, the negative impact is manifested in part – in reducing the speed-strength qualities and increasing the frequency of breathing. Positive trends (the completion of growth processes and the adaptation process) are confirmed by the growth (by the end of the first year of training) of power qualities and indicators of the functional state.

Conclusions

1. During the first year of training, ambiguous dynamics of the functional state, speed-strength and strength qualities of students was established.

2. We suggest to consider the indicator indices of the process of female students' adaptation to learning: the results of hand dynamometry (physical development index), long jump from the place (the indicator of physical readiness), the Genci test, CEBC and the endurance factor (indicators of the functional state).

Conflict of interest

The authors state that there is no conflict of interest.

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Changes in foot pressure on the ground during *mae-geri kekomi* (front kick) in karate athlete - case study

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

Abstract

Purpose: Biomechanical analysis of martial art techniques are objective and quantitative method, which may be useful in training practice for the purpose of improving these techniques as well as monitoring and enhancing athletes performance. The aim of this study was to assess selected kinetic parameters and lower limb loading during karate front kick, using force platforms, for both kicking and support leg.

Material: Karate athlete, second dan, black belt holder in Idokan style, participated in this case study. The subject performed front kick in the air (without a physical target), both for his right and left leg, while standing on the force platforms. For the purpose of kinetic data recording **two force platforms were used in this study** (Kistler force plate, type 9286AA, Kistler, Switzerland). Selected kinetic parameters for kicking and support leg as well as front kick execution time were analysed.

Results: Results of our case study revealed higher values of the kinetic parameters for the right leg, comparing to the left leg. This results confirm athlete's declaration of being right leg dominant.

Conclusions: Analysis of selected kinetic parameters may be useful in identifying lower leg laterization (leg dominance), as well as existing asymmetries between the dominant and non-dominant leg in karate and other martial art athletes.

Keywords: martial art, karate, kinetics, frontal kick, force platform

Introduction

Biomechanics of martial arts allows for identifying and better understanding the factors that can influence a successful performance at a competition, show or during a fight. This knowledge can also enhance the ability of proper learning and teaching of the karate strokes and techniques. The frontal kick is relatively easy to learn, but it is difficult to master karate technique. It includes rotational movements performed to produce high-speed movement of the lower leg kinematic chain segments. In the available scientific literature concerning the biomechanics of combat sports and martial arts it is not one of the most commonly analysed kicks, while the most attention is devoted to the roundhouse kick [1-4].

Previous studies concerning biomechanical analysis of this type of strokes have already provided some basic information. The average kicking time is about 0.63 seconds and the average speed is 10.40 m / s for the taekwon-do athletes [5]. It was found that the speed of the front kick technique mostly depended on the movement velocity in the knee joint and kicking time (duration of the kick) [5, 6]. Sorensen et al. [7] reported that in the case of high front kick, the thigh slowing is due to movement which depends on the initial movement in the lower limb rather than the inhibition activity. Differences in kinematics during performance of the frontal kick were observed in Shotokan karate athletes [8]. Depending on the athletes level of experience, more repeatability in the movement kinematics were observed, especially in the

pre-loading phase, which precedes the attack phase. It was found that the duration of the kick and the repeatability of the lower limb movement could be useful when selecting the top karate players and monitoring their preparation status. It is recommended that in karate sports training this type of kicking should be performed using physical targets [9].

We know that distance from the physical target affects kinetics of the kick [10]. Increasing distances reduces the impact force and increases the reaction time.

Speed is an important element of success in combat sports and self defence. Sometimes, the victory or the defeat in the confrontation depends on the athletes speed of reaction. However, it has been suggested that precision and kicking speed are opposite priorities [11,12].

Cynarski et al. [13] described that the karate front kick (*mae-geri kekomi*) should be done very precisely. All of the aforementioned movements should form a single fluent motion without any pauses, so that the first movement of raising the knee adds impact to the violent kick. If the kick is towards the *chudan* zone, i.e. at the height of the solar plexus, the striking surface (*chusoku*) shall move towards the target along a straight line in the final section of motion. The front kick is best performed from a stable stance. It can be done with the front leg or the back leg, as well as when stepping forward.

Therefore, the purpose of this study was to assess selected kinetic parameters and lower limb loading during karate front kick, using force platforms. Changes of the force of pressure applied to the ground for both kicking and support leg were recorded and analysed.

We hypothesised that we can observe some difference between the right and left leg due to the lateralization (lower leg dominance).

Material and methods

Participants

Karate athlete, second dan black belt holder in *Idokan* style [14], participated in this case study (age: 36 years; body mass: 97 kg; height: 177 cm).

The study procedure was approved by the Ethical Committee of the University of Rzeszow as a meeting the criteria of Ethical Conduct for Research Involving Humans. A subject participating in this study was informed about all testing procedures and has signed written informed consent.

Procedure

The athlete participating in our study was asked to perform front kick in the air (without a physical target), from *zenkutsu-dachi* standing position, both for his right and left leg, while standing on the force platforms. For the purpose of kinetic data recording two force platforms were used in this study (Kistler force plate, type 9286AA, Kistler, Switzerland), in order to acquire kinetic data for both kicking and support leg. Changes in pressure force applied to the ground for both legs were recorded and

analysed. Following parameters for the support leg were calculated: P_N - maximum force applied to the ground (pre-loading phase), P_K - maximum force applied to the ground during leg extension phase of the kicking leg (attack phase for the kicking leg). For the kicking leg following parameters were determined: F_T - maximum force applied to the ground (pre-loading phase), F_E - maximum force applied to the ground after the kick execution, T - front kick execution time (kicking foot with no contact with the ground)

Statistical analysis

Due to the fact that our research was a case study, there was no statistical analysis of the results applied [15]. Data in the results section of this article is presented as an average (maximum) value of selected kinetic parameters obtained from the force platform, as well as in the graphs.

Results

Table 1 presents the value of selected kinetic parameters of the right leg front kick performed by the karate player as well as the right leg front kick execution time, which is 0,95 second. Figure 1 is the graphical presentation of the kinetic parameters, acquired using the force platforms, both for kick leg (right) and support leg (left).

Table 2 presents the value of selected kinetic

Table 1. Selected kinetic parameters for right leg front kick

	P_N [N]	F_T [N]	T [s]	F_E [N]	P_K [N]
Kick leg (right)	-	1013,049	0,95	1208,694	-
Support leg (left)	1295,668	-	-	-	1025,557

Parameters for the kick leg (right) - F_T - maximum force applied to the ground (pre-loading phase), F_E - maximum force applied to the ground after the kick execution, T - front kick execution time (kicking foot with no contact with the ground)

Parameters for the support leg (left) - P_N - maximum force applied to the ground (pre-loading phase), P_K - maximum force applied to the ground during leg extension phase of the kicking leg (attack phase of the kicking leg)

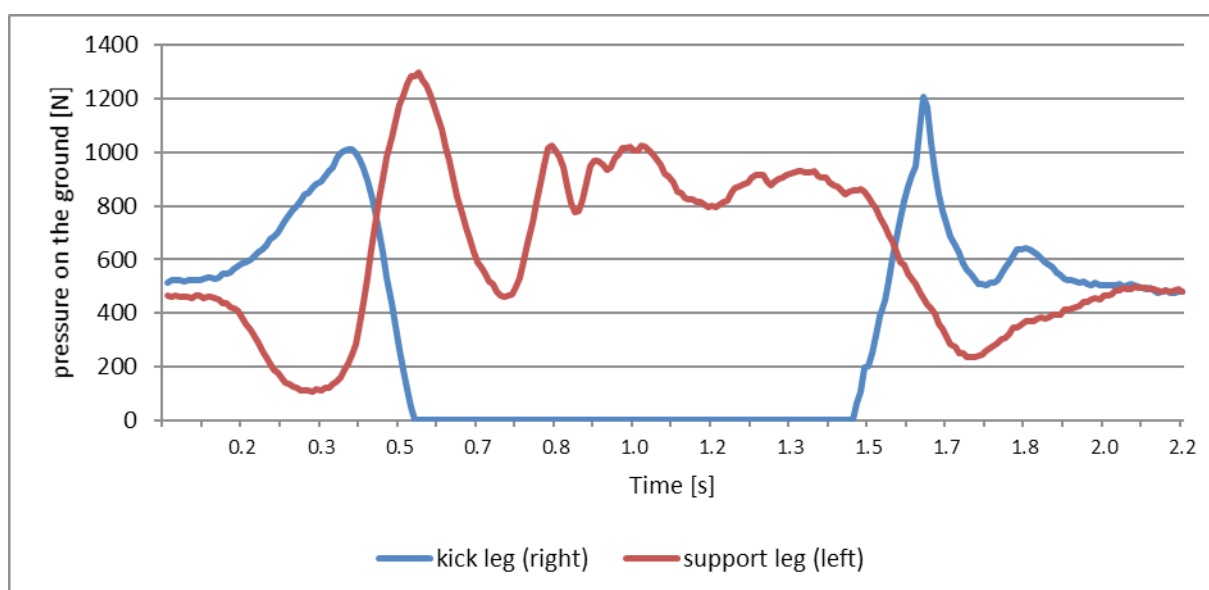


Fig. 1. Changes of foot pressure on the ground while performing the right leg front kick

parameters of the left leg front kick, as well as the left leg front kick execution time, which is 0,89 second. Figure 2 is the graphical presentation of the kinetic parameters, acquired using the force platforms, both for the kick leg (left) and support leg (right).

Discussion

Our case study results revealed that the maximum load on the support leg while performing a karate front kick was approximately 1295-1462 N - for the left and right leg respectively (tables 1,2). It has been reported that in taekwon-do players performing the jump front kick, the values of ground reaction forces were about 400 N higher, comparing to our results [16]. During the kicking leg extension phase (in the knee joint), the maximum values of the ground reaction forces for the support leg are around 1024-1025 N - for the left and right leg respectively (tables 1,2). With a constant body weight, the high speed of the kicking leg is associated with a large change in momentum. A large momentum (change in momentum) informs us about a great force impulse [17]. Thus, according to the third principle of dynamics, this should be reflected in the force of pressure on the ground,

recorded using force platforms. In the future, it is worth checking if there is a correlation between the speed of the kicking leg and the ground reaction forces of the support leg.

In our study the front kick execution time (time when the kicking leg has no contact with the ground) was 0,89 seconds for the left leg and 0,95 seconds for the right leg. Within this time, the kicking leg was extended and then returned to the starting position.

The athlete participated in this study declared that his dominant leg was the right leg. Results of our study confirmed this and revealed higher values of selected kinetic parameters for the right leg, comparing to the left leg. The maximum value of the force applied to the ground in the pre-loading phase - F_T (before the attack-phase) was almost 63 N higher for the right leg comparing to the left leg (tables 1,2). Interestingly, similar results were observed concerning maximum force applied to the ground with kicking leg after the kick execution (F_E) - 1082 N for the left leg and 1208 N for the right leg, with a difference of 126 N between the right and left leg (tables 1,2).

Such a methods of biomechanical analysis of karate

Table 2. Selected kinetic parameters for left leg front kick

	P_N [N]	F_T [N]	T [s]	F_E [N]	P_K [N]
Kick leg (left)	-	950,516	0,892	1082,424	-
Support leg (right)	1462,067	-	-	-	1024,301

Parameters for the kick leg (left) - F_T – maximum force applied to the ground (pre-loading phase), F_E – maximum force applied to the ground after the kick execution, T – front kick execution time (kicking foot with no contact with the ground)

Parameters for the support leg (right) - P_N - maximum force applied to the ground (pre-loading phase), P_K – maximum force applied to the ground during leg extension phase of the kicking leg (attack phase of the kicking leg)

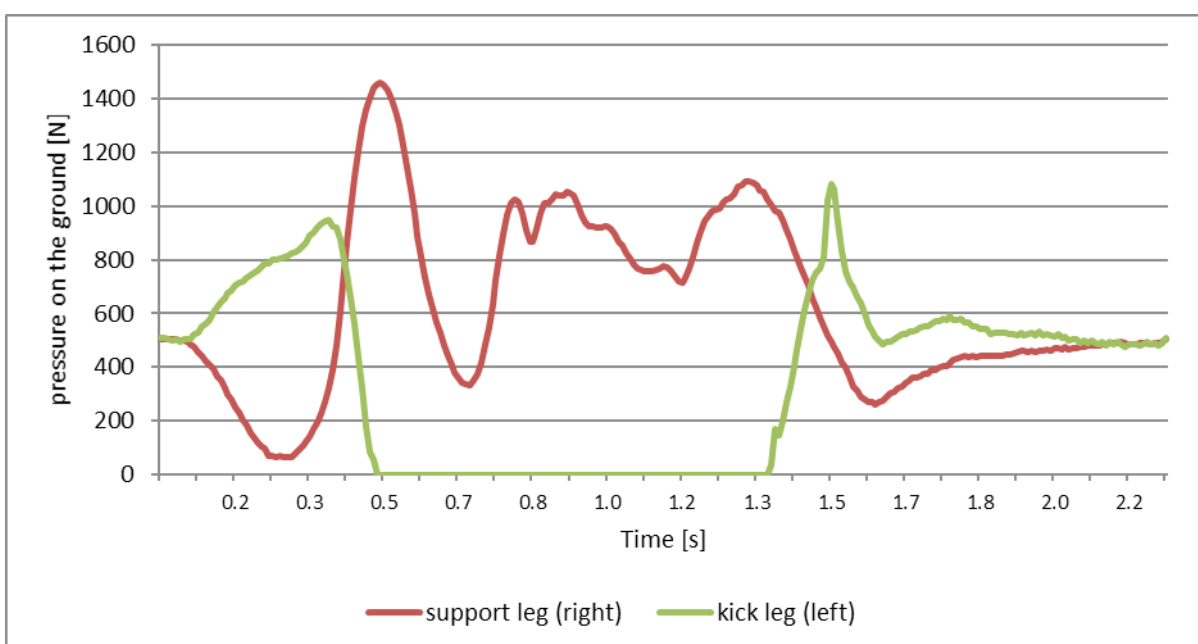


Fig. 2. Changes of foot pressure on the ground while performing the left leg front kick

techniques (as well as other martial arts and combat sports) provides precise and quantitative information about the movement, which may enable to improve these techniques in training practice and enhance athletes' performance [13, 18].

Our study has some limitation, due to its single-subject case study character. Although the results are promising and they can indicate the need for its continuation on a bigger group of subjects, which enables for its appropriate statistical analysis. The results presented here may also provide some initial, basic data for further comparisons in a similar research. They can also indicate the need for interdisciplinary exploration and research, which includes the area of therapeutic and rehabilitation activities inspired by martial arts [19-23].

Conclusions

Due to the study limitations, it is impossible to present any direct conclusion or statement. We can assume that analysis of selected kinetic parameters may be useful in identifying lower leg laterization (leg preference), as well as existing asymmetries between the dominant and non-dominant leg in karate and other martial art athletes. Besides the results of our study can highlight the importance of quantitative, biomechanical analysis of martial art techniques for the purpose of their improving in training and enhancing athletes performance.

Conflict of interests

The authors declare that there is no conflict of interests.

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Reviewing the effect of the stretch-shortening cycle workouts on shot hit performance

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Abstract

Purpose: The purpose of this study was to determine the effect of the stretch-shortening workouts for male football players between the ages of 18 and 20 on shot hit performance.

Material: A pretest-posttest trial method with the control group was used in the research. Sixteen male footballers between the ages of 18 and 20 voluntarily participated in our survey. The footballers were divided into two groups by the random method, and thus the experimental group (8 footballers) and control group (8 footballers) were constituted. The pretest values of the experimental and control groups were recorded by applying the Dewitt-Dugan shot hit test before eight weeks of training. The experimental group performed technical-tactical training with stretch-shortening cycle workouts for 90 minutes three days a week, while the control group solely performed technical-tactical training for 90 minutes three days a week. Both groups were tested after the eight-week training program to obtain the final test values. Two measurements each were taken from the athletes, and the evaluation considered the best data. SPSS 21 packaged software calculated the descriptive statistics of the data collected; these data were analyzed by Mann Whitney-U, and Wilcoxon Signed tests. Statistically, significance degree was set at ($p < 0.05$) level.

Results: The results of the experimental and control group were respectively found as $p = 0.01$ and the significant difference ($p < 0.05$) was found in the comparisons of in-group and posttest. The statistical values obtained in intergroup comparisons were found as $p = 0.75$ for the first test and $p = 0.48$ for the last test. There was no significant difference ($p > 0.05$).

Conclusions: In conclusion, while there is an effect of the stretch-shortening workouts on the shot hit performance of in-group athletes before eight weeks of technical-tactical football training, there is no significant difference between the groups. Stretch-shortening cycle workouts can be suggested as an addition to the training of the athletes before technical-tactical football training.

Keywords: football, hit, stretch-shortening, shot.

Introduction

Sport is an essential part of the modern human life and also one of the most beneficial social aspects that positively affect societies [1]. One branch of sport, football, attracts great attention and generates international excitement, contributing to tourism and the presentation of the countries within the code, uniting people across the globe [2]. Plyometric training is performed to increase the efficiency of the athlete in sports like football that necessitate frequent turning and twisting [3].

In plyometric workouts, concentric muscular contraction follows the eccentric muscular contraction during movements such as running, walking and jumping. This natural combination of the muscle is called a 'stretch-shortening cycle' (SSC) and referred to as the stretch reflex in the literature [4]. Plyometric training is mostly called 'elastic force training' 'reactive training' and 'eccentric training' and is divided into sub-classes like 'depth jump' and the 'strike method. A plyometric workout allows the muscle to reach maximal force as early as possible [5]. The purpose of these workouts is mostly related to elastic force and to provide expeditious application of a high amount of force within a short time by the concentric contraction after the eccentric contraction of the muscle. Thus, the elastic force arises by an excellent speed contraction and overcoming of resistance due to the musculo-nervous

system. This training is a type of positive, negative force workout and it aims to use rapid force and also develop explosive jumping [6, 7].

It is stressed that plyometric training has advantages and disadvantages on sport performance. It provides an advantage by speedy and explicit maximal force enhancement without any increase in body weight or any change in muscle mass due to being supported by the intramuscular coordination arising from the high load intensity. It should not be applied to children, beginners at the gym and young adults because extra strength and a well-prepared musculo-skeletal system are required. Plyometric workouts without following the rules may have possibilities of injury [8]. Plyometric training in young athletes should be progressed from easy to difficult. The sets applied ought not to be shorter than 6-8 seconds; and factors like the intensity, volume, frequency, and recovery should be considered when preparing plyometric training for young people [9].

We can see when looking at literature surveys that the motoric characteristics are based on the effects of the plyometric (stretch-shortening) cycle [7, 10]. Our study aims to determine whether the stretch-shortening cycle workouts have any effect on the shot hit performance of footballers.

Material and methods

Participants

Sixteen male footballers who play in the same team in the amateur league voluntarily participated in this study.

The participants' average age was 18.93 ± 0.77 year; height average was 170.87 ± 8.14 cm, bodyweight average was 66.55 ± 7.16 kg, sports experience average was 2.81 ± 0.75 years.

This survey was carried out using the simple random sampling method in the pretest-posttest trial model with a control group [11].

For the survey, 11/9 decision numbered, 2014/147 project numbered, 13,05,2104 dated Clinical Investigation Ethics Committee Report was taken.

Procedure

Pretest measurements of the Dewitt-Dugan shot test were received from 16 male footballers before the training. Each of the athletes took two test values, and the best value was accepted. The athletes were divided into two groups (experimental and control) after the measurement. Experimental and control groups performed training programs taking 90 minutes a day, three days a week, for a total of eight weeks. The experimental group athletes performed stretch-shortening cycle workouts and technical-tactical training while the control group athletes just performed the technical and tactical training. Both groups of athletes' posttest measurements of the Dewitt-Dugan shot test were recorded at the end of the eight-week training program. The data obtained were statistically evaluated.

Training Program of the Experimental and Control Groups

Two different training programs for 90 minutes were performed by athletes on non-successive days.

Experimental Group

The athletes performed 27-30 minutes stretch-shortening cycle workouts between 80%-85% intensity interval (information on the content of the training for five minutes, warm up running for 15 minutes, stretching for 10 minutes, totaling 24 units of training).

One Unit Training of Experimental Group

Training Purpose: Stretch-shortening cycle workouts.
Training Time: 90min.

Training Age Group: 18-20.

Control Group

After undertaking 30-minute preparation workouts, 50 minutes of technical-tactical training at 76% intensity were performed by the attendees. The training was concluded by 10 minutes of jogging-stretching workouts after the technical-tactical training.

One Unit Training of Control Group.

Training Purpose: Technical/Tactical.

Training Time: 90 min.

Training Age Group: 18-20.

Explanation of Training: 5 min.

Explanation of Training and Warmup Running: 25 minutes.

Stretching and Cooling Down Running: 10 minutes.

Basic Part of the Training: 50 minutes.

1st workout: 2:1, 2:2, 2:1 A free game was played on the condition that each of the players stands in his own area. The game was stopped by the trainer, and it was checked whether the players had violated the area or not. The players were warned on this issue. Points to consider: To create a free field and to be able to use it, support, quality pass, intrusion, creativity.

2nd workout: After the application was well understood, the workout continued as a competition by considering the points and removing the signs.

Measurement of Dewitt-Dugan Shot Test

The target seen in Figure 1 was drawn on a board. The attendees shot the ball five times from 27 meters away from the board. The scores that hit the target were recorded. The scores that hit the line were counted into the higher scored area. The values obtained were set as the scores. The missed shots were not included in the survey.

Statistical analysis

SPSS 21 packaged software analyzed the data. The Wilcoxon Signed Ranks test measured the in-group, and the Dewitt-Dugan shot hit test was performed pretest, and posttest. Between-groups, pretest, and posttest values were analyzed by the Mann-Whitney U test and a $p < 0.05$ significance level was sought.

Table 1: Stretch-Shortening Cycle

Line	Training Method	Intensity	Repetition	Set-relaxing	Total (min.)
A)	Preparation Stage				
1	Explanation of Training				5 min.
2	Warm-up				15 min.
3	Stretching				10 min.
B)	Stretch-Shortening Cycle				
1	S.T.A.A.S.H.F.T	80%	25	660(Sec.)	9 min.
2	S.T.Ç.K	85%	20	660(Sec.)	9 min.
3	A.S.T.İ	80%	25	660(Sec.)	9 min.
C)	Normal Team Training (Technical-Tactical)				25 min.
D)	Cooling down (Jogging-Stretching)				8 min.

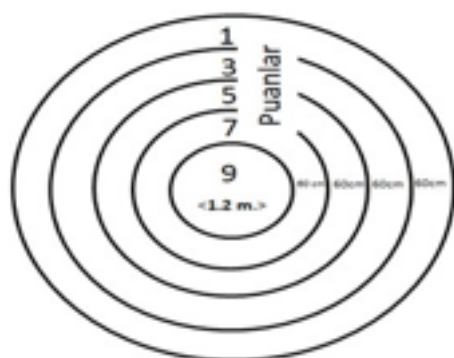


Figure 1. Dewitt-Dugan Board Measurements [12]

Results

As is in Table 1, the average age of the experimental group athletes was 18.87 ± 0.83 years, height average was 168.87 ± 7.80 cm, bodyweight average was 64.97 ± 7.26 kg, sports age average was 2.75 ± 0.70 years. On the

other hand, the average age of the control group athletes was 19 ± 0.75 years, height average was 172.87 ± 8.49 cm, bodyweight average was 68.12 ± 7.17 kg, sports age average was 2.87 ± 0.80 years.

As is seen in Table 2, a significant difference smaller than $p < 0.05$ was found when the Dewitt-Dugan shot tests of the control group athletes were compared. A significant difference smaller than $p < 0.05$ was also found when the Dewitt-Dugan shot hit tests of the experimental group of athletes were compared.

As is seen in Table 3, there is no significant difference, the p values of all the tests are $p > 0.05$

Discussion

This paper researches the effect of stretch-shortening cycle workouts performed by amateur male footballers between 18 and 20 years of age on shot hit performance. Orhan et al. [13] conducted a survey called 'the effect of rope and weight rope workouts on basketball skills.' In their investigation, the experimental groups performed rope and weighted rope workouts; while the control group performed only the technical training. At the end of the

Table 2. Anthropometric descriptive statistics of experimental and control group athletes

EXPERIMENTAL	N	Min.	Max.	Mean	Standard Deviation
AGE (year)	8	18.00	20.00	18.87	0.83
WEIGHT (kg)	8	56.30	76.10	64.97	7.26
HEIGHT (cm)	8	160.00	181.00	168.87	7.80
SPORT AGE (year)	8	2.00	4.00	2.75	0.70
CONTROL	N	Min.	Max.	Mean	Standard Deviation
AGE (year)	8	18.00	20.00	19	0.75
WEIGHT (kg)	8	59.10	78.40	68.12	7.17
HEIGHT (cm)	8	160.00	184.00	172.87	8.49
SPORT AGE (year)	8	2.00	4.00	2.87	0.80

Table 3. Comparisons of Wilcoxon Signed Ranks test data of the control and experimental group

Experimental Group	Pretest Mean. \pm SD	Posttest Mean. \pm SD	p
Dewitt-Dugan Shot TEST	23 ± 5.31	28.87 ± 3.31	0.010*
Control Group	Pretest Mean. \pm SD	Posttest Mean. \pm SD	p
Dewitt-Dugan Shot TEST	22.37 ± 5.37	28.12 ± 5.05	0.011*

*($p < 0.05$)

Table 4. Comparison of the test values of Experimental and Control group athletes via Mann Whitney U Test

Experimental Group and Control Group Tests (mann-whitney u)	p
Dewitt-Dugan Shot Test Pre-measurement	0.750
Dewitt-Dugan Shot Test Post-measurement	0.489

*($p < 0.05$)

study, a significant difference ($p < 0.01$) was confirmed in pointed shot number values of the experimental groups before and after the training. On the other hand, there was no significant difference ($p > 0.05$) in pointed shot number values between experimental and control groups. In the research done, no statistically significant difference is confirmed when the last measurements of the Dewitt-Dugan shot test are compared after the training performed by the athletes of the experimental and control groups ($p = 0.489$).

Özbek [14] conducted research to review the effect of preparation period and upper extremity force workouts on the shot hit of male basketball players between the ages of 15 and 17. He determined a significant difference ($p < 0.01$) in shot hit values of quick power training performed with jumping and sprint workouts. Also, in this survey, the value is accepted as $p = 0.01$, and the significant difference is also confirmed in the pretest and posttest measurements of control group athletes in the Dewitt-Dugan shot test ($p < 0.05$). These two surveys verify each other regarding the effect of the training performed because both athlete groups applied the training program which can develop quick power and affect the shot hit performance.

Kurban's [15] research, 'Reviewing the effect of football training on the technical progress of boys between 10-13 ages' shows the positive effect of the football training on the shot hit performance ($p < 0.05$). Kurban asked the participants to undertake some technical workouts like inside cut, shot, dribble, and jink. Then, a significant difference in the shot hit performance was observed. In this same study, the control group of athletes performed similar training and a significant difference ($p < 0.05$) was found when the pretest and posttest measurements of the Dewitt-Dugan shot test of the athletes were compared ($p = 0.01$). It may be thought that the technical training affects the shot hit values positively.

Ölçücü [16] researched the effect of plyometric training on the strengthening of arms and legs, service, forehand, backhand, striking velocity, and the percentage of hits for male tennis players whose age average was 22.10 ± 1.33 . In this study, the experimental group performed the plyometric workout in addition to classical tennis training; the control group only completed the classical tennis training. At the end of the research, the plyometric training positively affected the backhand, cross and service hit of the athletes.

Canikli [17] actualized a study to analyze the effect of plyometric training on backhand and forehand, striking velocity and hit percentages of male university students who play tennis. While the experimental group performed plyometric training in addition to the classical tennis training, the control group solely carried out the classical tennis training. It was determined at the end of the study that the plyometric training affected the backhand, cross and service hit of the athletes positively ($p < 0.05$). The p-value was found as 0.48 in the posttest measurements between groups, and no significant difference ($p > 0.05$) was found at the same time. We can link this different

conclusion with the ball being moveable in hit tests performed by the tennis players. Quite the reverse in our research, the footballers hit a dead ball. The number of human subjects was 40 in the surveys of Ölçücü [16] and Canikli [17]. We had only 16 participants. These different participant numbers produced the different results.

In Fletcher and Hartwell's [18] survey called 'The effect of 8 weeks combined weight and plyometric training program on the striking velocity and hit distance for the golfers'. The experimental group performed weight and plyometric training in addition to the normal golf workouts. The control group carried out classical golf training. It was found at the end of the study that the weight and plyometric training program had a positive effect on the performance for hitting the golf ball to the final pit ($p < 0.05$). The p-value was found as 0.48 in pretest and posttest measurements between groups. There was no significant difference ($p > 0.05$). Fletcher and Hartwell conducted plyometric workouts in addition to the golf training. However, the plyometric ones were performed before the technical-tactical ones. There are also studies similar to that of Fletcher and Hartwell. These studies made us think that the plyometric training may be effective on the hit performance. However, the exercise alignments being different may be the reason for the different results.

Eler's [19] study, 'The effect of the strength training particular to handball on some of the performance parameters of young handball players,' was undertaken with 16-year-old male handball players. The experimental group carried out 72 strength and technical training sessions over 12 weeks. The control group solely performed the technical training. They determined statistically significant decrements in technical skills like a shot hit by jumping, and dribbling for 30 meters in the experimental group ($p < 0.05$). The reasons for the different conclusions are as follows: our research took eight weeks, the number of stretch-shortening cycles and technical workouts was 24, and thus there was less training over a shorter term.

Ürer [20] examined the effect of plyometric exercises on the upper and lower extremities on vertical jump performance, and upper block hit ratio for male handball players in the 15-17 age group. It was determined that plyometric training has no effect on top block shot performance ($p > 0.05$). Ürer's survey took six weeks. The athletes performed plyometric exercises before the technical workouts two days a week, besides the normal handball exercises applied five times a week. The greater training frequency may have negatively affected the conclusion.

As a consequence, we observed that the stretch-shortening cycle workouts performed before eight weeks technical-tactical training positively affected the shot hit performance of the athletes. Moreover, it can be suggested that this kind of exercise should be performed by elite athletes, different age groups and a bigger sample. As an extra, the hit ratios of the athletes during the Dewitt-Dugan shot test can be specified and evaluated as well.

Conclusions

As a result, it was found that stretch-shortening cycle training before 8-week technical-tactical soccer training session in athletes significantly improved shot hit performance when compared to athletes who had technical-tactical training session there was no significant difference.

It may be advisable to conduct studies with different age groups and with more subjects.

It may be suggested that the examination the effect of Stretch-Shortening Cycle Workouts on the shot hit performance in elite athletes.

When the Dewitt-Dugan board smash test is being performed, it may be advisable the determination of the percentage of hit points and evaluation in athletes.

The effects of the same work on female soccer players might be examined.

Conflict of interests

The authors declare that there is no conflict of interests.

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Prediction and increasing of general level of students' endurance by the exercises of aerobic direction

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Abstract

Purpose: to test experimentally the level of aerobic activity on the overall endurance of students in groups of table tennis.
Material: The first-year students (n = 106; n = 53 - control group, n = 53 experimental group) took part in the experiment. It was used Cooper's test. It was used a fractal analysis for analyzing the results.
Results: The results point to disadvantages in the students' physical education program. The program is offered for special sports training (table tennis – 75%) and aerobic classes (cross training and elements of basic aerobics – 25%). It is shown the method of forecasting. The use of the methodology allowed significantly improve the prediction accuracy and stability of the forecast. This reduces the effect of the duration of the retrospective period on the parameters of the forecast model.
Conclusions: the program of physical education for students with sports orientation (sectional classes, table tennis) is grounded. The program includes aerobic classes (cross training and basic aerobics).
Keywords: aerobic exercise, general endurance, table tennis, the Hurst method, fractal analysis.

Introduction

The problem of improving the process of physical education of students for many years is the subject of attention of specialists [1-3]. An analysis of literary sources shows that the level of physical training, mental and moral strength of the majority of students remains rather low [4, 5]. This indicates a deterioration in the physical, mental and moral development of the younger generation [6, 7], progress in motor activity deficit [8-10]. Such indicators lead to a deterioration in the health of students.

All these require finding new ways to improve the physical, mental and moral condition of student youth [11, 12]. According to the results of studies [13, 14], students assessed the importance of development of physical qualities as follows:

1) endurance - 41,8%, 2) strength - 14,9%, 3) agility - 13,7%, 4) flexibility - 12,2%, 5) coordination - 9,8%, 6) speed - 7,6%.

And their own level of physical fitness was estimated as follows:

1) strength - 22,3%, 2) coordination - 19,5%, 3) speed - 16,1%, 4) flexibility - 15,3%, 5) agility - 14,9%, 6) endurance - 11,9%.

The above facts indicate that students understand the important effect of endurance and its significance in solving the set tasks of preparation [15]. They also realize that this physical quality in most of them is the worst [14]. Questions for improving the physical training of students have recently been considered in research works of a large number of researchers [16, 17]. Grinko V.M. studied the

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effect of aerobic exercise on students' health [18]. Izaak S.I. monitored the physical activity of students [19]. Other studies point to the need: to take into account the individual characteristics of students [20, 21]; formation of an active life position of students [22]; prediction of student success [23, 24]; introduction of objective criteria for assessing the physical development of students [25, 26]; special control during endurance training [27-29].

There is a large number of works where physical qualities and various types of endurance are studied [30, 31]. The authors consider the effect of cross training and elements of basic aerobics on endurance [7, 13, 18]. These approaches have significantly improved overall endurance. The basis of the proposed program is to determine the state of overall endurance on the basis of the Cooper test. However, one can argue about the possibility of endurance development in other areas. An example is a fractal analysis by the Hurst algorithm [32]. In the work of Anis A.A. et al [33] it was investigated the value of the adjusted scale of the Hurst index, which characterizes the fractal time series for the range of independent normal matches of these series. In the work of Clegg R.G. [34] provides practical guidance on measuring the Hurst parameter for time series of different lengths. The use of fractal analysis of time series in the economy was investigated in other papers [11, 12]. The authors gave a fractal view of the financial turbulence of time series.

In work of Dubnic'kij V.Iu. [3] it was investigated the methods of forecasting time series, which represent the value of securities, taking into account the fractal dimensionality of a number of observations. In such approaches, the results of the run can be represented as

time series. For fractal analysis of such time series, it is proposed to use the Hurst algorithm [35, 36]. So, in work of Grinko V.M. et al [13] it was proposed algorithm for fractal analysis of short time series for analysis of the average number of errors in playing table tennis. In other works [11, 34] the application of chaos theory to fractal analysis of long time series in the economy is investigated.

In other studies, the fractal analysis revealed the following:

- This demonstrates the importance of consideration of gait variability when using treadmills for research or clinical purposes. Treadmill training may induce invariant gait patterns, posing difficulty in translating locomotor skills gained on a treadmill to overground walking conditions [37];
- Interventions that aim to improve gait function in patients with neurological disorders should consider the heterogeneous relationship between gait variability and neurological conditions [38];
- These analysis techniques have provided new insights into how systems (1) maintain pattern stability, (2) transition into new states, and (3) are governed by short-and long-term (fractal) correlational processes at different spatio-temporal scales [39].

Despite the large number of studies, the issue of forecasting the time series of physical education, taking into account their fractal properties, is not well understood. Therefore, this question remains controversial and requires further research.

The purpose of the research: experimentally determine the effect on the general endurance of aerobic exercises (cross training and basic aerobics) in sports-oriented groups (sectional exercises) playing table tennis. Also, justify the need to include these classes in the curriculum of physical education.

Materials and methods.

Participants. The experiment was attended by 106 first-year students ($n = 53$ - control group and $n = 53$ - experimental group). We received informed consent from all the participants to participate in this experiment.

Organization of research. At the first stage, a confirmatory experiment was conducted. The purpose is to establish the identity of control and experimental groups. Determine the initial level of development of the experiment participants. As a result, there was no significant difference between them.

At the second stage implementation of the aerobic training program in table tennis has been carried out. The purpose of this approach is to identify an increase in the level of general and special endurance. The experiment was conducted during the school year from October 2015 to June 2016.

Students of the control group were engaged in the program of a higher educational institution for groups with sports orientation (sectional classes) table tennis. The program consists of the following distribution of educational material: theoretical training, general-

physical and special-physical training, technical training, calibration and control standards, competitions. Classes were held four hours a week during academic year [40].

Students of the experimental group were engaged in the program that was developed for increasing the level of general and special endurance. Our approach combines a program for special sports training (table tennis - 75%) and aerobic classes (cross training and elements of basic aerobics - 25%) [40]. Until the middle of December, students every fourth lesson engaged in cross-training in the fresh air. Then they went to the hall, where within the experiment they continued to engage in basic aerobics (every fourth lesson). At the end of March, students went to fresh air, where they continued to engage in cross training (every fourth lesson).

At the third stage a repeated comparative experiment was conducted. The purpose of the experiment is to check the degree of aerobic activity on the physical condition of the students. In both groups, control measures were carried out at the level of general endurance. The Cooper test was used [35]. To analyze the results of running on the Cooper test, it is proposed to use fractal analysis. Fractality means self-similarity: on a different scale, the time series maintains its structure. A system of calculations was used which focused on the definition of special endurance of students [13]. To analyze the Cooper test it was used data from the control and experimental groups (Table 1, 2).

Table 1. Results of the Cooper test for the control group

Serial number of the Cooper test	Number of meters passing by students (Y_i)
1	109,870
2	109,910
3	109,915
4	109,925
5	109,950
6	109,980
7	110,005

Table 2. Results of the Cooper test for the experimental group

Serial number of the Cooper test	Number of meters passing by students (Y_i)
1	109,610
2	109,790
3	110,015
4	110,300
5	110,55
6	111,95
7	111,20

According to the algorithm of finding the Hurst index and the data of the table 1 let's calculate the Hurst parameters. This allows you to determine the time series and establish its persistence or anti-persistence [32]. This makes it relatively simple and reliable to choose

the method of forecasting the further development of the investigated process.

Based on the obtained data we build dependence (Fig. 1) to determine the Hurst indicator of the control group.

The abscissa (X) axis shows the period (n) on a logarithmic scale. The ordinate (Y) shows the corresponding R/S average value on a logarithmic scale.

By the relation (Fig. 1) we find the equation of linear regression in the logarithmic form:

$$\text{Ln}(R/S) = 0.3696 * \text{Ln}(n) + 0,088.$$

The linear gradient tangent is the Hurst index ($H=0,3696$). Thus (Table 1), the Hurst index lies within the limits $0 \leq H < 0,5$. This kind of data is often referred to as “return to the average” [41]. This, in turn, indicates that appropriate prediction methods can be used to construct the theoretical equation [13].

We make similar calculations for data in table 2.

We construct a dependence (Fig. 2) to determine the Hurst index of the experimental group.

The abscissa (X) axis shows the period (n) on a logarithmic scale. The ordinate (Y) shows the corresponding R/S average value on a logarithmic scale.

Equation of linear regression in a logarithmic form for an experimental group:

$$\text{Ln}(R/S) = 0,3907 * \text{Ln}(n) + 0,09.$$

The linear gradient tangent is the Hurst index ($H=0,3907$). Thus, the time series for the experimental group (Table 2) is also an anti-fast clock. Therefore, it is possible to use the same methods of forecasting as for the time series of the control group (Table 1).

Next, we check the result for statistical significance [36]. We use a system of calculations on the example of determining the special endurance [13].

It is established that the time series (Table 1, 2) are antipersistent. This allows them to compare and identify the effects of training methods on the results of overall endurance. The results of the comparison of time series are shown in Fig. 3.

As can be seen from the Fig. 3 methods of increasing overall endurance begin to influence the results after the second test. To estimate the results of the running of the experimental group relative to the control, we use the known relation [42]:

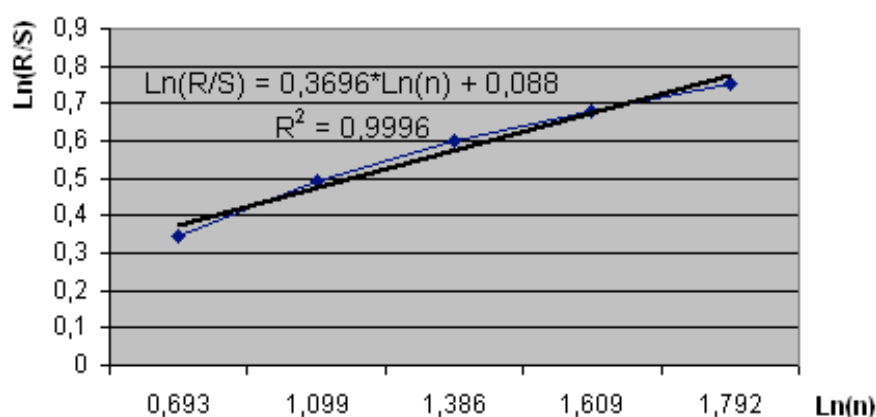


Fig. 1. The dependence ($\text{Ln}(R/S)$) from $\text{Ln}(n)$ (natural logarithm of the average value of R/S on the natural log of the length of the adjacent period n) of the Cooper test of the control group.

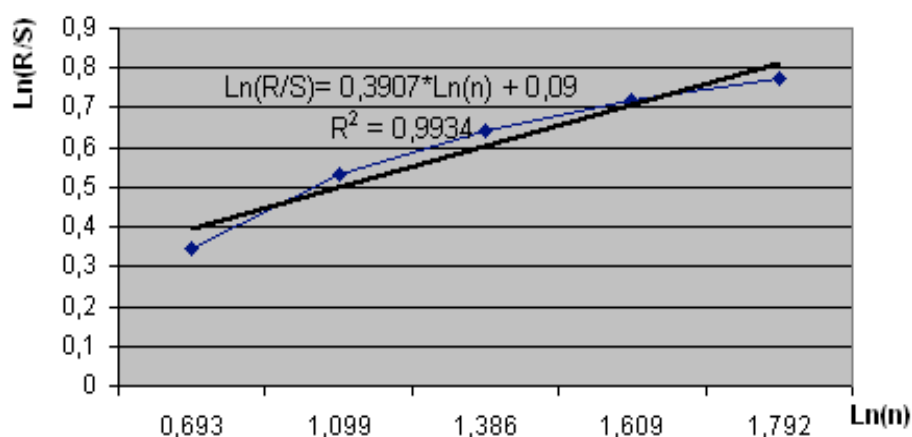


Fig. 2. The dependence of $\text{Ln}(R/S)$ from $\text{Ln}(n)$ (the natural logarithm of the mean value of R/S from the natural logarithm of the length of the adjacent period n) of the Cooper test of the experimental group.

$$\varepsilon = [(Y_2 - Y_1)/Y_2]/100, (1)$$

where n – is number of the Cooper test, Y_2 – is the results of experimental group, Y_1 – is the results of control group, ε – is the deviation of the results of the experimental group from the control group in %.

The results of quantitative comparison of the time data of the control and experimental group are summarized in Table. 3.

Statistical analysis: In the study was used a fractal analysis (the Hurst algorithm). For the processing of experimental data it was proposed R/S method. It is made the forecasting of the results for the future to determine the effect of aerobic classes on the level of overall endurance.

Results

Let's compare control group data at the beginning and at the end of the experiment.

As can be seen, the result of the control group at the end of the experiment improved by 0,135 m. This suggests that the overall endurance of the control group remained almost unchanged.

Next, compare the experimental group data at the beginning and at the end of the experiment.

As can be seen, the result of the experimental group at the end of the experiment improved by 2,01 m. This indicates a significant improvement in the results of overall endurance.

Next, it is made forecasting results for the future. We use the method of exponential smoothing [15, 36]. To calculate this method we use the formula:

$$U_{t+1} = \alpha \times y_t + (1 - \alpha) \times U_t, (2)$$

where t is the period preceding the forecast; $t + 1$ - forecast period; $U_t + 1$ is a predicted value; α is the smoothing parameter; U_t is the actual value of the investigated indicator for the period preceding the forecast; U_t is the exponential weighted average for the period preceding the forecast.

When forecasting with the exponential smoothing method, you must choose the smoothing parameter α and the initial value U_t . When choosing the smoothing parameter α for small numeric rows, all past observations (or almost all) must be taken into account. To do this we use the formula [43]:

$$\alpha = 2/(n + 1), (3)$$

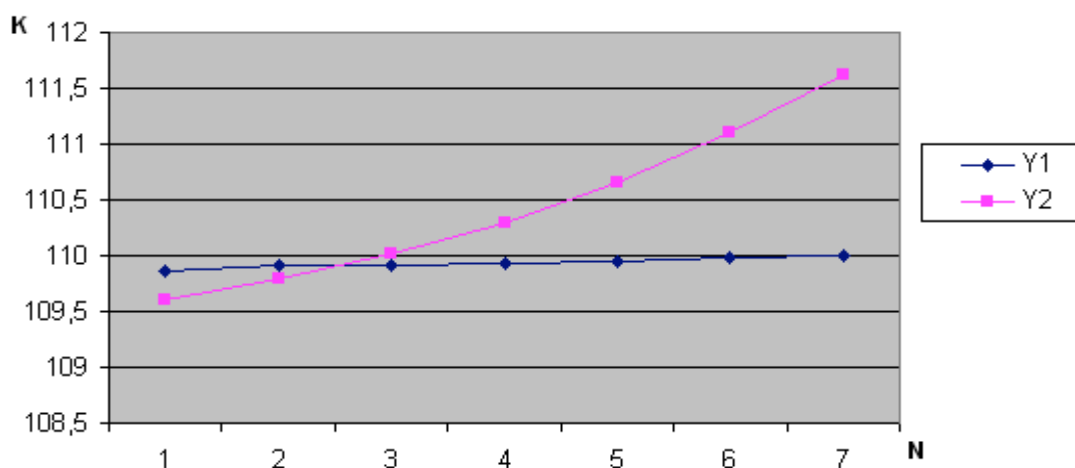


Fig. 3. Comparison of data of control (Y_1) and experimental (Y_2) groups, K – number of meters passing by students of the control and experimental groups, N – number of the Cooper test

Table 3. Comparison of time series Y_1 and Y_2

Serial number of the Cooper test	Number of meters passing by students of control group in 12 minutes (Y_1)	Number of meters passing by students of experimental group in 12 minutes(Y_2)	Deviation of data Y_2 from Y_1 , % $\varepsilon=100 (Y_2-Y_1)/Y_2$
1	109,87	109,61	-0,237
2	109,91	109,79	-0,109
3	109,915	110,015	0,091
4	109,925	110,3	0,340
5	109,95	110,655	0,637
6	109,98	111,095	1,004
7	110,005	111,62	1,447

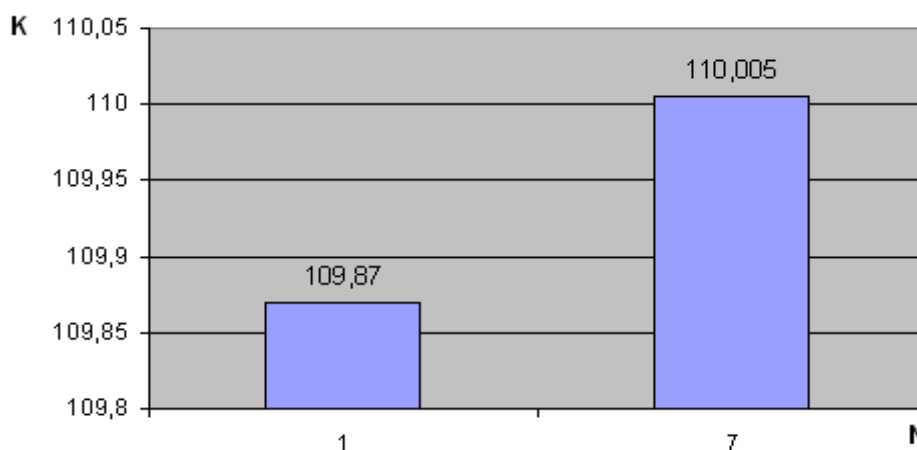


Fig. 4. Comparison of the control group data at the beginning and at the end of the experiment, **K** – number of meters passing by the control group students in 12 minutes (Y_1), **N** – number of the Cooper test.

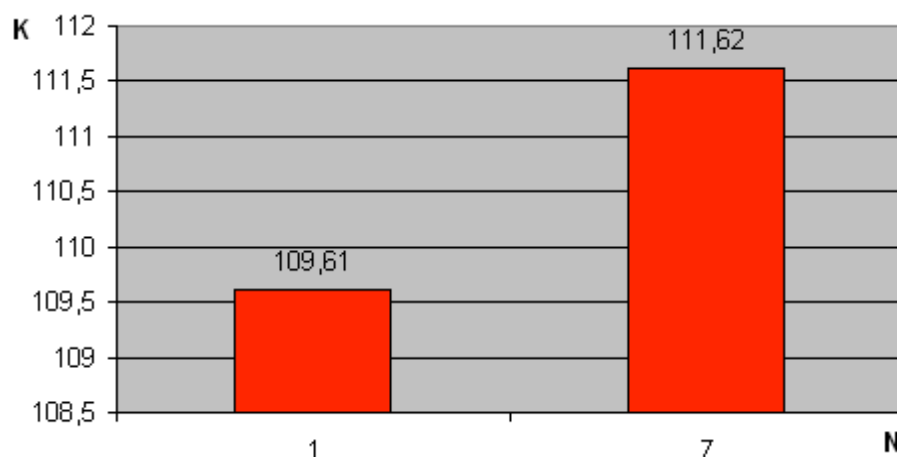


Fig. 5. Comparison of the data of the experimental group at the beginning and at the end of the experiment, **K** – is the number of meters passing by the students of the experimental group in 12 minutes (Y_2), **N** – number of the Cooper test.

where n is the number of observations included in the smoothing interval.

The initial value U_t can be calculated as the average of all observations (or as the initial first value). For the first method (as the average value of all observations), the initial value $U_t = 109,936$ (for data Y_1). For data Y_2 the initial value $U_t = 110,440$. For the other method, $U_t = 109,87$ (for data Y_1). For data Y_2 , the value $U_t = 109,61$.

Average relative error is calculated according to the formula:

$$\varepsilon = \frac{1}{n} \cdot \sum_{i=1}^n \frac{|Y_i - U_{t+1}|}{Y_i} \quad (4)$$

We obtain: $\varepsilon = 0,031\%$ for the first calculation method; $0,04\%$ for the second calculation method. This is much less than 10% , so the forecast accuracy is high.

For the experimental group, similar calculations were made and the average relative error was determined: $\varepsilon = 0,52\%$ for the first calculation method; $\varepsilon = 0,54\%$ for the second calculation method. This is much less than 10% , so the forecast accuracy is high.

Discussion.

A comparison of our data with the results of other studies [3, 15] suggests higher rates of overall endurance of students in our study. The authors of works [1, 4] are limited only by the influence of aerobic exercises on general health. Barchukova G.V. et al. [40] use aerobic exercise only at the beginning of the exercise and, finally, during general physical training. The obtained results are supplemented by scientific data on aerobic occupations and their impact on general endurance [10, 13, 18].

In the study, we used a fractal analysis. One of the advantages of the calculation method is that fractal analysis allows us to identify stochastic (random) time series [33, 34]. In such time series there is no long-term statistical dependence. Stochastic time series can not be predicted by known methods of extrapolation. Its main advantages are the simplicity of the calculation procedure and the ability to record the “weights” of the source information. Using the system of “scales” information can significantly improve the prediction accuracy and stability of the forecast. This reduces the effect of the duration of the retrospective period on the parameters of

the forecast model. This approach is consistent with the results of another study [44]. The authors propose the use of physiological indicators to predict tennis performance.

Other research on the problems of training athletes also uses forecasting techniques [45-47]. Due to this approach, the authors managed to optimize the physical load on the students and reduce the duration of training. Tests for individual groups of students were classified according to similar approaches [48]. The authors emphasize the combination of methods of forecasting and pedagogical control of motor readiness of students. Our study also shows the ability to predict student outcomes in table tennis lessons. The only difference is the use of different forecasting methods.

Our results suggest a higher effectiveness of the methodological approach to developing a program for students with athletic groups. Such a program combines the usual means of developing physical qualities with an emphasis on special endurance. We have grounded the program of physical education for students of groups with a sports orientation (sectional classes, table tennis). The

program includes aerobic classes (cross training and basic aerobics).

Financing

The work performed in accordance with the thematic plan of research work of the Kharkiv State Academy of Physical Culture "The effect of taking aerobic character on general and special endurance in groups with a sports orientation".

Conclusions

The curriculum for sectional tennis lessons includes cross training and elements of basic aerobics. This has more qualitative effect on the development of overall endurance among students. The method of exponential smoothing makes it possible to predict the results for the future.

Conflict of interest

The authors state that there is no conflict of interest.

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Motor skills and functional characteristics of students of different somatotypes

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Abstract

Purpose: The purpose of the article is to study correlation of motor and functional characteristics of students of different somatotypes.

Material: it was examined first year students (n=577, 17-18 years old). All students were trained in discipline "Physical education". It was carried out somatotyping. It was considered motor skills and functional characteristics of students.

Results: it was determined the reliable differences in values of parameters of motor tests and functional characteristics of students' organism. It is determined that by the end of the first year of study the positive dynamics is registered: in sthenics (in two of seven motor tests); in asthenics (in four tests). It wasn't found the reliable positive changes in group of hypersthenics. Students of sthenic and asthenic somatotypes have higher functional reserves of cardiorespiratory system, than girls of hypersthenics somatotype.

Conclusions: constitutional features of motor skills and functional parameters of students of different somatotypes allow to concretize provisions of methodology of planning the individual differentiated training in discipline Physical education.

Keywords: students, somatotypes, motor skills, functional fitness, physical education.

Introduction

The somatotype is relative (conditional) genetic marker which defines somatic and physical health of the person. The somatotype is criterion of health of the specific person [1, 2] and population in general [3]. It is impossible to consider features of morphofunctional condition of organism without its constitutional features [4].

The works concerning communication of somatotype with motor characteristics of person are of interest. It was noted the higher rates of physical fitness of representatives of macrosomic somatotype in group of children of the second childhood (engaged in circus art) in comparison with schoolgirls of the same somatotype (engaged in physical education at school) [5]. It was widely used the constitutional typology in fitness programs for correction of person's somatotype [6, 7] and rational organization of aerobics' group trainings of fertile age women [8-10].

Nowadays physical education trainings at school mean 14 types of motor loads. Such loads consider somatotype of school pupils. Somatotype defines significant amount of specific features of demonstration and dynamics the morphofunctional parameters [11].

Students with macrosomic somatotype relate to category of persons with low functional reserve of cardiovascular system. On the contrary, representatives of microsomic type have high functionality of this system. Features of morphofunctional condition of students' organism of different somatotypes should be considered during development of educational process creation algorithm in physical training [12].

Study of questions of somatotype's correlation has distinctive functional characteristics. It is the

important direction of researches in the field of physical education with development of person's motor skills [4, 13]. It allows to reveal weaknesses of the physical and functional skills of pupils, to make correction into training programs of physical education [14]. Negative characteristics of somatic and physical health parameters of Russian students sped up the research directed to study of integration of physical education and sport with constitutional typology [15-17]. Such methodological approach to physical education of youth is relevant and actual nowadays [18].

Hypothesis. Authors assume that received data concerning features of motor skills and functional characteristics' demonstration of organism of representatives of different somatotypes will promote development of individual and motor educational approaches in physical education classes.

The purpose of the research is to study correlation of motor and functional characteristics of higher education institution's students of different somatotypes.

Material and methods.

Participants. It was examined first year students (n=577, age of 17-18 years) of Irkutsk National Research Technical University. All students belongs to main medical group according to health reasons (have no deviations in state of health). All students attended classes in discipline "Physical education". Participation in research does not violate rights and does not endanger students' wellbeing. The research is conducted according to ethical standards of committee on the rights of experiments of Helsinki declaration of 2008 [19].

Organization of research. At the beginning and the end of academic year was carried out pedagogical monitoring of parameters of motor tests in students of

different somatotypes. Somatotyping of students was carried out according to scheme of M.V. Chernorutsky with calculation of Pinie index value according to the formula:

$$(I) = L - (P + T),$$

where L – is full length standing body (cm), P – is body weight (kg), T – is chest circumference on exhalation (cm).

At index value <10 somatotype was evaluated as hypersthenic, in the range of index from 10 to 30 – is sthenic (N) and > 30 – is asthenic (A) [20].

For the characteristic of correlation of somatotypes with functional parameters were measured:

- heart rate before load (HR, beats / 10 sec);
- heart rate after 20 squats per 30 sec (HR, beats / 10 sec);
- time of HR recovery (min) after 20 squats;
- systolic blood pressure (BPS), mm Hg;
- diastolic blood pressure (BPD), mm Hg.;
- vital lung capacity (VLC, l);
- dynamometry of wrists of both hands (kg).

It was calculated:

- Robinson index (IRob = HRxBPS: 100 relative units),
- vital index (VI= VLC/BM, ml/kg), where BM – (body mass),
- strenght index (SI = is muscular strenght of wrist / BMx100%).

The main motor skills of students were evaluated. Tests were used: on high-speed endurance and agility (10 times shuttle run x 5 m, sec); speed (20 m run without a pause, sec); high-speed and strength endurance of flexors of the body (set-up, times per 30 sec); strength and strength endurance of girdle of superior extremity muscles (hang on horizontal bar, sec); dynamic muscular strength of appendicular muscles (standing long-jump, cm); active flexibility of backbone and hip joints (sit and reach, cm); general endurance (5 min run, m) [21].

Statistical analysis. Application programs “StatSoft Statistica 6.1”, “Microsoft Excel” and the author’s program complex “Analysis of Data of Physical Health of Population” (state registration program №2010612275, of 26.03.2010) were used for calculation of received data. Arithmetic mean value of parameters (M), mean-square deviation (σ) and standard mistake (m) were calculated. Evaluation of differences reliability of distinctions of average values of independent sample was carried out by parametrical methods with the help of Student’s t-test on the basis of normal Gaussian distribution of the studied quantitative characteristic. Differences between values of parameters at level $p < 0,05$ considered statistically significant.

Results.

The sthenic (S) somatotype in examined girls was registered in 64,7%. Girls of hypersthenic (H) and asthenic (A) somatotypes meet less often (9,9% and 25,4% respectively). The characteristic of motor skills in representatives of different somatotypes is presented in table 1.

There are differences between values of parameters of motor tests of girls of different somatotypes. Representatives of sthenic and asthenic somatotypes have higher rates in comparison with hypersthenic girls ($p < 0,05$) in the following tests: strength and strength endurance of muscles of girdle of superior extremity; high-speed and strength endurance of muscles of flexors of the body; dynamic muscular strength of girdle of inferior extremity; flexibility and general endurance. The best results are registered in asthenic ($p < 0,05$) in motor tests: strength and strength endurance of muscles of girdle of superior extremity; high-speed and power endurance of muscles of flexors of the body; dynamic muscular strength of girdle of inferior extremity and flexibility.

Table 1 demonstrates that to the end of training positive dynamics is registered: in sthenic – in two of seven tests (20 m run without a pause and 5 min run); in asthenic – in four tests (20 m run without a pause, hang,

Table 1. Dynamics of parameters in motor tests in girl-students of different somatotypes (M±m)

Tests	September			Mai		
	H (n=57)	S (n=373)	A (n=147)	H (n=57)	S (n=373)	A (n=147)
Shuttle run (sec)	22,8±0,43	21,9±0,12	21,7±0,13	23,2±0,42	22,2±0,17	21,96±0,39
20 m run without a pause (sec)	3,98±0,26	4,62±0,17	4,64±0,26	3,68±0,08	3,60±0,04**	3,50±0,06**
Hang (sec)	7,59±0,52	8,67±0,33*	9,92±0,5*	8,31±0,89	8,73±0,35	12,02±0,6**
Sit-ups (times)	20,01±0,91	22,1±0,35*	23,5±0,51*	20,2±1,21	22,61±0,5	26,4±1,33**
Sit and reach (cm)	11,44±0,89	14,29±0,53*	14,96±0,66*	13,53±0,72	15,88±0,49	14,67±0,81
Standing long-jump (cm)	135,1±4,01	150,5±1,11*	157,8±1,69*	135,8±3,41	152,2±1,29	161,3±2,1
5 min run (m)	789,7±18,6	860,4±14,1*	856,2±22,6*	775,5±42,5	907,7±12,7**	918,5±12,9**

Note.*– statistically significant differences between somatotypes ($p < 0,05$); **– statistically significant differences between examinations ($p < 0,05$); Somatotypes: H – hypersthenic; S – sthenic; A – asthenic.

sit-ups, 5 min run). In group of hypersthenics there are no reliable positive changes in any motor tests.

Features of the characteristic of functional parameters in representatives of different somatotypes are given in table 2.

In students with sthenic and asthenic somatotypes of key parameters' value (BP systolic, HR at rest per 10 sec; time of HR recovery after 20 squats per 30 sec) is less, than values of the same parameters in hypersthenics ($p < 0,05$). Robinson index in sthenics and asthenics is lower in comparison with hypersthenics. There are no reliable differences of BPD in girls of different somatotypes.

The lowest values of VLC parameters and muscular strength of wrists of both hands is registered in girls of sthenic and asthenic somatotypes. These girls have the highest values of VI and SI parameters (tab. 2).

Discussion

The physical education is effective mean of person's health maintenance and promotion at any age. Hypokinesia and hypodynamia of the studied youth [22] is followed by underdevelopment of motor skills, health deterioration [23, 24] and work of functional systems of organism [25, 26]. It is relevant to search new approaches to increase in efficiency of physical education trainings in higher education institutions on this background [12, 27, 28].

Some authors suggest to determine somatotypes, i.e. to differentiate them according to extent of development

of the total sizes of body: individuals with small body sizes are microsomatics (asthenics); macrosomatics (hypersthenics) are individuals with big sizes. Average position is held by mesosomatics (sthenics) [29]. The analysis of scientific and methodical literature shows that orientation of certain motor skills development of the person has to be based on somatotypes [17, 30, 31].

Our researches demonstrate that girls of sthenic and asthenic somatotypes have advantage over hypersthenics in such motor skills as: strength and strength endurance of muscles of girdle of superior extremity; high-speed and strength endurance of muscles of flexors of the body (fig. 1); dynamic muscular strength of girdle of inferior extremity; general endurance (fig. 2). It is confirmed by reliable values of parameters in the corresponding motor tests in students of sthenic and asthenic somatotypes in comparison with hypersthenics.

R.N. Dorokhov's methodology [32, 33] was used in our previous researches. Results demonstrated that students of mesosomatic and microsomatic somatotypes had better developed endurance, high-speed, strength and coordination skills. The somatotyping methodology of M.V. Chernorutsky was used in the given research. Results confirm earlier received data concerning correlation of motor and the morphofunctional parameters of person's somatotype.

There are researches about genotypic features of girls of different somatotypes to perception of physical loads [34]. The level of development of the main physical

Table 2. The characteristic of functional parameters in girl-students of different somatotypes ($M \pm m$)

Functional parameters	Somatotypes hypersthenic (n=57)	sthenic (n=373)	asthenic (n=147)	P<0,05
Systolic blood pressure (BPS), mm Hg	109,8 \pm 0,93	105,7 \pm 0,26 *	105,0 \pm 0,42 *	1-2; 1-3;
Diastolic blood pressure (BPD), mm Hg	70,25 \pm 0,91	69,29 \pm 0,32	68,91 \pm 0,58	
Heart rate before load (HR, beats / 10 sec)	11,9 \pm 0,06	11,7 \pm 0,02 *	11,3 \pm 0,04 *	1-2; 1-3; 2-3
Heart rate after 20 squats per 30 sec (HR, beats / 10 sec)	21,2 \pm 0,22	21,0 \pm 0,07	21,0 \pm 0,13	
Time of HR recovery (min) after 20 squats	1,58 \pm 0,05	1,45 \pm 0,01 *	1,48 \pm 0,03 *	1-2; 1-3;
Robinson index, relative units	78,4 \pm 0,67	74,2 \pm 0,15 *	71,2 \pm 0,22 *	1-2; 1-3; 2-3
Vital lung capacity (VLC, l);	2667,2 \pm 31,2	2663,5 \pm 10,1	2616,4 \pm 20,5	
Vital index, ml/kg	39,3 \pm 0,46	47,3 \pm 0,14 *	52,2 \pm 0,18 *	1-2; 1-3; 2-3
Dynamometry of the left hand, kg	26,07 \pm 0,48	23,7 \pm 0,15 *	23,8 \pm 0,24 *	1-2; 1-3
Force index of the left hand, %	39,1 \pm 0,44	41,9 \pm 0,12*	47,5 \pm 0,15*	1-2; 1-3; 2-3
Dynamometry of the right hand, kg	27,4 \pm 0,51	24,5 \pm 0,15 *	24,7 \pm 0,26 *	1-2; 1-3;
Force index of the right hand, %	41,1 \pm 0,47	43,3 \pm 0,16 *	49,3 \pm 0,17 *	1-2; 1-3; 2-3

Note. * – statistically significant differences between somatotypes ($p < 0,05$)

skills in preschool children has differences depending on somatotype. The best results in parameters of speed, endurance, flexibility, high-speed and strength tests are peculiar to girls of mesosomic and microsomic somatotypes. Girls of macrosomic somatotypes demonstrate the best results in research of muscular strength of wrists [35]. It is correlated with received data. Children of microsomatic and mesosomatic types have higher rates in comparison with macrosomatics: speeds of muscles contraction of girdle of inferior extremity; speed and strength of muscles contraction of both extremities [36].

Women of the second mature age (microsomatic type) have higher rates of vital index, general endurance, speed and coordination, low level of absolute strength's development [37]. It is correlated with received data.

In the end of pedagogical monitoring we have registered positive dynamics of parameters values in sthenics in two of seven motor tests. The increase in values of parameters in 20 m run without a pause was 22,0%, in 5 min run was 5,5%. Asthenics have increase in values of parameters in four tests – 20 m run without a pause was 24,5%, in hang – was 21,1%, in set-up was 12,3%, in 5 min run was 7,2%. In group of hypersthenics

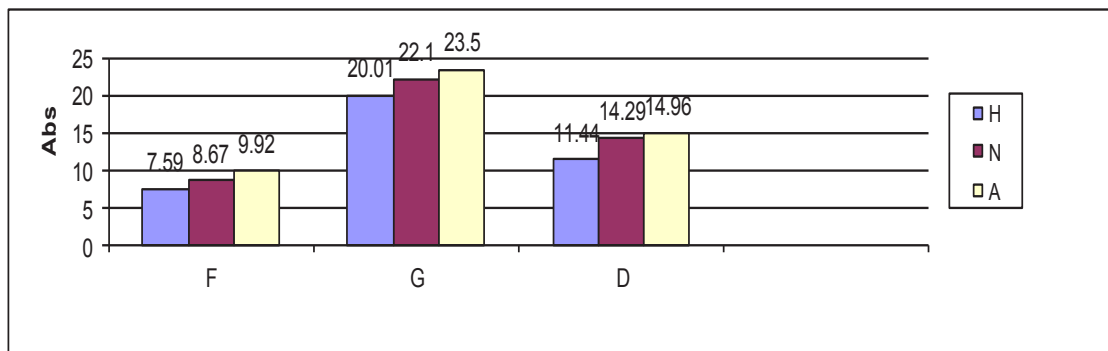


Fig. 1. The characteristic of motor skills in students of different somatotypes: H – hypersthenics; S – sthenics; A – asthenics; F – hang on horizontal bar; G – set-up; D – forward bend; Abs – absolute number.

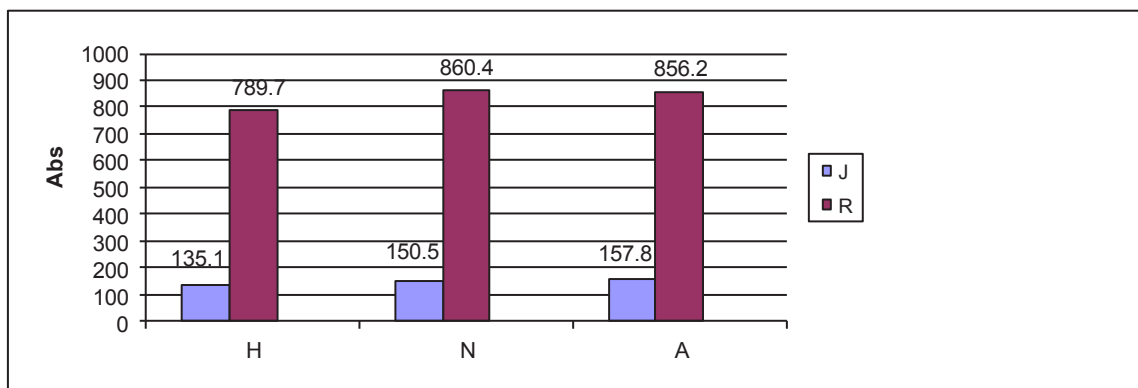


Fig. 2. The characteristic of dynamic force of girdle of inferior extremity and general endurance in students of different somatotypes: H – hypersthenics; S – sthenics; A – asthenics; J – long jump from the spot, cm; R – 5 min run, m.

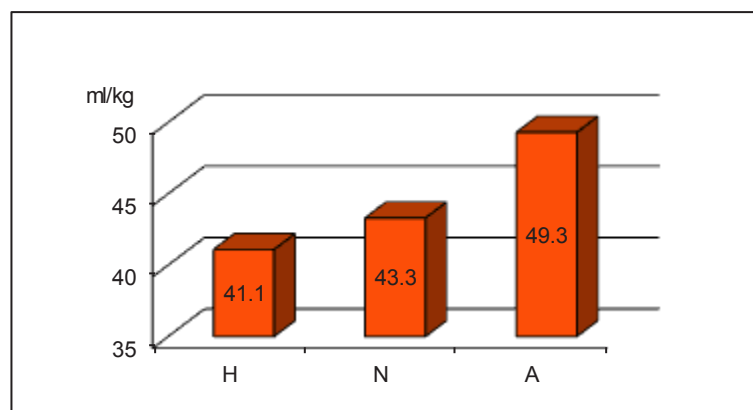


Fig. 3. The vital index in students of different somatotypes: H – hypersthenics; S – sthenics; A – asthenics

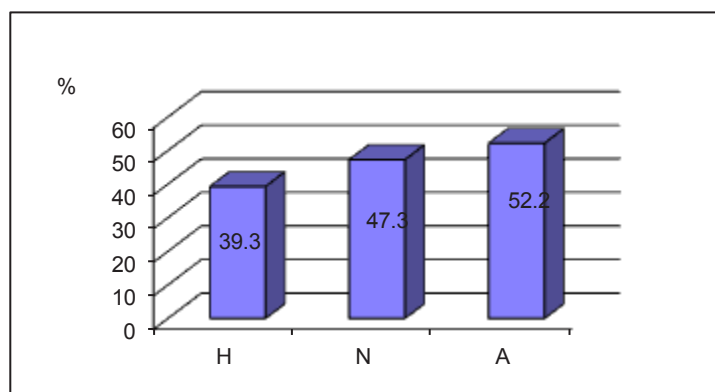


Fig. 4. The strength index of the right hand in students of different somatotypes: H – hypersthenics; S – sthenics; A – asthenics.

there are no reliable positive dynamics of parameters values in any motor tests.

It is known that the functional systems of organism considerably provide performance of person's physical activity [38]. It is determined that reserves of cardiovascular system are higher in sthenics and asthenics in comparison with hypersthenics. Asthenics and sthenics have less HR at rest (per 10 sec) and time of HR recovery (after 20 squats per 30 sec), than hypersthenics ($p < 0,05$). Robinson index was 5,7% lower in sthenics and 9,1% lower in asthenics in comparison with hypersthenics. Our data confirm results of researches [12, 37] concerning parameters' of reserve opportunities values of women cardiorespiratory system considerably depend on somatotype.

Girls of microsomatic type have low parameters' values of body length and weight, chest circumference. These girls have higher functionality of organism, in comparison with girls of macrosomic somatotype with higher rates of physical development [12].

High values of Robinson index and minute volume of blood circulation testify to heavy load on cardiovascular system of students of hypersthenic somatotype [39].

According to our data value of vital (fig. 3) and strength indexes of students' right hand wrist (fig. 4) have dynamics to increase from hypersthenic to asthenic somatotype.

Study of 7-16 years old schoolgirls testified that girls of macrosomic somatotype had higher level of absolute vital capacity of lungs. Girls of microsomatic type had low level of absolute vital capacity of lungs. However the vital index was authentically high in girls of microsomic somatotype [34]. These data is correlated with results of our researches concerning absolute and relative vital capacity of students' lungs. Low level of relative values of vital capacity of lungs leads to underdevelopment of

aerobic endurance of girls. Low level of the strength index parameter characterizes underdevelopment of muscular system of girls. It is necessary to use the differentiated approach in development of endurance and strength in students of hypersthenic somatotype at physical education classes. Also girls need to perform regular independent physical exercises in extracurricular time. Such loads should to be coordinated with teachers.

The research allow to correct pedagogical process of the individual differentiated physical training of students with use of constitutional typology. Results of our researches and data of other authors allow to make the following recommendations:

- 1) it is necessary to use sport and game technologies, endurance exercises, swimming, slow long run, fitness aerobics, breathing exercises planning educational process on physical training for girls of hypersthenic somatotype;
- 2) girls of asthenic somatotype should to pay more attention to speed development as physical quality.

Conclusions

1. Students of 17-18 years old of three somatotypes (asthenic, sthenic, hypersthenic) have distinctive parameters of motor skills and reliable difference ($p < 0,05$) in a number of functional characteristics of respiratory, cardiovascular and muscular systems of the body.

2. The received data concerning constitutional features of motor skills and functional body characteristics of students of different somatotypes allow to concretize provisions of methodology of planning of individually differentiated training in discipline "Physical education" at higher education institution.

Conflict of interests

The author declares that there is no conflict of interests

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The ways of improvement special physical training of high-qualified women volleyball players in competitive period of annual macrocycle

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Abstract

Purpose: to evaluate the influence of creating the program of training process in the competition period of the annual macro cycles on the level of special physical training of women volleyball players.

Material: women volleyball players of high qualification participated in the experiment (n=14, age 20-22 years). An assessment of the level of special physical fitness of volleyball players was conducted. It is used author's program.

Results: features of the functional dependence of the level of general physical preparedness with the separate components of the special physical preparedness of volleyball players are established. The peculiarities of dynamics of indicators of athletes' special physical training in the competition period are determined. The strongest correlation relationship was the level of general physical fitness with: the level of general and hopping endurance; the level of development of jumping; special dexterity; special endurance; speed and strength of hands. As part of corrective modules, the training load of aerobic-anaerobic direction was increased. The main means of compound character training are: complex-coordinated and technical actions in combination with the accuracy of transmission; response to moving object; locking; attacking strikes.

Conclusions: application of the experimental program of training process construction helps to maintain high level of basic indicators of athletes' special physical fitness during the competitive season. The experimental program involved the redistribution of training loads of aerobic and anaerobic-aerobic orientation within the framework of correcting modules.

Keywords: special, physical, preparedness, volleyball, women, competitive period.

Introduction

Volleyball in modern sport firmly occupies one of the leading places in polarity. The achievement of high sports results in volleyball is extremely complex [1, 2]. The team's skill development is aimed at finding new forms of organization of volleyball training [3, 4]. The training of volleyball players is enhanced by the competence of the coaching staff [5, 6]. Particular attention is paid to raising the levels of general physical and special physical, functional, technical and tactical and psychological preparedness [7, 8]. It is proved that insufficient level of special physical fitness of athletes of different specialization does not allow them to be realized at the highest level [9, 10]. In a number of scientific papers, the problem of increasing the skill of teams is determined, which has a direct dependence on the interaction of individual players in the team and on the level of preparedness of each individual athlete [11, 12]. It is also offered a complex of special physical training facilities that corresponds to the technical and tactical actions of athletes [13, 14].

The severely indicated problem is manifested today in women's volleyball. There is an insufficient level of efficiency of training sessions, which should be aimed at increasing the special physical fitness of volleyball players. This significantly reduces the ability of the domestic volleyball players to achieve high sporting results in the international arena [15, 16].

The problem of improving the process of special physical training of volleyball players at the stage of

maximum realization of individual capabilities is devoted to many studies of specialists in the field of sports [5, 17]. The authors established: indicators of body volleyball players' response to standard physical activity [18]; the main causes of injury in volleyball [19].

Today, some authors propose to raise the level of special physical fitness of volleyball players by introducing: combined exercises of anaerobic aerobic orientation [20]; special exercises to enhance exclusively anaerobic abilities of the body [2; 21]; special exercises for the development of speed-strength abilities [22, 23]; special exercises on the development of the main components of special physical fitness [24, 25]. Particular attention deserves attention to the study of the application of specific training targets of specific direction in separate micro- and mesocycles of the training process [6].

At the same time, the question of finding the most effective means of optimizing the special physical fitness of volleyball players is still very relevant today [26-28].

In the opinion of low specialists, the promising direction of the solution of this issue is the development of new programs of training sessions at different periods of the annual training cycle. It takes into account the functional dependence of individual components of special physical fitness of athletes with a general level of physical fitness [6, 29, 30].

Therefore, the development of training programs can be considered as modern approaches to increase the special physical fitness of athletes. Such approaches are a powerful factor in optimizing the training process of volleyball players.

Hypothesis. It is planned to build a program of training sessions in a competitive period that takes into account

functional dependencies: between the level of general physical fitness of athletes and the individual components of their special physical preparedness. It is assumed that the introduction into the training process of volleyball players experimental program of training sessions will significantly optimize the training process.

The purpose of the work is to determine the influence of the experimental program of constructing a training process in the competition period of the annual macrocycle on the level of special physical fitness of volleyball players of high qualification.

Materials and methods

Participants. In research participated high-class volleyball players ($n=14$, masters of sports, aged 20-22 years old) of volleyball club "Orbita-ZTMK-ZNU" ("Orbita-ZTMK-ZNU", Zaporizhzhya, the super league of the Ukrainian Championship) with.

Organization of research. Testing the level of special fitness training of athletes was conducted at the beginning and end of the competition period of the annual macro cycles of the 2014/15 season (first stage of the experiment) and 2015/2016 (second phase of the experiment).

The results of the first stage of the experiment were used to develop the author's program for constructing the

training process of volleyball players VC "Orbita-ZTMK-ZNU" in the competition period of the next competitive season (Table 1).

The basis of the experimental program consists of the following principles: the compliance of included in the program sports training facilities for age characteristics of volleyball players; continuity and cyclicity of the training process; gradual increase of loads; modular construction of the training process in the competitive period. The program of volleyball training sessions was presented in the form of three competitive (Z-1, Z-2, Z-3) and two corrective (K-1, K-2) modules.

The content of the training sessions within the framework of the competition modules was determined by the calendar of competitions of the Ukrainian volleyball championship (super league). The content of corrective modules was conditioned by: 1) test results after each competitor module; 2) the results of competitive activities of volleyball players in the previous adversary module. Changes in the amount of physical activity (corrective modules) are presented as percentages of the absolute values of physical activity data (previous competition module).

The main structural elements of the proposed program were special-preparatory, special exercises, means of

Table 1. Experimental program of planning training sessions in the competitive period of the annual cycle of training for women's volleyball team of higher qualification

Load volume, means of preparation and mode of operation	Program modules				
	Z-1	K-1	Z-2	K-2	Z-3
General developing exercises, hours	5,5	-1,3	5,85	-0,6	6,0
Exercises on stretching of muscles, acrobatics, hours	5,7	-1,6	6,75	-3,4	7,0
Aerobics (special coordination, mixed mode of heart rate 140-170 beats per minute ⁻¹), hours	2,0	0	0	+4,5	0
Volume of background running (uniform running, crosses, aerobic mode, heart rate 130-150 beats per minute ⁻¹), hours	0	+6,7	0	+3,4	0
The volume of special running combined with the elements of the game technique (mixed mode, heart rate 145-185 beats per minute ⁻¹), hours	2,8	+2,1	2,9	-0,3	2,0
Athleticism: special power and speed training (mixed mode, heart rate 145-185 beats per minute ⁻¹), hours	1,5	+0,8	1,5	0	2,0
Swimming, relay-race and water games (aerobic mode, heart rate 130-160 beats per minute ⁻¹), hours	1,0	+1,7	0	+4,5	2,0
Volume of technical training: feeding, transmission, attacking strokes, blocking (mixed mode, heart rate 135-170 beats per minute ⁻¹), hours	4,12	+6,5	9,0	0	6,0
Tactical training: individual, group, team (heart rate 135-165 beats per minute ⁻¹), hours	10,38	-3,6	10,0	+3	10,0
Volume of integral preparation (mixed mode, heart rate 150-190 beats per minute ⁻¹), hours	17,0	+2,8	18,5	-2,8	24,0
The amount of gaming training (mixed mode, heart rate 150-190 beats per minute ⁻¹), hours	10,0	-13,1	10,5	-6,8	10,0
Testing training	1,0	0	1,0	0	1,0

Note: Z – Competitive module; K – corrective module. Corrective module graphs show data on changes in the volume of relevant loads (in percentages) from their absolute values in the previous adversary module.

general physical training.

To assess the development of special physical qualities of volleyball players, it was used a set of informative tests [7, 15]. All volleyball players registered the following indicators of special physical fitness: jumping (jump up from place, cm); speed (test 9-3-6-3-9 m. – numbers indicate the distance to run on the volleyball court, c); jump stamina (number of ball losses); high-speed endurance (running 92 m “herringbone”, c); general endurance (exercises in attacking impact from zones 2/4, c); special acrobatic endurance (c); mobility in the shoulder joints (conditional units, c.u.); leg force (number of squats for 20 s); the strength of the muscles of the hands (a drop of a scored ball weighing 1 kg, m); muscle strength of the abdominal press and back (the number of torso lifts from the position lying on the back for 10 s).

It was also determined the level of general physical fitness [31]. The algorithm of the survey assumed: the implementation of the standard submaximal veloergometric test PWC170, measuring the length (cm) and weight (kg) of the body of athletes. It was carried out an automatic calculation of the absolute and relative importance of total physical capacity, absolute and relative value of aerobic capacity. Calculated quantitative values of the following indicators were determined: alactated and lactate power and capacity; anaerobic exchange threshold; heart rate at the threshold of anaerobic metabolism; total metabolic capacity; backup capabilities; the efficiency of the energy supply system for muscle activity.

Statistical analysis. Statistical processing of the research results was carried out using packages of

standard programs “STATISTICA 7.0” and Excel with the calculation of the following indicators: arithmetic mean (\bar{x}), mean square deviation (σ), error arithmetic mean (S). It was also used correlation analysis.

Results.

The results obtained at the first stage of the experiment indicated that during the competitive season there was a characteristic gradual deterioration of the special physical fitness of volleyball players (Table 2).

It was established the following: at the end of the competition period there was a significant deterioration in overall and jump resistance ($28,55 \pm 1,60\%$ and $50,70 \pm 1,69\%$ respectively), jump ($10,0 \pm 1,32\%$), strength feet ($11,9 \pm 1,41\%$), hands ($11,2 \pm 1,77\%$), muscles of the abdominal press and back ($17,5 \pm 1,18\%$).

By the end of the season there was a significant deterioration of the high-speed endurance volleyball players ($4,75 \pm 1,30\%$), speed ($5,92 \pm 1,17\%$), special agility ($2,40 \pm 1,46\%$) and mobility of shoulder joints ($7,16 \pm 1,38\%$).

It should also be noted that negative qualitative changes in these indicators, which were already considered as mostly average.

In order to determine the reasons for these changes, we conducted an analysis of the correlation of the indicators of special physical fitness of volleyball players with their level of general physical fitness (Table 3).

During the competitive season, the strongest correlation between the level of general physical fitness (LGPF) with: the level of general and hopping endurance;

Table 2. Indicators of special physical preparedness of high qualification volleyball players at the beginning and end of the first stage of the experiment ($\bar{x} \pm S$)

Indicators	Beginning	Ending	$\Delta\%$
General endurance (sec)	103,92 \pm 2,21 above average	133,58 \pm 2,74*** average	28,55 \pm 1,60
Hopping endurance (amount of losses)	5,92 \pm 0,40 above average	8,92 \pm 0,54*** average	50,70 \pm 1,69
Speed endurance (sec)	24,76 \pm 0,21 above average	25,93 \pm 0,17*** average	4,75 \pm 1,30
Jumping ability (cm)	60,83 \pm 0,84 above average	54,75 \pm 0,73*** average	-10,0 \pm 1,32
Speed (sec)	8,45 \pm 0,14 above average	8,95 \pm 0,08** average	5,92 \pm 1,17
Special dexterity (sec)	3,38 \pm 0,02 above average	3,46 \pm 0,02* below average	2,40 \pm 1,46
Mobility of the shoulder joints (conventional units)	1,61 \pm 0,04 average	1,72 \pm 0,04 average	7,16 \pm 1,38
Strength of legs (number of times for 20 sec)	17,50 \pm 0,45 above average	15,42 \pm 0,45** average	-11,9 \pm 1,41
Strength of hands (m)	17,08 \pm 0,45 average	15,17 \pm 0,66* average	-11,2 \pm 1,77
Strength of press and back (number of times for 10 sec)	6,67 \pm 0,50 above average	5,50 \pm 0,31 average	-17,5 \pm 1,18

Note: * - $p < 0,05$; ** - $p < 0,01$; *** - $p < 0,001$ compared to the values of the indicators at the beginning of the experiment.

Table 3. Coefficients of correlation between the level of general physical fitness and indicators of special physical fitness in volleyball players at the beginning of the first stage of the experiment ($\bar{x} \pm S$)

Correlation pairs	Beginning	Ending
Level of general physical training – General endurance	0,69±0,17* (2,86)	0,63±0,20* (2,43)
Level of general physical training – Hopping endurance	0,67±0,18* (2,71)	0,62±0,21* (2,37)
Level of general physical training – Force endurance	0,61±0,21* (2,31)	0,61±0,21* (2,31)
Level of general physical training – Jumping ability	0,64±0,2* (2,50)	0,61±0,21* (2,31)
Level of general physical training – Speed	0,61±0,21* (2,31)	0,57±0,23 (2,08)
Level of general physical training – Special dexterity	0,63±0,2* (2,43)	0,59±0,22 (2,19)
Level of general physical training – Mobility of the shoulder joints	0,55±0,23 (1,98)	0,41±0,28 (1,35)
Level of general physical training – Strength of legs	0,59±0,22 (2,19)	0,55±0,23 (1,98)
Level of general physical training – Strength of hands	0,61±0,21* (2,31)	0,62±0,21* (2,37)
Level of general physical training – Strength of press and back	0,42±0,27 (1,39)	0,34±0,29 (1,08)

Note: * - the true values of the correlation coefficients.

the level of development of jumping; special dexterity; special endurance; speed and strength of hands.

At the second stage of the experiment, an analysis of the peculiarities of the dynamics of the level of special physical fitness of volleyball players in the competitive period of 2015/2016 was conducted. This made it possible to evaluate the effectiveness of the developed training programs.

At the end of the experiment there was observed among the athletes a significant decrease in only their overall endurance (by 11,09±1,15%), high-speed endurance (by 2,11±1,38%) and special agility (by 1,56±1,52%) (Table 4).

Changes in the remaining indicators of special physical training of volleyball players in the experimental group were insignificant and unreliable.

After the completion of the second stage of the experiment, there were no qualitative changes in the indicators of the special physical training of volleyball players (with the exception of the level of hopping endurance).

Discussion.

The analysis of special physical training of volleyball players showed a gradual deterioration of the indicators of their special physical training to the end of the competitive season. This fact coincides with the research data of other authors [3, 17, 24].

It is known that special physical training increases the functionality of the body. As a result, there is an improvement in the mobile qualities of volleyball players

needed to improve sports results. The studies of a number of authors [8, 22] determined that the study of the features of this relationship can be the basis for the compilation of an optimal program of training sessions. This is important for the various stages of the annual cycle of training (especially during the competition period).

This conceptual position was confirmed by our research. This gave an opportunity to substantiate the need for further improvement of the level of special physical fitness of athletes. At the basis of the experimental program of creating a training process were taken into account functional dependencies of the level of general physical preparedness of volleyball players with separate components of their special physical fitness. The developed program of constructing a training process in a competitive period is based on the modular principle. The program provides for the redistribution of the training load volumes of aerobic and aerobic-anaerobic orientation within the framework of corrective modules.

We conducted a correlation analysis of the relationship of indicators of the level of general physical fitness with indicators of special physical fitness. This allowed to identify the main emphasis on changes in volumes of special physical training.

As part of corrective modules, the training load of aerobic-anaerobic direction was increased, which was performed at heart rate (HR) 145-180 beats per minute⁻¹. The main means of training mixed nature are the following: complex-coordinated and technical actions in combination with the accuracy of transmission; response to moving object; technical blocking; attacking strikes.

Table 4. Indicators of special physical fitness of volleyball players at the beginning and end of the second stage of the experiment ($\bar{x} \pm S$)

Indicators	Beginning	Ending	$\Delta\%$
General endurance (sec)	108,17 \pm 3,17 above average	120,17 \pm 1,8*** above average	11,09 \pm 1,15
Hopping endurance (amount of losses)	6,17 \pm 0,53 above average	7,08 \pm 0,36 average	14,81 \pm 1,21
Force endurance (sec)	24,93 \pm 0,15 average	25,46 \pm 0,14** average	2,11 \pm 1,38
Jumping ability (cm)	59,92 \pm 1,07 above average	57,92 \pm 0,71 above average	-3,33 \pm 1,2
Speed (sec)	8,64 \pm 0,12 average	8,58 \pm 0,05 average	-0,71 \pm 1,08
Special dexterity (sec)	3,41 \pm 0,02 average	3,47 \pm 0,02* average	1,56 \pm 1,52
Mobility of the shoulder joints conditional units	1,67 \pm 0,03 average	1,70 \pm 0,02 average	1,74 \pm 1,28
Strength of legs (number of times for 20 sec)	16,75 \pm 0,46 average	16,67 \pm 0,28 average	-0,48 \pm 1,17
Strength of hands (number of times for 10 sec)	16,25 \pm 0,35 average	16,67 \pm 0,31 average	2,56 \pm 1,33
Strength of press and back (number of times for 10 sec)	6,75 \pm 0,41 above average	6,75 \pm 0,25 above average	0 \pm 1,17

Note: * - $p < 0,05$; ** - $p < 0,01$; *** - $p < 0,001$ compared with the beginning of the second stage of the experiment.

Volleyball is characterized by a complex manifestation of speed in gaming situations that are continuously changing. It requires: the manifestation of the reaction with the choice and reaction to a moving ball; performance of repeated start accelerations during blocking or strikes during an attack; performance of technical and gaming interactions with partners at the fastest pace [3, 26]. Therefore, the volume of special running training combined with the elements of the game technology was increased. The hours of integral training were also increased, which enabled the athletes to increase their speed. To improve the special speed, it was recommended to use repeated, interval and competitive training methods.

Execution of technical techniques in volleyball is characterized by the manifestation of power qualities. This refers to the explosive force that manifests itself in the special jump. The training program envisaged an increase in the amount of exercise that was aimed at improving the special force and speed-power abilities. The main means have become various jumps, few jumps one by one, jump to a height (50-70 cm), jumps through barriers, exercises with encumbrance. The obtained experimental data confirm the research of specialists on improving the special physical fitness of volleyball players: the use of special exercises (anaerobic regimen at heart rate of 190-200 beats per minute⁻¹, maximal tempo) with the manifestation of significant muscle tensions in the minimum time [2, 22, 24].

In the framework of the pilot program, an increase in the amount of running training (uniform running, cross), swimming (aerobic regimen – heart rate 130-150 beats

per minute⁻¹) was envisaged, use of exercises for special coordination (aerobic-anaerobic regimen – heart rate 140-170 beats per minute⁻¹. Our data supplements the information of other researchers [20] that an integrated approach is needed to improve the special physical fitness of volleyball players, which combines aerobic and mixed-action exercises.

Confirmation of the correctness of our positions regarding the content and directions of special physical training of volleyball players is shown in the work of V.M. Kostiukevich [6] and studies by other authors [9, 16, 32]. The results of our study supplement the information of authors [7, 10, 32] on modern approaches to optimize the level of special physical fitness of volleyball players.

The results of the conducted research indicate a significant increase in the effectiveness of the training process of volleyball players. Confirmation of this was a successful statement by VC “Orbita-ZTMK-ZNU” in the competitive season of 2015/2016 (silver medals of the Ukrainian Championship).

The results of our study as a whole coincide with the data of the above studies. It should be noted, however, that the importance of optimizing the level of special physical training of volleyball players is to determine the general orientation of the training process and the specific volume of physical activity of different orientations.

Conclusions.

It is confirmed that maintaining a high level of special physical fitness of volleyball players in a competitive season for a long time is necessary to achieve high sports

results.

It was established that the introduction into the training process of volleyball players of high qualification of the experimental program in the competition period requires the emphasis on the exercises of anaerobic and aerobic-anaerobic orientation. This contributes to the significant optimization of the level of special physical fitness of volleyball players.

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Conflict of interest.

The authors state that there is no conflict of interest.

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Problems of physical activity in vocational training of future teachers

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Abstract

Purpose: The purpose of the research is to define a real condition of physical activity of future primary school teachers. To determine possible problems and ways of physical activity organization of students with the low level of motor activity.

Material: Students participated in a research (n=214; 162 students of 2-4 courses of daytime study, 18-20 years age; 52 students of extramural form of study, 20-30 years age).

Results: The necessity to increase students' and practicing teachers' physical activity level was determined (low level: 55.8% – extramural form of study, 37.7% – daytime study; average level: 34.6% – extramural form of study, 48.1% – daytime study; high level: 9.6% – extramural form of study, 14.2% – daytime study). It is determined that future primary school teachers have pedagogical barriers to carry out physical education classes. Among the main reasons were determined the followings: health's problem, overweight, fear of responsibility for children's health. However teachers understand the necessity of physical self-improvement only at informative level.

Conclusions: Purposeful and regular physical activity of students will promote health saving process and overcoming barriers in physical activity organization of next generation.

Keywords: student, teacher, primary school, physical activity, health.

Introduction

Upbringing of healthy next generation is a priority task of each country. Scientists study features of judo athletes attitude to sports activity [1]; influence of study style at motivation formation in physical training [2]; training process of 6-7 years climbers at the initial stage of preparation with application of the main motor actions and complete method [3]; use of health and fitness technologies at the work with preschool children [4]; introduction of Bothmer Gymnastics to form ability of a rhythm reconstruction [5].

However these problems are unresolved without training of qualified personnel. Now scientists search biomedical, psychological and pedagogical instruments to create health saving and health forming educational environment for students and pupils. Scientists offer the following:

- to use exercises from hatha yoga for students at physical education classes as means of somatic health and physical activity improvement of the personality [6];
- to apply physical training programs, sports-oriented approach to training of functional force [7, 8];
- strengthening of strategy of study using assessment for learning (AFL) [9];
- to form goals for achievement and to encourage students to physical training exercises [10, 11];
- to use potential opportunities of all components of health saving technology (axiological, gnosiological, health saving, emotionally volitional, ecological, health and fitness) [12, 13];
- to form a healthy lifestyle and to change approaches to carry out physical education classes in educational establishment [14, 15];
- to compensate intellectual and mental loads by optimum physical activity [16, 17];

- to use Bothmer Gymnastics as "spatial dynamics" which is intended to improve person's physical and mental balance [18].

High-quality training of specialists provides first of all improvement of quality and efficiency of study process in higher educational establishments [19, 20]. The scientists carry out comparison of physical education organization features by experts in the field of physical training and by primary school teachers [21]. It is investigated the problem of physical education teachers' attitude to modern trends and techniques of physical training formation [22], their understanding of educational value of the motor activity and ways of motor skills development [23].

The primary school teachers could have difficulties at physical education classes: misunderstanding of all opportunities for motor skills development of children, lack of experience of the organization of out-of-school physical activity of the personality [24]; limited time for preparation in educational establishment for pupils' physical training [25]. The primary school teachers could improve quality of physical education study at primary school with sports-oriented preparation in educational establishment and by means of experts [26].

Also there are active researches of training system improvement of future experts and professionalism of the practicing primary school teachers according to the following directions:

- strengthening of interrelation between the pedagogical theory and practice of pupils physical education formation [27, 28];
- increase in prestige value and importance of physical education class among teachers, formations of humanistic values [26];
- formation of experience of health and fitness activity in educational establishment, involvement of students into traditional forms of physical education and to wide

range of motor actions [29];

- development of postdegree programs of teachers' education [30];
- creation of prerequisites for self-education of experts [31].

Scientists proved close connection between indicators of intellectual working capacity, physical state and physical activity [20]. Researchers distinguish the high level of functionality of students among indispensable conditions of educational process' efficiency. This concept means sufficient mental and physical working capacity [32, 33]. People with appropriate motivation on self-education in the field of physical training will be physically active during lifetime. The internal motivation could become a key to achievement of the goals in education, especially in the field of physical training [34].

Group of scientists studied categories of intentions of future primary school teachers concerning physical education study at school and their ability to overcome barriers in the organization of physical activity (absence of space, lack of the equipment, bad weather, diffidence and so forth) [25]. In our opinion, physical activity has to become important humanistic value. It will promote high performance of the personality. Physical activity of students consists of motor actions which is necessary condition of activity and increase in working capacity [35]. Iermakova T.S. studied experience of formation of students' culture health in Poland and feature of ensuring their physical activity. The scientist conducted research of values of future primary school teachers. Among important priorities Ukrainian students defined the followings:

- necessity of health improvement;
- increase in knowledge of concrete humanity subjects;
- promotion of healthy lifestyle [36, 37].

Malinauskas R. also emphasizes importance of concrete values for sport experts. Values characterize behavior of people and promote development of personality. Humanistic values are important (health, physical development and human communication) [38].

Scientists determined contradictions which appear in the course of physical condition improving of population:

- between demand in highly qualified specialists with excellent health and lack of technologies to decrease the number of students with health problems [39];
- between theoretical researches in the field of health-improving technologies and their insufficient use in study process at educational establishments [39];
- between necessity to get considerable volume of information by students and lack of time [32];
- between gradual, long-term process of future expert formation and desire of self-realization as soon as possible [32].

It is relevant to determine contradiction between necessity of health saving, activization of students' physical activity and insufficient covering and developing of appropriate technologies and techniques of training.

The analysis of scientific literature covered necessity to organize person's moderate physical activity as 30-60 minutes per day [11]. Ukrainian scientists determined

that such indicator for students has to be 12-14 hours per week at sufficient physiologic load [35]. Therefore it is possible to assume that organization of physical activity of future primary school teachers of non sports subjects will influence on: health improvement of future teachers; positive attitude to physical education classes at primary school.

The purpose of the research is to define a real condition of physical activity of future primary school teachers.

The task of the research is to determine possible problems and ways of physical activity organization of students at classes with the low level of motor activity.

Material and methods

Participants: students (n=214) getting bachelor degree on specialty «Primary education» at Vinnytsia State Pedagogical University named after Mykhaylo Kotsiubynsky (Ukraine) participated in a research. Participants were students of 2-4 courses of daytime study (n=162, age – from 18 to 20 years) and students of extramural form of study (n=52, age – from 20 to 30 years, have 1-6 years of work experience as primary school teacher) who entered the university on the basis of qualification level “Junior specialist”.

Organization of research: study of physical activity level was carried out with the help of technique of Fleming research. It is allowed to define quantitative and qualitative daily physical activity of students. The different daily activity is at the bottom of such chronometry [40]. Each participant of experiment carried out the fixing of physical activity exercises with different intensity and fixing of performance time. Data was registered into special form. All physical activity of the person is divided into five levels. Each level is corresponded to the certain types of physical activity:

- basic (sleep, relax);
- in sitting position (watching tv, reading, preparation for study at education establishments, driving, board and computer games, eating and so forth);
- small (personal hygiene, condition with low mobility, study at education establishment, using transport, walking);
- average (housekeeping, walks, morning exercises);
- high (participation in specially organized physical training classes, dances, intensive games, run, skating, rollers, bicycle and so forth) [41].

Use of weighing coefficients different by intensity of physical activity types gave the opportunity for each respondent to define quantitative value of students' daily physical activity index (I_{PA}).

The attitude of students to problems of teachers' and children' physical activity of primary school was studied by means of specially developed questionnaire. It consisted of questions of essence of a healthy lifestyle and its components; influence of sports and physical exercises on health and efficiency of the teacher and child. Students expressed own position relatively: reasons of sedentary lifestyle of the modern person; role of the teacher in a physical development of child; dependence of physical

culture development level of pupils on physical activity of the teacher.

All students were participated as volunteers and gave the written consent to participate in a research on condition of anonymity. Before the beginning of experiment students were briefed on the purpose of research and on the possibility to finish the participation in any time without explanation.

Statistical analysis: it was used the method of transformation of empirical data of poll into quantitative indices. The students' daily physical activity index (I_{PA}) was counted by formula 1. The basic level of physical activity corresponds to weighing coefficient k which is 1,0; to sedentary – $k=1,1$; to small – $k=1,5$; to average – $k=2,4$; to high – $k=5,0$ [42].

$$I_{PA} = \sum_{n=1}^m t_m \times k,$$

where m – is the number of notes in the registration form, each of them correspond to certain type of activity, t_m – is the time spent on it, k – is the weighing coefficient of appropriate level of student's physical activity.

The obtained data were processed by means of Microsoft Excel.

For data processing of questionnaire was carried out the scale – improvement of initial empirical data by their transfer to scales indices, percentage frequencies.

Results

According to the numerical values of physical activity indexes all students were divided into three groups by

levels of physical activity: low ($I_{PA} < 31$ point), average ($31 \leq I_{PA} \leq 34$), high ($I_{PA} > 34$ points).

Results of research testified domination of average and low levels of physical activity of «Primary education» specialty students (fig. 1). The comparative analysis of the obtained data demonstrated that quality of students' physical activity of extramural form of study is much lower in comparison with students of daytime study. It is revealed that most of respondents (91,4%) is not satisfied with the own level of physical activity. They understand its value for own health, but consciously prefer intellectual activity.

Students of daytime study (76,5%) chose lack of time for independent work of all study subject as the reason of sedentary lifestyle. Students with the high level of study progress note that thorough preparation causes three-four hours sleep per day. According to the results of poll students with high level of physical activity consciously chose a priority of physical self-improvement over the academic progress in study.

Students of daytime (98,8%) and extramural form of study (100%) chose physical culture and physical culture with prerequisites among subject with physical activity. According to students' point of view, teachers of other subjects paid no attention to the organization of physical activity. There are only several disciplines where teachers use interactive forms of work with students on laboratory classes.

51,9% of daytime and extramural form of study students convince that parents have responsibility for physical development of child. They have to take care of morning exercises, sports sections for the child and active family vacation. They consider own role in educational

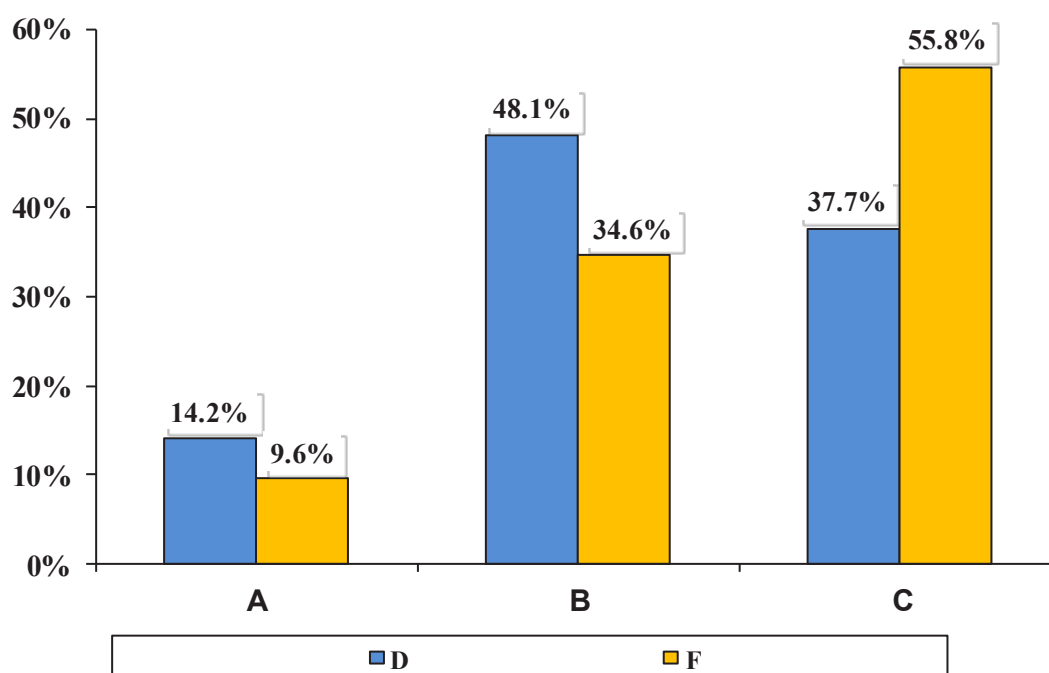


Fig. 1. Percentage distribution of daytime and extramural form of study students by levels of physical activity: A – high level; B – average level; C – low level; D – daytime form of study; F – extramural study form of study.

work with parents only.

Extramural form of study students (88,5%) defined a tendency to decrease in physical activity after graduation from pedagogical colleges. All students of this group work as primary school teachers. It is connected with the fact that all free time after work they spend with family and fill out documentation. People of countryside (78,8%) consider that housework is the main type of physical activity. This type of activity increases during the spring farm work.

It is determined that future primary school teachers have pedagogical barriers in carrying out physical education class. Among the main reasons were chose the following: health problems, overweight, fear of responsibility for children's health. In this situation teachers understand the necessity of physical self-improvement only at informative level.

Generalization of students' answers results allow to draw a conclusion that modern primary school teachers have insufficient understanding of dependence of pupils' physical culture development level on their physical activity. Not sufficient attention is paid to physical activity breaks during the classes. Rather often teachers have insignificant set of exercises. Physical activity breaks use during all study period of child at primary school. As a result children lose interest and do physical exercises poorly. A lot of teachers consider physical education classes at primary school as an opportunity for child to get rid of excess energy. Plans of educational work of primary school teachers are overloaded with educational conversations on various subjects, in particular concerning physical training. However only physically active teachers prefer organize joint vacation with pupils (hikes, sports competitions, travels, outdoor games and so forth). Teachers do not carried out gymnastics before classes and health hours.

Discussion

Our researches prove and complete data about features of students' and primary school teachers' physical activity. Thus, in the course of experimental study scientists drew the following conclusions concerning primary school teachers:

- only physically active teachers can effectively form physical culture of children [27];
- teachers have to be encouraged to active life style to form models of physical activity [25];
- it is necessary to consider advanced pedagogical experience in the process of future teachers training [30];
- it is necessary to form students' confidence in own pedagogical knowledge, especially it concerns students who have negative experience of physical education classes at school [43].

Our research:

- pays attention on the problems of physical activity organization of future primary school teachers in the course of academic load;
- confirms necessity to consider influence of physical activity on intellectual efficiency of students depending

on specifics of future professional activity [44];

- expands limits of researches which are directed to activization of students' physical activity only at physical education classes.

We analyzed the specialists' curriculum and training programs by specialty «Primary education». All study disciplines (about 50) were divided into levels of motor density:

1. Physical education, sports sections by free choice of students (high level).
2. Physical education with prerequisites (average level).
3. Didactics, introduction to scientific and pedagogical researches, fundamentals of mathematics with teaching technique of educational field "Mathematics", fundamentals of informatics with teaching technique (low level).

The majority of subjects do not provide the active motor activity of students. There is a necessity to search the ways of physical activity activization, to carry out special sports, health and fitness events with students.

For the purpose of students' physical activity activization was offered the following:

1. To use elements of Bothmer Gymnastics. It is also consisted of special rhythmical and breathing exercises which can be carried out in different starting positions (sitting, standing).
2. To carry out kinesiological physical activity breaks for sense of sight, body posture, relax.
3. To coordinate the list of theoretical and practical tasks for independent study. To decrease the list of these tasks and to increase the quality of performance and so forth.

Relevant questions are:

- research of influence of different methods, methods of teaching and students' organization at vocational training classes on the level of their physical activity;
- determination of teachers' physical activity level; influence of teachers' active lifestyle on the formation of students' motivation to physical education classes;
- proving or disposing of correlation of mental welfare levels of future primary school teachers and physical activity.

Conclusions

1. The primary school teachers are important persons in the process of pupils' health saving and strengthening.

2. If physical training classes are conducted by experts on specialty «Physical training and sport», then primary school teachers are responsible for the organization of health and fitness events for primary school. It is important component of pupils' physical training formation. Such health and fitness events are physical activity breaks, gymnastics before classes, organized active breaks, health hours and so forth. Therefore physical activity is important factor of teachers' professionalism formation.

3. Values are formed in the social environment. The question of humanistic values' formation at future primary school teachers in the field of physical education and sport

and physical activity in particular is relevant.

4. The important question is formation of students' motivation to motor activity not only at physical education classes, but also at the all disciplines of professional cycle. Physical training of students in the course of study can be carried out not only at physical education classes and

sports sections. It is necessary to carry out this work at all disciplines of bachelors study.

5. Children and students need creation of health saving and health forming environment.

Conflicts of interest

The authors declare that there is no conflict of interests.

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The prediction of success in kickboxing based on the analysis of morphofunctional, physiological, biomechanical and psychophysiological indicators

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Abstract

Purpose: To substantiate and develop a methodology for predicting success in kickboxing on the basis of analysis of morphofunctional, physiological, biomechanical and psychophysiological indicators.

Material: it was examined athletes of kickboxing (n=185, age 18.58 ± 0.46 years). It was studied the features of physical development (n = 18). The main biomechanical parameters (n=45) were determined. Goniometric indices of limb joints (n=29) were studied. It was studied the features of psychophysiological reactions (n =76). The adaptive capabilities of the cardiovascular system were studied (n=17). The prognostication is carried out by means of a sequential Wald procedure. Prognostic coefficients and their informativity were calculated.

Results: a prognostic table was developed containing the indicators of the functional state of kickboxing athletes. The table includes 31 criteria, the informativeness of which varied within 115,45 – 2,23. The content of the forecast consists in: an evaluation of the results; determination of the corresponding prognostic coefficient; summation of coefficients. The threshold was set at the level ± 13, which corresponds to a probability of 95% (p<0,05). Exceeding the positive threshold means a high level of success for the athlete. When the negative threshold is reached, the probability of success is low.

Conclusions: The proposed methodology is based on a sequential analysis of Wald. The technique is a simple, informative and objective tool for monitoring and predicting the status of athletes.

Keywords: kickboxing, forecast, success, morphofunctional, physiological, biomechanical, psychophysiological, indicators.

Introduction

Forecasting success in sports is one of the key scientific and practical tasks. Evaluation of the probability of high performance involves studying indicators that reflect the level of sportsmanship, identifying the most informative and establishing dependencies between them.

Forecasting success requires an integrated approach. Thus, Baláš J. et al. [1] found that strength and endurance of hands are the most informative predictors of alpinist skill. The high prognostic significance of hand strength is proven in swimmers [2].

Ray Smith B.P. and Drew M.K. [3] determined the relationship between the failure of athletes and the burden of injury / illness. The authors used logistic regression. A curve analysis was conducted to determine the optimal threshold for the completion of the training week in order to maximize the chances of success.

Schick M.G. et al. [4] considered the physiological requirements for women – athletes of mixed martial arts. The conclusion is made about the importance of the development of speed and agility for success.

Buse G.J. et al. [5] note that the preparation of high-level kickboxers should be based on a set of factors, including physical exertion, optimal rest and nutrition and psychological preparation. Training should influence the aerobic and anaerobic characteristics of athletes' metabolism.

Williams S. et al. [6] revealed clear negative

associations between injuries and success in the team. The authors found that a moderate reduction in the burden of injuries can have a significant impact on the results of competitions for professional rugby union teams.

Hastie P.A. et al. [7] found that the use of graduated competition would increase the opportunities for participation in the game and the successes of the athletes of higher and lower levels.

Iavorskaia T.E. [8] proposed to use a number of statistical methods (regression, vector, matrix, dispersion and factor analysis, the theory of multidimensional linear regression in Euclidean space) to predict performance in sports.

Linear regression analysis confirmed that the pick and roll could be predicted in the final classification of the teams [8]. Conclusively, coaches of the high level European clubs should focus on training the players to the most effective phases of the pick.

Winter C. and Pfeiffer M. [9] considered important theoretical requirements for the analysis of sports games (for example, interaction between the two parties, procedural sequence of actions or the value of tactical behavior), the value of the introduced parameters, called tactical metrics, is illustrated. Discriminant analysis, based on the values of factors, leads to a correct classification of 64,8%, identifying winners and losers. This successful discrimination reveals the connection between the success of the match and the presented metrics.

By considering the important theoretical requirements for the analysis of sports games (like the interaction

between two parties, the procedural sequence of action or the significance of tactical behaviour) the meaning of the introduced parameters, called tactical metrics, is illustrated. Discriminant analysis based on the factor values leads to a correct classification of 64.8% identifying winners and losers. This successful discrimination reveals a connection between match success and the presented metrics.

Sport-confidence is considered a critical success factor for sport performers at all levels [10]. Researchers have suggested that sport-confidence is a multidimensional rather than a unidimensional construct, and the sport-confidence model identified three types of sport-confidence (i.e., physical skills and training, cognitive efficiency, and resilience) that are important for success in sport.

Zaporozhzanov V.A. et al. [11] confirmed the feasibility of the metric method of calculating the reliability of the results of control measurements used to diagnose psychophysiological fitness and predict the growth of skill. Metric estimates of the reliability of measurements are calculated – stability, consistency, informative data of the control data. These estimates are used for the current diagnosis and prognosis of the sports capabilities of the examined

The interaction between teams' behaviour is from high relevance for success in sports games [12]. Odds ratio analysis revealed advantageous defensive tactics against specific offensive behaviour. Summarizing, results indicate that artificial neural networks are appropriate to model the interaction between teams based on players' positions.

In sports, fast and accurate execution of movements is required. It has been shown that implicitly learned movements might be less vulnerable than explicitly learned movements to stressful and fast changing circumstances that exist at the elite sports level. Present findings may be important for sports because children with superior implicit learning abilities in early learning phases may be able to learn more (durable) motor skills in a shorter time period as compared to other children.

Thus, the available literature data indicate the possibility of predicting success in sports based on the results of morphological, functional, physiological and psychophysiological data. The forecasting tool is the mathematical methods and used in statistics. However, in kickboxing, this problem does not yet have a final solution. This also determined the relevance of this study.

The aim of the work was to develop a methodology for predicting success in kickboxing based on a complex of morphofunctional, physiological, biomechanical and psychophysiological indicators.

Materials and methods.

Participants. The results of a survey of kickboxing athletes ($n = 185$, age 18.58 ± 0.46 years) were used as a main material. The features of physical development ($n=18$) were studied. The main biomechanical parameters ($n=45$) were determined. Goniometric indices of limb

joints ($n=29$) were studied. We studied the features of psychophysiological reactions ($n = 76$). The adaptive capabilities of the cardiovascular system ($n=17$) have been studied.

Organization of the study. All athletes were divided into groups, depending on the type of martial arts. Allocated group: athletes kickboxing; wrestlers; athletes karate, taekwondo, etc. [14-16].

In assessing the characteristics of physical development, kickboxing athletes were divided into two groups, depending on the level of skill. The first group – masters and candidates for master of sports, the second group – amateurs and athletes up to 1 category inclusive [17].

In assessing the adaptive capabilities of the cardiovascular system, kickboxing athletes were divided into two groups, depending on the type of reaction. The first group includes athletes with a normotonic type of reaction. The second group includes athletes whose reaction type was different from normotonic [18].

As a tool for solving the prognostic problem, a sequential Wald procedure was applied [19]. As boundary values, the mean values of the studied indices in the groups were chosen. Then, the probability of a smaller or larger value of the indicators relative to the average values was determined. Then the prognostic coefficients and the informativeness of the traits studied were calculated.

The characteristics in the table are arranged in decreasing order of informativeness. The value of informativity less than 2,0 was considered insignificant. Indicators with this or a lesser value were not included in the table. In the case of the same informative value, the order of location is determined randomly.

Statistical analysis. The analysis of the obtained data was carried out with the help of licensed packages of Excel spreadsheets. Prognostic coefficients were calculated using the formula:

$$PF = 10 \times \lg [p(D_1/S)/p(D_2/S)] \quad (1)$$

where PF is the prognostic factor, $p(D_1/S)$ is the probability of the presence of the characteristic, $p(D_2/S)$ is the probability of the absence of the characteristic.

The multiplication factor by 10 is introduced in order to the PF to be an integer. This facilitates the forecast procedure.

Informativeness was calculated in accordance with the Kullback formula:

$$I = PF \times 0.5 \times [p(D_1/S) - p(D_2/S)] \quad (2)$$

where I is informative character of the characteristic. The other notation is the same as in the previous formula.

Results.

The developed prognostic table combines indicators reflecting the peculiarities of the functional state of kickboxing athletes. It includes 31 indicators. The signs are included taking into account the reliability of the

differences and the informativeness of the evaluated traits. The signs describe the physical, goniometric, biomechanical and functional indices of athletes. A large number of prognostic criteria can significantly increase the probability of obtaining a certain forecast. The results are shown in Table 1.

Analysis of the indicators (Table 1) shows that the most important for predicting success in kickboxing are: biomechanical indicators (8 criteria), goniometric indicators (7 criteria) and anthropometric indicators (7

criteria). Analysis of these criteria proves their importance as predictors of success in kickboxing. Thus, an increase in the amplitude of movements in the shoulder and elbow joints reflects the increased possibility of applying strong and qualitative strokes. This is an important factor in success in kickboxing.

Anthropometric indicators (circumference of the shoulder and wrist) illustrate the level of development of the muscles of the extremities. This should also be evaluated as evidence of the possibility of inflicting heavy

Table 1. Forecasting the success of kickboxing athletes

Index	Forecasting coefficients		Informativeness
	Existing	Lack	
Bending of the right shoulder joint more than 190°	5	-3	115.45
Diastolic pressure at rest in less than 69 mm Hg	3	-2	52.98
The thickness of the left hand is larger 2 cm	2	-4	40.51
Amplitude of the R wave of the electrocardiogram (ECG) at rest is greater than 0,419 mV	2	-4	36.44
Extension of the right wrist joint more than 58°	2	-2	31.44
Leaving the left shoulder joint more than 174°	2	-4	26.65
Vital lung capacity more than 3,2 l	2	-2	24.65
Thigh mass more than 9,37 kg	2	-2	23.46
Weight of forearm more than 1,07 kg	2	-2	23.46
Shoulder weight more than 1,75 kg	2	-2	23.46
The main central moment of inertia of the forearm relative to the sagittal axis is greater than 58,36 kg*cm ²	2	-2	23.46
The central central moment of inertia of the tibia with respect to the longitudinal axis is greater than 56,88 kg*cm ²	2	-2	23.46
The main central moment of inertia of the thigh relative to the longitudinal axis is greater than 325,96 kg*cm ²	2	-2	23.46
The main central moment of inertia of the shoulder relative to the longitudinal axis is greater than 34,24 kg*cm ²	2	-2	23.46
Bending of the right elbow joint more than 120°	2	-2	19.70
Extension of the right shoulder joint more than 72°	2	-2	19.70
Bringing the right shoulder joint more than 30°	2	-2	19.70
Circumference of the right shoulder more than 32,4 cm	2	-2	19.57
Circumference of the left shoulder more than 32,3 cm	2	-2	19.57
Flexion of the left knee joint more than 77°	2	-1	15.41
The main central moment of inertia of the forearm relative to the longitudinal axis is greater than 10,22 kg*cm ²	2	-1	13.52
Speed of the line more 136 mm/s	1	-2	12.85
The response time of choice is less than 576 ms	1	-1	11.56
The QT interval value of the ECG after the load is less than 269 ms	1	-4	10.41
Resistance to knocking down signals of simple motor skills more than 82%	1	-1	5.86
Shoulder width more than 42,4 cm	1	-1	5.38
Circumference of the right wrist more than 17,3 cm	1	-1	4.40
Circumference of the left wrist is larger than 16,8 cm	1	-1	4.40
Heart rate at a load of less than 130 beats per minute	1	-1	2.56
The amplitude of the R wave of the ECG after loading is greater than 0.22 mV	1	-1	2.56
The number of touches of simple motor skills is more than 27 in 10 seconds	1	-1	2.23

strikes.

The mass of the segments of the limbs and the main central moments of their inertia relative to the sagittal and longitudinal axes also illustrate the biomechanical characteristics of shock actions in kickboxing.

An important predictor of success in kickboxing should be recognized the high adaptive potential of the organism, the expansion of the functionality of athletes. This is evidenced by the value of lung capacity: an indicator reflecting the increased functional state of the respiratory system of athletes.

The importance of increasing the adaptive capacity for success in kickboxing is confirmed by the presence of five indicators of the state of the cardiovascular system in the table. They illustrate the dynamics of heart rate, blood pressure (BP) and ECG parameters (at rest, under load and in the recovery period). The developed prognostic technique proves the importance of evaluating the reaction of athletes to metered physical loads. Athletes with a high level of adaptive capabilities have a high probability of success.

The last four indicators of the prognostic table belong to the group of psychophysiological indicators. They illustrate the speed of reaction to various stimuli, the level of attention and coordination. These qualities are prognostically important for success in kickboxing.

These tables confirm the high information value of such indicators. The value of the indicators ranged from 115,45 to 2,23. There was also a coincidence of this parameter. Thus, for seven biomechanical parameters, the informativeness was 23,46. For three goniometric indicators, the informativeness was 19,70. For shoulder circumferences, the informativeness was 19,57. For the circumference of the wrist, the informativeness was 4,40. For the heart rate and the amplitude of the R wave, the informativeness was 2,56. In these cases, the order of presentation of the characteristics in the table was determined randomly.

The developed table allows to carry out the forecast of sports success of kickboxing athletes. The content of the forecast consists of an assessment of their results, determination of the corresponding prognostic coefficient and their summation. The thresholds were set at the level ± 13 , corresponding to a probability of 95% ($p < 0.05$).

Exceeding the threshold of +13 means a high level of success for the athlete in kickboxing. If the opposite maximum values are reached, the probability of success is extremely low. If the prediction procedure is completed and none of the maximum values is reached, then a decision is made about an undefined forecast. In this case, research is needed to obtain additional information.

The proposed forecasting scheme has a universal nature and can be used at various stages of assessing the functional state of athletes. As a significant advantage of the developed methodology, it should be noted that the overwhelming number of criteria are manageable. Such criteria can change in the process of optimally constructed training.

Depending on the purpose, it makes sense to

make appropriate changes in the forecast table (that is, the number of methods used). So, at the stage of the preliminary forecast it makes sense to conduct: anthropometric research; analysis of goniometric indices of limb joints; psychophysiological research; determine the response to standard loads. This gives the coach the maximum information about the athlete's functional state. Also allows to determine the perspective of the athlete and the introduction of individual corrections in the training program.

For the current forecast of training construction, tolerance to physical loads has the greatest importance. Therefore, this prediction can be based on a standard ergonomic and biomechanical study. A forecast of competitive success requires a comprehensive assessment with the application of all groups of criteria.

Discussion.

The research scheme suggested an analysis of a complex of diverse indicators. This allows to significantly increase the efficiency of the forecast and coincides with the opinion of many specialists. Thus, Slimani M. et al. [20] analysed the anthropometric, physiological and psychological characteristics of kickboxers. The features of the constitution of kickboxers of different levels, the status of the adaptive status of the cardiorespiratory system are established. A high level of skill is combined with a good development of the muscular strength of the limbs, a high level of self-confidence, working capacity and the ability to adapt. Specific psychophysiological characteristics affect the capacity and productivity of the activity and should be taken into account in the preparation.

Similar data in many respects are given by Ouergui I. et al. [21]. The authors investigated the hormonal, physiological and physical changes in the body of kickboxers during a real fight. The effectiveness of the tests used as tools for assessing athletes' preparedness is proved.

Podrigalo L.V. et al. [22] proposed a comprehensive approach to assessing the success of athletes in arm-wrestling.

In our study, we used a comparison of athletes engaged in different types of martial arts. This approach is also widely used in modern scientific research. Thus, Bounty P.L. et al. [23] analysed literature on mixed martial arts (MMA). The authors emphasize the inadequacy of complex studies devoted to improving the success of athletes.

Comparison of the characteristics of athletes of different types of martial arts allows: to assess their specificity; highlight the main factors that affect success. Our studies have proved the validity of such a campaign in the analysis of biomechanical, psychophysiological and goniometric indicators [14-16]. This served as the basis for including these groups in the prognostic table.

The high informativeness of goniometric indicators is confirmed by the data of other studies. Thus, Machado S. et al. [24] compared isokinetic indicators of the knee

joint of kickboxing and taekwondo athletes. The authors used the Biodex Multi-Joint System dynamometer 3. The proximity of training in these sports caused the absence of differences in the maximum torque and the relative balance of flexor agonists and extensor muscles.

Similar results were obtained by Szafranski K. et al. [25]. The authors compared the moments of muscular strength of flexors and extensors of the knee joint in static and isokinetic conditions in kickboxers and athletes. The possibility of using these indicators for the prognosis in martial arts has been confirmed.

Similar results were obtained by Machado S. M. et al. [26]. The authors analysed the efficiency of flexion and extension of the knee in athletes' kickboxing and taekwondo. All have confirmed the dependence of power and torque on training experience. It is proved that the ability to increase muscle mass is associated with the energy capacity of contraction and with motor coordination.

Catikkas F. et al. [27] note an insufficient number of studies of kinanthropometric (Kinanthropometric) features of Turkish martial arts athletes. The authors studied the physique of athletes in karate, taekwondo, kickboxing and judo. It was established that the mesomorphic component of the somatotype is dominant. The body mass index was related to the average values, the specific gravity of the fat was low. Informative indicators were the width of shoulders and hips. These data coincide with our results.

Podrigalo L.V. et al. [28] used the method of indexes to predict the success of athletes of single combats. The revealed differences illustrate the specificity of sports, the differences in the physique of fighters and athletes of martial arts.

Inclusion in the number of prognostic indicators of the results of psychophysiological studies is also due to their high informativeness. Thus, Slimani M. et al. [19] evaluated the results of functional tests of high-level kickboxers during the national championship. The athletes were divided into groups depending on the results of the fights. The winners had significantly better mental performance. The presence of regression links of success was confirmed according to the results of this test. It is offered to use mental working capacity for the forecast of success in kickboxing.

Volodchenko O. et al. [15] confirmed the presence of differences in the psychophysiological status of athletes' kickboxing, wrestling, karate, taekwondo. The established features reflect the specifics of sports and should be used as predictors of success. This served as the basis for including this group of criteria in the prognostic table.

Conclusions.

Thus, the conducted studies allowed to substantiate and develop a comprehensive methodology for predicting success in kickboxing. The technique is based on the Wald's sequential analysis procedure. The proposed methodology can be used for forecasting at various stages of preparation. The technique is a simple, adequate and informative tool for monitoring the functional state of kickboxing athletes.

Conflicts of interest

The authors declare that there is no conflict of interests.

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