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CONTENTS

The peculiarities of motor fitness' classification model of 6-10 years old girls

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Abstract

Purpose: The purpose of the research is determination of motor fitness' classification model of 6-10 years old girls.

Material: in the research 6 years old girls (n=36), 7 years old girls (n=48), 8 years old girls (n=57), 9 years old girls (n=38), 10 years old girls (n=46) participated. Testing program includes commonly known tests.

Results: With age there happened some changes of coordination and power fitness, endurance, quickness, flexibility indicators. Suggested set of tests could be used for final control of girls' motor fitness.

Conclusions: In the process of analysis was calculated canonic coefficients of discriminant function (not standardized). These coefficients are multipliers of the set values of variables, which are components of discriminants functions. On the basis of them it is possible to classify girls by the level of motor fitness according to their age.

Keywords: motor abilities, discriminant analysis, classification model, girls.

Introduction

The problem of motor activity and health strengthening is rather relevant in Ukraine and in Europe. The scientists concentrate attention on innovative approaches to physical education, and also on realization of differentiated approach to physical education of children's and teenagers' [1, 2, 4]. Health improvement and rising of children's and teenagers' workability depends on optimal motor activity, which is ensured by physical education at school. The planning of educational process and integrative physical training of pupils provides the necessary amount of motor activity [11, 3].

The main task of school age children's physical education is teaching of motor actions [4, 17, 30]. The training process is regarded from the following positions: organization and educational management [11, 19, 35]; motivation for motor functioning (the higest level of exercise mastering provoques the large amount of motor activity [32, 21]). In educational process is investigated connection of training efficiency and motor functioning: successful education induces to increase motor activity's amount [14, 15]; cognitive and motor training emphasizes at nesessity to join the mental and motor components of motor fitness [18, 16]. Special attention is paid on influence of motor fitness on study's effectiveness [33, 34, 29] and influence of physical loads on study's effectiveness [22, 28].

One of conditions of schoolchildren's physical education effectiveness is organization of pedagogic control at physical culture lessons [26, 27, 36]. Effectiveness of pedagogic control depends on the presence of object to be controlled and informative value of indicators, which characterize the changes of his/her state [7, 8, 9]. It was found that modeling is an effective method of receiving new information for realization of current and final control on the base of children's and teenagers' testing [6, 13, 23]. Factorial and discriminant analysis is one of methods of statistic modeling. Effectiveness of their application is illustrated by scientific data [5, 31, 24]. The mentioned works witness about demand in searching methodological approaches to solution motor fitness problem and its pedagogical control in schoolchildren.

It should examine the opportunity to use discriminant analysis for study peculiarities of motor fitness of 6–10 years old girls.

The purpose of the research is to determine motor fitness' classification model of 6-10 years old girls.

Material and methods

Participants: in the research 6 years old girls (n=36), 7 years old girls (n=48), 8 years old girls (n=57), 9 years old girls (n=38), 10 years old girls (n=46) participated.

Organization of the research: The following methods of the research were used: analysis of scientific literature, pedagogic testing and methods of mathematical statistic. Discriminant analysis was used as the method of modeling.

In testing program we included commonly known tests [23]. For assessment the girls' motor fitness we registered the results of the following motor tests: static stance on one foot (sec.); walking along segments of hexagon (steps); combined movements of arms, torso and legs (errors); walking along straight line after 5 rotations, deviations (cm); shuttle run 4×9 m (sec.); 30 m run (sec.); frequency of arms' movements (times); catching of falling Dietrich's stick (cm); long jump from the spot (cm); 300 meters' run (sec.); arms' bending and unbending in mixed hanging on rope (times); torso rising in sitting position during 1 minute (times); torso bending from sitting position (cm); index assessment of backbone mobility; index assessment of shoulder joints' mobility.

Statistical analysis: processing of the research material was carried out with the help of IBM SPSS 20 program. Discriminant analysis helped to create prognostic model of belonging to group. This model builds discriminant function (or set of discriminant functions, if they are more than two) in the form of predictors-variables linear combination. It ensures the best groups' distribution.

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These functions are built basing on set of observations, belonging to groups of which is known. Further, these functions can be applied to new observations with known predictors-variables and unknown group belonging.

For every canonic discriminant function we calculated own value, dispersion percentage, canonic correlation, Wilks' Lambda, χ- Chi-square.

Results

The analysis permitted to determine, that statistically confident differences between mean group indicators were observed in the following below tests:

coordination abilities: in tests №№ 1-5 with age there are statistically confident differences in results of testing. Results improves in test № 1 «Static stance on one foot (sec.)» ($p < 0,001$), test № 2 «Walking along segments of hexagon (steps)» ($p < 0,001$), test № 4 «Walking along straight line after 5 rotations, deviations (cm)» ($p < 0,001$), test № 5 «Shuttle run 4×9 m (sec.)» ($p < 0,001$), test № 3 «Combined movements of arms, torso and legs (errors)» ($p < 0,1$). The least dynamics of results is observed in test № 3. The exercises of combined movements of arms, torso and legs are difficult for 6–10 year old girls;

quickness: in tests for different demonstration of quickness with age is observed statistically confident dynamics. Results improves in test № 6 «30 m run» ($p < 0,001$), test № 7 «Frequency of arms' movements» ($p < 0,001$), test № 8 №21 «Catching of falling Dietrich's stick (cm)» ($p < 0,001$). The most dynamics of results is observed in test № 6 «30 m run»;

power abilities: in tests № 9 «Long jump from the spot (cm)» ($p<0,001$), № 11 «Arms' bending and unbending in mixed hanging on rope (times)» ($p < 0,001$), is observed statistically confident dynamics of results;

endurance: in tests № 10 «300 meters' run» ($p < 0,001$), № 12 «Torso rising in sitting position during 1 minute (times)» ($p < 0,001$) is observed statistically confident dynamics of results;

flexibility: in tests №№ 14-15 with age is observed statistically positive confident dynamics of testing results, in test № 13 «Torso bending from sitting position (cm)» dynamics of results isn't statistically confident.

Thus, with age there are differences in indicators of coordination and power fitness, endurance, quickness, flexibility. Suggested set of tests could be used for final control of motor fitness of 6-10 years old girls.

The results of discriminant analysis indicate, that first canonic function explains variation of results by 85,3%, the second – by 8,1%. It witnesses about their high informational potential. Correlation coefficient between calculated values of discriminant function and indicators of belonging to group equal to r=0,831. It witnesses about high prognostic potential of first canonic function. The first canonic function's own value witnesses about successfully selected coefficients in it.

The analysis of canonic functions points that first and second functions have high discriminant potential and meaning in interpretation in respect to general communality (λ=0,216 and statistical significance p=0,001 for all set of canonic functions).

Normalized coefficients of canonic discriminant function give opportunity to define correlation of variables' contribution in function result.

1. The highest contribution in the first canonic function is provided by the following variables:

Shuttle run 4×9 m – ,552;

Catching of falling Dietrich's stick – ,343;

Walking along segments of hexagon (steps) – -,344;

300 meters' run – ,329;

2. The highest contribution in the second canonic function is provided by the following variables:

Combined movements of arms, torso and legs – -,577;

Long jump from the spot – ,553;

Static stance on one foot – ,522;

Frequency of arms' movements – -,424;

3. The highest contribution in the third canonic function is provided by the following variables:

Shuttle run 4×9 m – ,717;

Index assessment of backbone mobility – ,604;

Frequency of arms' movements – ,488;

4. The highest contribution in the fourth canonic function is provided by the following variables:

Index assessment of shoulder joints' mobility – ,627;

Long jump from the spot – -,615;

Torso rising in sitting position during 1 minute – ,507.

On the basis of results of variables from the first list could classify 6–10 years old girls, from the second list – 7–10 years old girls; from the third list – 8–10 years old girls; from the fourth list – 9–10 years old girls.

It is determined, that maximum discriminant potential have first and second functions. That's why variables from the first and second lists play the main role in classification.

Structural coefficients of canonic discriminant function are correlation coefficients of variables with function. They determine the influence power of independent variables on dependent.

1. The maximum influence power of independent variables on dependent in the fist function have:

Shuttle run 4×9 m (sec.) – ,715;

300 meters' run – ,531;

30 m run – ,477;

Long jump from the spot – -,462;

Catching of falling Dietrich's stick – ,385;

Walking along segments of hexagon (steps) –-,228;

2. The maximum influence power of independent variables on dependent in second function have:

Static stance on one foot – ,363;

Combined movements of arms, torso and legs – -,351;

3. The maximum influence power of independent variables on dependent in third function have:

Frequency of arms' movements – ,384;

Index assessment of backbone mobility – ,377;

Arms' bending and unbending in mixed hanging on rope (times) – -,202;

Torso bending from sitting position – ,135;

4. The maximum influence power of independent variables on dependent in fourth function have:

Index assessment of shoulder joints' mobility – ,596;

Walking along straight line after 5 rotations, deviations – -,342;

Torso rising in sitting position during 1 minute – ,331.

The analysis of correlation coefficients determines, that for 6–10 years old girls is significant the complex development of motor abilities; for 7–10 years old girls the attention is paid on development of coordination abilities; for 8–10 years old girls – on quickness, power and flexibility; for 9–10 years old girls – on flexibility, motor coordination and power endurance.

In table №1 the canonic (unnormalized) coefficients of discriminant function are given, which are multipliers of the set values discriminant functions. On the basis of comparison of obtained data with function's centrodes (table №2) it is possible to classify each particular case. The results of classification are given in table №3. 59,8% of output group observations were classified correctly. It made possible to claim that classification of 6–10 years old girls is possible according to suggested set of tests.

Discussion

The obtained results supplement the data about methodological approaches to the pedagogical control of motor abilities development [37, 35]. The results extend opportunities of modeling in the process of new information's receiving about dynamics of motor abilities development of children [37, 29]. The effective use of factorial and discriminant analysis in determination of motor fitness structure of children and teenagers is proved [10, 20, 25]. The received data is important for estimation of primary school age readiness to study motor fitness. They complete data about influence of motor fitness' development level on study's effectiveness [12, 35]. They

Table 1. Unnormalized coefficients of canonic discriminant function. 6–10 years old girls

Test title	Age				
	6	7	8	9	10
Static stance on one foot (sec.)	-,003	,081	-,007	,022	-,003
Walking along segments of hexagon (steps)	-,154	-,019	,008	,002	-,154
Combined movements of arms, torso and legs (errors)	,057	-,189	-,029	,059	,057
Walking along straight line after 5 rotations, deviations (cm)	,000	,001	-,004	-,005	,000
Shuttle run 4×9 m (sec.)	,500	,364	,649	-,071	,500
30 m run (sec.)	,366	,202	-,342	,007	,366
Frequency of arms' movements (times)	-,017	-,040	,046	-,002	-,017
Catching of falling Dietrich's stick (cm)	,047	-,016	,017	,015	,047
Long jump from the spot (cm)	,002	,030	,013	-,033	,002
300 meters' run (sec.)	,019	-,015	-,023	-,006	,019
Arms' bending and unbending in mixed hanging on rope (times)	-,005	-,013	-,047	,018	-,005
Torso rising in sitting position during 1 minute (times)	-,013	,019	,005	,055	-,013
Torso bending from sitting position (cm)	,010	-,019	,058	,040	,010
Index assessment of backbone mobility	,015	-,036	,080	-,004	,015
Index assessment of shoulder joints' mobility	,392	,705	-,190	1,760	,392
(Constant)	-13,463	-6,996	-9,522	-,255	-13,463

Table 2. Functions in groups' centrodes. 6–10 years old girls

Girls' age	Function			
	1	2	3	4
6 years	2,843	,501	,173	,054
7 years	,632	-,575	-,481	,083
8 years	-,239	-,132	,139	-,277
9 years	-1,085	-,293	,610	,191
10 years	-1,697	,611	-,306	,050

Table 3. Results of groups' classification. 6–10 years old girls

Index	Girls' age	Predicted belonging to group					Total
		6 years	7 years	8 years	9 years	10 years	
Frequency	6 years	30	6	0	0	0	36
	7 years	4	27	15	1	1	48
	8 years	4	9	28	7	8	56
	9 years	0	1	13	15	9	38
	10 years	0	0	4	8	34	46
%	6 years	83,3	16,7	,0	,0	,0	100,0
	7 years	8,3	56,3	31,3	2,1	2,1	100,0
	8 years	7,1	16,1	50,0	12,5	14,3	100,0
	9 years	,0	2,6	34,2	39,5	23,7	100,0
	10 years	,0	,0	8,7	17,4	73,9	100,0

also point at necessity of power abilities development [20, 25].

In the process of analysis was calculated canonic coefficients of discriminant function (not standardized). These coefficients are multipliers of the set values of discriminant functions. On this base it is possible to classify girls by the level of motor fitness according to their age and it is of practical significance.

Conclusions

So, discriminant analysis permitted to answer the question: how confidently it is possible to separate one form from other by set of offered variables; which of variables influence most significantly on separation of forms; to which form object belongs on the base of discriminant variables' values.

The suggested set of tests could be used for final control of motor fitness of 6-10 years old girls.

On the basis of canonic coefficients of discriminant function is possible to classify pupils by the level of motor fitness according to the girls' age, which has practical importance for effective development of physical training programs of primary school age children.

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Conflict of interests

The author declares that there is no conflict of interests.

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The control system for special preparedness of cyclists

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Abstract

Purpose: to develop a system for monitoring the level of special preparedness of cyclists (specialized in individual race for 4 km) on the basis of the indicators of the cardiorespiratory system.

Material: The study involved bicyclists (n=14, age 18-22 years).

Results: The step-increasing load to the full allows to determine the maximum functional opportunities of the body of cyclists. The coefficient of efficiency of the functioning of the cardiovascular system is equal to the ratio of the average distance value of the pulse to the maximum value of the pulse. Using the linear regression equation, it is possible to predict the magnitude of the pulse at a given speed of movement.

Conclusions: It is possible to find out the individual characteristics of athletes with the help of an indicator of the effectiveness of the functioning of the cardiovascular system. One can compare the activity of the cardiovascular system of athletes of different qualifications, different age groups, gender, level of preparedness. The degree of realization of the functionality of cyclists is calculated by a special formula and serves to monitor the training and competitive process. The results of the studies make it possible to predict the result by evaluating the level of special physical preparation.

Keywords: cycling, pulse, control system, prognosis, success.

Introduction

The problem of testing athletes is one of the most urgent in modern sports and should be solved on the basis of achievements in physiology, biochemistry, biomechanics, pedagogy and other sciences [2, 3, 38, 39]. It is impossible to control the process of training athletes without objective criteria for assessing the level of special preparedness [8, 17, 25, 40]. The authors note the need to take into account the functional capabilities of the cardiovascular and respiratory systems of the body.

One of the most informative indicators of the functional state of the body of athletes (specializing in sports for endurance) is the level of maximum oxygen consumption [16, 36]. In studies of foreign authors found that the most informative indicators in assessing the functional readiness of athletes of high qualification is: the magnitude of the oxygen cost of one meter of the path at a standard speed [11, 37]; oxygen consumption level (Vo_2) at speed of movement 85-90% from the competitive; speed of movement along the threshold level of anaerobic exchange.

Hydren J.R. and Cohen B.S. showed the possibility of achieving maximum effectiveness in endurance exercises in highly qualified athletes [19]. Mueller S.M. et al. found that aerobic intensive interval training improves cardiovascular ability, but it can reduce the endurance of cycling [26]. Nakahara H. et al. examined the effects of intensive interval training at a frequency of once a week on cardio-respiratory function at rest and during exercise [27]. The authors found that intensive interval training markedly improves cardiorespiratory function and causes morphological adaptations of the heart.

In cycling the methods of modeling are used in various studies. Caddy O. et al. used computerized planimetry and compiled a reverse integration model to simulate a 4-kilometer distance [12]. The authors showed the possibility of a small and significant increase in productivity at a distance of 4 km. Childers W.L. et al. compiled a race model for 4 km using the Monte Carlo method [13]. The authors established a relationship between power losses and aerodynamic coefficients. Luth M.T. et al. used modeling techniques to study the relationship between passion, normative orientation and the satisfaction of qualified cyclists [24]. These data show that not all forms of passion are useful for classes. Data helps explain the relationship between passion and satisfaction.

Improving the performance of athletes requires: individual approaches to training [15], proper pedagogical control [14], selection of adequate tests [29], optimization of physical activities [28, 32], observance of rest and training regimes [31], accounting of the body's functional reserves [33], predicting the success of athletes [20, 30], the use of rehabilitation means and readaptation to work [34, 35].

Some researchers [22, 36] notice that during examining a homogeneous group of athletes using standard tests, the maximum oxygen consumption value has a low correlation with the athletic result. In their opinion, testing should be carried out in conditions that are as close as possible to those that are competitive in terms of the structure of the movement and the duration of the task. Under such conditions the factors that limit the availability of work will manifest.

The purpose of the study is to develop a system for monitoring the level of special preparedness of cyclists (specializing in individual race for 4 km) on the basis of indicators of the cardiorespiratory system.

Materials and methods

Participants. The study involved bicyclists (n=14, age 18-22 years). Athletes had sports qualification as

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a candidate for master of sports and master of sports. Athletes specialize in individual race at 4 km.

Organization of the study.

To determine the maximum functional opportunities of the cardiorespiratory system of the body of cyclists was used step-increasing load to the full. The cyclists performed work with a pedaling frequency of 90 revolutions per minute using the veloergometer "Monark". The load increased by 2,70 kGm / min. every 2 minutes [21-23]. At the same time an analysis of exhaled air was carried out on the automatic gas analyzer of the company "Beckman". The pulse rate was determined by the electrocardiographic method (electrocardiograph "Salut"). Prior to work and on the 3rd minute of recovery, was dipped blood sampling to determine the acid-base balance (pH).

To determine the level of cardiovascular system functioning, bicyclists participated in competition, where the pulse was recorded throughout the race using the Puls-6 radiotelemetric system.

To determine the dependence of the pedaling speed from the intensity of the functioning of the cardiovascular system, cyclists performed a special test program on the track in 5 pulse regimes (130, 150, 160, 170, 180 bpm, 4 km distance). The work with the constant value of the functioning of the cardiovascular system was simulated. The time of passage of each half of the circle (166,7 m) and the average speed over the entire distance were measured.

To maintain a certain heart rate in studies was used autocarillary ACL-75, which provided standard testing conditions for all athletes.

Statistical analysis. Average values of indicators and their errors (X±m), degree of difference of means and reliability of differences (t, p) were determined. The amount of dispersion was set – a variant around the mean (σ, CV). The degree of interrelation between the studied indicators (r) was determined.

In carrying out complex pedagogical, biomechanical and biological surveys with the participation of athletes adhered to the legislation of Ukraine on health protection, the Helsinki Declaration of 2000, directive No. 86/609 of the European Society on the participation of people in biomedical researches.

Results

At the carrying out step-increasing load to full, a bicycle ergometer obtained the data (Table 1). The data allow to judge individual characteristics of the activity of the cardiorespiratory system of the cyclists' body.

The values of the obtained indices testify to the maximum stress of the functioning of the examined systems of athletes' organism. The correlation relationship of studied parameters with the results in the individual race at 4 km is unreliable (with the exception of the pulse rate). Therefore, it is impossible to use these data to predict the sports result (Table 2).

Step-increasing load to full allows to determine the maximum functionality of the cyclists' body. The maximum value of the pulse in the test has a negative value of the correlation coefficient and the sports result (r_{tk}=–0,578, p<0.1). This indicates an inverse relationship between the studied indicators. Excessive increase in the pulse when performing work on a veloergometer indicates an ineffective activity of the cardiovascular system. To determine the level of functioning of the cardiovascular

Table 1. The indices of the maximum functional capabilities of the cardiorespiratory system of the organism of cyclists in step-increasing load to full

Parameters	Indices physiological				biochemical	
	MMV (l)	Vo_2 max (l)	Vo_2 (ml/кg)	f_h (bpm)	pH before the load	pH after the load
X	151,811	4,441	63,112	198,611	7,381	7,216
б	31,242	0,539	6,941	2,760	0,012	0,076
m	11,811	0,204	2,620	1,040	0,005	0,029

Notes: MMV – maximum pulmonary ventilation (l); Vo2 max – maximum consumption of oxygen (l); Vo2 – oxygen consumption (ml/kg); fh – pulse (bpm)

Table 2. Coefficients of correlation between the investigated parameters of the cardiorespiratory system of the body of athletes and the result in the race for 4 km

Investigated parameters	Vo_2 max, (l/min)	Vo_2 (ml/кg/min)	f_h, (bpm)	pH
Speed in race, (m/s)	0,320 unreliable	0,390 unreliable	- 0,578 p<0,1	0,442 unreliable

Notes: Vo2 max – maximum oxygen consumption (l / min); Vo2 – oxygen consumption (ml / kg / min); fh – pulse (bpm); p – level of significance of the correlation coefficient

system of cyclists in conditions of competitive activity, the pulse rate was used during the individual pursuit race at 4 km (Table 3).

Three indicators are calculated that characterize the intensity of the functioning of the cardiovascular system.

1. The average distance of the pulse is 184,9 beats per minute: characterizes the level of functioning of the cardiovascular system of cyclists in the race for 4 km. This value has a negative relationship with the result in the race. The correlation coefficient is equal to r_{tk}=−0,440.

2. The value of the pulse at the 1st minute of the work reflects the speed of the cardiovascular system and the entire organism as a whole. It is to the 40-60th second of the work that anaerobic and aerobic energy supply mechanisms are fully activated. In our study, the pulse at the 1st minute of work was 172.1 ± 8.7 bpm.

3. The maximum pulse value reflects the maximum level of functioning of the cardiovascular system. The maximum pulse value is 192±5.29 bpm: correlates (r_{tk} =0.78, p <0.1) with the maximum pulse value that was obtained in the bicycle ergometer test in the laboratory. The maximum pulse value has a negative correlation coefficient with the result in the race (r_{tk} =-0,515; p <0.1).

The coefficient of efficiency of the functioning of the cardiovascular system (CE_p) is equal to the ratio of the average distance value of the pulse ($f_{h\Delta}$) to the maximum value of the pulse ($f_{h\,max}$):

$$CE_p = (f_{h\Delta}/f_{h\,max}) \text{ x } 100\%,$$

$$CE_p = (184,9/\ 192,0) \text{ x } 100\% = 96,3\%.$$

The lower the value of the efficiency factor, the more effectively the cardiovascular system of athletes works. This indicator (CE_p) will be more informative if it is calculated taking into account the average speed. Using the indicator CE_p, it is possible to compare the activity of the cardiovascular system of athletes of different qualifications, different age groups, gender, and level of preparedness. This allows to find out the individual characteristics of athletes.

The level of functioning of the cardiovascular system of cyclists in the race (according to the pulse rate for the 1st minute and the maximum pulse) is close to the limiting level (as in the laboratory). After the period of operation (60-90 s), the pulse curve is practically maintained at the same level – 182,34-189,4 bpm. In this case, there is an insignificant increase in the pulse at the finish: 192,0±5,3 bpm. The dynamics of the speed of movement is more variable. After the initial acceleration on the 30th s the speed reaches 13,47 m/s. Then the speed gradually decreases to 12 m/s and again increases at the end of the 5th minute (11,95 m/s).

The high informativeness and reliability of the pulse rate in the race was used as a basis for the methodology for assessing the level of special functional readiness of cyclists. The obtained data (Table 4) made it possible to determine the dependence of the speed of movement on the intensity of the cardiovascular system during the passage of a distance of 4 km.

The curved line of change in the speed of movement of cyclists, depending on the level of the pulse, can be described by the equation of linear regression of the type $y=a+bX$. For our study, the equation looks like this:

$$V = 0,0536X + 2,354, \qquad \text{(I)}$$

where V – the speed of movement (m/s)

X – the value of the programmable pulse in bpm.

The coefficients ***a*** and **b** in the equation are 2,.354 and 0,0536.

Equation (I) allows analytically determine the speed of movement, depending on the selected heart rate. The linear regression equation looks like this:

$$f_h = 17,883X - 35,480, \qquad \text{(II)}$$

Table 3. Change in the value of the pulse (fh) of cyclists during an individual pursuit race at 4 km

Parameters	Time of race, (s)							
	15	30	60	90	120	180	240	300
X	134,5	159,2	172,1	182,3	184,0	187,1	189,4	192,0
б	12,7	9,8	8,8	7,4	6,8	6,2	5,5	5,3
m	4,9	3,7	3,3	2,8	2,6	2,3	2,1	2,0

Table 4. Change in the speed of the distance 4 km, depending on the pulse

Indices	Parameters	Pulse regimes of work (bpm)				
		130	150	160	170	180
An average speed in the test, (m/s)	*X*	9,136	10,497	11,177	11,550	11,733
	б	0,281	0,162	0,163	0,096	0,104
	m	0,106	0,061	0,062	0,036	0,039
PS, (bpm)	–	0,237	0,238	0,239	0,245	0,253

Note: f_h – pulse (bpm)

where X – the specified speed of movement (m/s).

The coefficients ***a*** and ***b*** in the equation are 35,480 and 17,883.

Using the linear regression equation, it is possible to predict the magnitude of the pulse at a given speed of movement. The disadvantage of this method is to maintain one of the selected parameters (pulse or speed) at a constant level.

In this study, we determined the relationship between the speed of movement at different heart rates (tests V_{130}, V_{150}, V_{160}, V_{170} и V_{180}) and the results that were shown by cyclists in the individual pursuit race at 4 km. In the tests modes of load on the pulse were in the range of various power supply mechanisms.

The speed of cycling in the tests V_{130}, V_{150} and V_{160} is not reliably linked to the results that were shown in the pursuit race at 4 km (Table 5). In these tests, the body of athletes operates in a moderate and high-power zone (approaching the threshold of anaerobic exchange). The result in the race depends not only on aerobic performance. The result in the race is determined by anaerobic performance. This is taken into account by the work itself in the tests V_{170} and V_{180}. Tests have a high reliable relationship (r_{tk}=0,670; p<0,1 and r_{tk}=747; p<0,1). This allows them to be used in assessing the level of special preparedness of cyclists.

The obtained data (the correlation between the speed in the race and the speed in the tests V_{170} and V_{180}) can be described by the linear regression equation:

$$V_{170}=766X+3,616, \quad \text{(III)}$$

$$V_{180}= 1,471X - 4,796, \quad \text{(IV)}$$

where V – the predicted speed in the race (m/s),

A – the speed of movement in the tests V_{170} and V_{180} (m/s).

The coefficients ***a*** and ***b*** in the equation are as follow 4,796 and 1,471.

Equations III and IV allow to predict the result in the race and perform an analysis of the degree of realization of the functional capabilities of the organism, depending on the shown result. The degree of implementation of the functionality is understood as the ratio of the displayed speed in the race (V_t) to the predicted speed for the selected test V_{170} and V_{180}.

Lets consider this on the following example: rider *A* (P-us) in the test V_{180} developed a speed of 11,645 m/s. On the basis of equation III, the speed in the race must be 12,33 m/s (V_d=1,471x11,645−4,796). In reality, athlete *A* showed in the race speed of 12,49 m/s. Hence the degree of implementation of the functionality is:

$$SR = (V_t / V_d) \text{ x } 100\%,$$

where V_t – the real speed in the race (m/s),

V_d – predicted speed in the race (m/s).

For the rider A (P-us), the degree of realization of the functional capabilities (*SR*=12,49:12,33)x100%=101,3. This figure is higher than the average for the group. For the rider *B* (Sh-ko): in the test V_{180}, the speed of movement is 11,634 m/s; the speed in the race according to equation IV must be 12,32 m/s. Really, the athlete showed 12,16 m/s. Consequently, the degree of realization of its functional capabilities (*SR*=12,16:12,32)x100% is 98,7%. Athlete B (Sh-ko) has not realized its potential functionality.

Discussion

The data obtained by us coordinate with the results of studies of the cardiorespiratory system of cyclists by other investigators [4, 25, 37]. In the experiments [11, 17], the obtained data indicated a low efficiency of the cardiovascular system. This is due to the increase in the pulse when doing work on a veloergometer. It is known that the magnitude of the pulse reflects not only the adaptation of the human body to the load [6, 7]. Pulse is an important indicator of the cardiovascular system. The pulse affects the amount of minute blood volume. According to the data of [7], the magnitude of the minute volume of blood is mainly increased due to the increase in the pulse rate.

Beattie K. et. al. investigated the effect of a 20-week maximum and explosion-force training effect on explosive force, VO (2) max, body composition of cyclists [9]. The study demonstrates that 20 weeks of such training can significantly improve the maximum strength, the specific explosive force of a bicycle and the maximum oxygen consumption of cyclists. Borges N.R. et. al. studied autonomic cardiovascular modulation in well-trained masters and young cyclists after a high-intensity interval training [10]. The authors found that the physical training of qualified athletes has a significant effect on the autonomous function. These data are confirmed by our research.

The data obtained by us are confirmed in the works of other researchers, who also simulated various versions of the distribution of the athletes' efforts in an individual

Table 5. Correlation of the speed of movement of cyclists in the tests and results in the individual pursuit race at 4 km

Indices	The speed of movement in the test (m/s)				
	130	150	160	170	180
The size of correlation coefficient (r_{tk})	0,390 unreliable	0,420 unreliable	0,510 unreliable	0,670 p<0,1	0,747 p<0,1

Note: *p* – level of significance

pursuit race at 4 km [1]. A similar character of the dynamics of the pulse and the power of pedaling was obtained earlier [2]. The authors modeled the speed for individual pursuit at 4 km on a bicycle ergometer for cyclists of different age groups. Hittinger E.A. et. al. determined the effect of the MOC (maximum oxygen consumption) on peak loads, submaximal and peak cardiovascular hemodynamics, and the saturation of peripheral capillary oxygen under simulated conditions in experienced cyclists [18]. The authors found that ischemic pre-conditioning can improve blood flow and oxygen delivery to tissues (including skeletal muscles) and has the potential to improve intense aerobic exercise.

However, the predicted result in the race according to equation (IV) based on the test V_{180} reflects only the contribution of the functional readiness of cyclists. This result does not take into account the influence:

- moral-strong-willed qualities and mental properties of personality [5];
- the level of tactical preparedness [2].

Conclusions

1. Using the indicator CE_p, it is possible to compare the activity of the cardiovascular system of athletes of different qualifications, different age groups, gender, and level of preparedness. This allows to find out the individual characteristics of athletes.

2. The degree of realization of the functionality of cyclists is calculated by a special formula. The formula serves to control the training and competitive process.

3. The results of the research allow to predict the result by evaluating the level of special physical training.

Conflict of interest

The authors state that there is no conflict of interest.

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Relationship of psychophysiological characteristics with different levels of motivation in judo athletes of high qualification

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Abstract

Purpose: to study the connection of psychophysiological characteristics with different levels of motivation in judo athletes of high qualification.

Material: highly qualified athletes were examined, members of the National Judo Team (men). All athletes (n = 25) were divided into three groups, depending on the level of motivation to achieve success.

Results: it is established that the high level of motivation for achieving success in judo is provided by activation of neurodynamic, cognitive functions and the level of light resistance. Athletes with a high level of motivation to achieve success is observed the predominance of the values of neurodynamic functions: endurance of the nervous system; speed of visual reactions. Athletes with an average level of motivation to achieve success identified higher values: productivity, speed, accuracy, effectiveness of verbal information. Athletes with a predominance of avoidance of failure motivation have a preference for other groups in the speed, efficiency and stability of the processes of thinking and processing information.

Conclusions: judo athletes with a predominance of motivation to avoid a failure form coping strategy to prevent psycho-emotional stress. This helps to minimize the exhaustion of vegetative resources in conditions of extreme sports activity. Judo athletes with high level of motivation to achieve success, the presence of mental state of relative comfort is associated with the search for support among others and orientation toward internal beliefs.

Keywords: psychophysiological, achievement motivation, judo athletes, neurodynamic, cognitive.

Introduction

Numerous studies indicate the presence of external factors affecting the effectiveness of sports activities in extreme conditions. These allowed determining basic, psychophysiological and neurodynamic properties of the athlete. These include individual psycho-physiological features and criteria for professional fitness, which determine differentiated approach to selection and orientation in sports [1, 2]. Such are the properties of higher nervous activity: strength, mobility and balance of nervous processes. Psychophysiological characteristics (as derivatives of the properties of higher nervous activity) are generally considered to be the basis of human abilities and components of the individual style of activity [3]. In the judgment of Teplov B.M., only a combination of different abilities characterize this person [4].

The properties of the nervous system are manifested not so much in productive as in the procedural characteristics of activity. The procedural characteristics of the activity are largely determined by the individual-typological properties of the individual [5].

Merlin V.S. was developed the theory of integral individuality. The connections between the multilevel properties of individuality vary depending on what actions, operations and intermediate goals the person chooses to accomplish the tasks. Stable individual systems of goals, actions and operations in the objective activity are designated as an individual style of human activity [6]. The style of activity is formed depending on the role of various factors: turn for work in different modes; the ratio of general and special abilities; typological properties; anthropometric data; morphological features [7]. However, the formation of individual strategies in sports occurs against the background of the corresponding achievement motivation [8].

Achievement motivation is one of the most essential properties of personality [9]. The question of the relationship of individual psychological characteristics with the processes of motivation has a particular importance [10]. The motive of achievement is one of the leading motives of the subject of sports activity. The motif is ambiguously associated with individual typological characteristics. The motive of achievement forms statistically significant positive relationship with the indicators: orientation to a certain activity; adaptability to external conditions; combinatorial thinking; spatial imagination. Motive of achievement forms statistically significant negative correlation with the indicators of: anxiety, emotional instability [11].

Just under the testing of the motor abilities it is impossible to obtain complete information about the athlete's readiness for the competition. In competitive conditions, the physical qualities and sides of preparedness are not manifested in isolation, but in a complex relationship [12].

The motivation of achievement, in modern combats,

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is important for psychological and tactical training [13]. In the conditions of competitive activity the realization of the motivational program largely depends on the athlete's ability to adequate perception and organization of external information [14].

The aim of the work is to study the connection of psychophysiological characteristics with different levels of motivation for attaining high qualification in judo athletes.

Materials and methods

Participants. Highly qualified athletes, members of the National Judo Team (men) were examined. All athletes (n = 25) were divided into three groups, depending on the level of motivation to achieve success (according to Mehrabian A. [15]). The first group is athletes with a high level of motivation to achieve success (n = 9). The second group is athletes with an average and above average levels of motivation to achieve success (n = 10). The third group is athletes with low and below average levels of motivation to achieve success (n = 6).

The design of the research.

The motivation for achievement was based on a questionnaire test (Mehrabian A. [15]), adapted by Shapkin S.A. [16]. The test is intended to diagnose two generalized motives of the individual – the motive for success and the motive for avoiding failure. At the same time, the prevalence of one or another motive is evaluated. The test is built on the basis of the theory of achievement motivation by J. Atkinson. The test is a questionnaire, the design of which uses factor analysis. Factor analysis has two forms – male and female. The male form includes 32 points, the female – 30. The degree of agreement with the statement can range from a complete denial to full acceptance. High test scores indicate a predominance of motivation for success. Low test scores indicate a predominance of avoidance of failure.

Neurodynamic, psychomotor and cognitive characteristics of judo athletes were examined for study the connection of psychophysiological characteristics with different levels of motivation [3, 5].

Neurodynamic and psychomotor characteristics have been studied with the help of the following techniques: tapping test (endurance of the nervous system), reaction to a moving object (balance of nervous processes), functional mobility of nervous processes and time of a simple sensorimotor reaction.

The study of cognitive functions included: evaluation of perceptual velocity, methods of comparing numbers, memory for words and establishing patterns.

Statistical analysis. Processing of findings was carried out with the help of computer packages of applied programs "Statistica 6.0". It is established that the studied indicators are not amenable to the law of normal distribution. Therefore, to determine the statistical differences between the samples, the criterion for signed Wilcoxon rank sums was used. To demonstrate the distribution of data were used the interquartile range, the first (25%) and the third (75%) quartiles.

Results

Table 1 presents the average values of neurodynamic and psychomotor indicators.

Analysis of the results of the tapping test shows that there are significant differences between the first and second groups of athletes in terms of endurance, stability and porosity. At the same time, the indices of endurance and stability are significantly higher in judo athletes of the second group. The values of the duty cycle are significantly higher in athletes of the first group (Table 1).

Under the comparison of the values of the first and third groups of athletes in terms of the level of achievement motivation, significant differences in indices of endurance, frequency of contact and stability were established (Table 1). In this case, the values of the endurance index are higher for athletes of the first group. The values of the frequency of touch and stability are higher for athletes of the third group (Table 1).

The stability index in the conditions of tapping test is characterized by the level of variability (coefficient of variation). The smaller the coefficient of variation, the higher the stability index of taping test.

The features of cognitive functions in judo have been studied with the help of the technique "Perceptual speed", "Comparison of numbers", "Memory for words" and "Establishment of regularities".

Table 2 represents the average values of cognitive functions in athletes with different levels of motivation to achieve success.

The analysis of the parameters of the method "Perceptual speed" indicates a significant difference in accuracy between athletes of all three groups. Higher level of values is observed in athletes of the second group – with an average and above average levels of motivation to achieve success.

According to the efficiency index – significantly high values for judo athletes of the second group were determined. In terms of productivity and speed, there are no significant differences (Table 2).

The values of the indicators of the method "Comparison of numbers" indicate the presence of significant differences between the first and second groups of athletes in all respects: efficiency, latency of reaction, accuracy and stability. At the same time, higher level of values for all these indicators is determined by athletes in the second group – athletes with an average and above average levels of motivation to achieve success. This indicates higher level of development in athletes of this group: operative visual memory and counting intelligence; high speed of analysis and processing of information when making decisions; stability of performing actions; higher level of concentration and stability of attention (Table 2).

There are also significant differences between the first and third groups of athletes in terms of performance such as: effectiveness, reaction latency and stability. Moreover, higher level of values of these indicators is determined in judo athletes of the third group – athletes with low and below average levels of motivation to achieve success (Table 2).

Table 1. Neurodynamic and psychomotor characteristics of high qualification judo athletes with different levels of motivation (median, lower quartile, upper quartile)

Indicators	High level of motivation to achieve a success, first group (n=9)	Average level of motivation to achieve a success, second group (n=10)	Motivation to avoid a failure, third group (n=6)
Tapping test			
Tolerance, standard unit	(-1,47); (-1,68); (-0,24)	(-1,27)*; (-2,33); (-1,23)	(-1,63)***; (-2,21); (-1,23)
Touch frequency, quantity	5,98; 5,50;6,21	5,94; 5,50;6,05	6,03; 5,48;6,63
Stability, %	13,20; 9,04;16,21	8,96*; 7,67;14,48	9,93***; 8,85;10,16
Off-duty factor, standard unit	3,32; 3,00;3,81	3,66*; 3,29;4,49	3,88**; 3,05;4,08
Balance of nervous process			
Accuracy, standard unit	2,83; 2,67;3,22	2,73*; 2,45;3,12	2,62***; 1,89;3,15
Stability, standard unit	3,70; 2,91;4,10	3,30; 3,22;4,30	3,35***; 2,69;3,83
Excitation, standard unit	(-0,82); (-1,78); (-0,22)	(-0,54)*; (-1,28); (-0,01)	0,09; (-1,09);0,69
Functional mobility of nervous processes (FMNP)			
Dynamism, standard unit	70,40; 60,57;79,12	70,00; 66,00;75,85	82,52;*** 74,72;85,47
Capacity, standard unit	1,76; 1,64;1,84	1,81*; 1,57;1,92	1,88;*** 1,77;2,00
Full speed of information organization, ms	380,00; 350,00;410,00	350,00; 320,00;410,00	350,00; 290,00;380,00
Impulsion, standard unit	(-0,06); (-0,13);0,07	(-0,01); (-0,19);0,09	0,01; (-0,02);0,18
Sensomotor reaction (SMR)			
Latency period of reaction, ms	260,00; 258,67;274,77	281,60*; 248,40;316,03	263,28***; 253,00;270,77
Stability, %	16,76; 13,70;22,11	13,46; 10,71;16,06	17,39; 12,08;21,13

Notes: * -p <0.05, in comparison with athletes with a high level of motivation to achieve success; ** - p <0.05, in comparison with athletes with an average and above average levels of motivation to achieve success.

A significantly high level of efficacy and latency of the reaction was revealed in athletes of the third group (Table 2). The lower values of the latency index of the reaction in judo athletes of the third group testify to the high speed of analysis and processing of information when making a decision.

The average values of the indicators of the method "Memory for words" indicate the presence of significant differences only in terms of the speed between the judo athletes of the second and third groups. Moreover, higher values in the third group of judo athletes are athletes with low and below average levels of motivation to achieve success. This determines in athletes of this group higher level of visual short-term memory for verbal information (Table 2).

Analysis of the values of the indicators of the method "Establishment of regularities" indicates the presence of significant differences in performance and speed between the first and second groups of athletes. Above the level of values in the second group – athletes with an average and above average levels of motivation to achieve success (Table 2). This indicates higher level: ingenuity; ability to perceive and re-encode information; attention and memory; speed formation of skills and skills required for non-standard ways of processing information. Also, reliable differences in terms of productivity, accuracy and efficiency were determined. Higher level of values is observed in athletes of the first group. According to the speed indicator, there is a tendency to the reliability of differences between the athletes of the first and third groups. According to the efficiency index, there is a tendency to the reliability of the differences between the

Table 2. Cognitive functions of high qualification judo athletes with different levels of motivation (median, lower quartile, upper quartile)

Indicators	High level of motivation to achieve a success, first group (n=9)	Average level of motivation to achieve a success, second group (n=10)	Motivation to avoid a failure, third group (n=6)
Perceptual speed			
Productivity, standard unit	58,00; 51,00; 72,00	60,50; 51,00; 71,00	68,00; 54,00; 73,00
Speed, standard unit	17,00; 14,24; 19,25	16,13; 13,50; 18,75	18,50; 16,50; 19,25
Accuracy, standard unit	0,93; 0,90; 0,99	0,97*; 0,90; 0,98	0,93**; 0,70; 0,97
Effectiveness, standard unit	40,03; 38,86; 54,74	46,00*; 41,41; 57,24	54,00; 27,08; 60,83
Congruence of numbers			
Effectiveness, standard unit	1457,65; 976,55; 1709,10	959,27*; 917,93; 1125,80	836,72***; 811,03; 875,83
Latency period of reaction, ms	1365,60; 953,11; 1634,15	919,78*; 886,24; 1081,80	836,71***; 792,02; 865,97
Accuracy, standard unit	0,96; 0,92; 0,97	0,96*; 0,95; 0,98	0,97; 0,95; 0,98
Stability, %	34,14; 27,32; 40,30	26,07*; 22,47; 29,72	21,71*; 20,90; 24,09
Memory for words			
Productivity, standard unit	19,00; 17,00; 21,00	20,50; 18,00; 22,00	21,00; 19,00; 26,00
Speed, standard unit	10,90; 6,50; 12,48	9,55; 8,78; 12,20	15,71**; 11,08; 17,23
Accuracy, standard unit	0,65; 0,60; 0,70	0,70; 0,60; 0,73	0,70; 0,63; 0,87
Effectiveness, standard unit	34,31; 30,00; 43,75	42,28; 30,00; 48,89	43,89; 34,31; 72,22
Establishment of regularities			
Productivity, standard unit	19,00; 17,00; 23,00	20,50*; 15,00; 22,00	19,00***; 18,00; 22,00
Speed, standard unit	3,83; 3,40; 4,79	4,66*; 3,50; 5,09	4,48;*** 4,31; 6,46
Accuracy, m	0,92; 0,80; 0,98	0,89; 0,60; 0,95	0,84***; 0,72; 0,88
Effectiveness, standard unit	76,00; 50,66; 82,80	71,00т; 30,00; 82,80	61,50***; 46,80; 74,80

Notes: * -p <0.05, in comparison with athletes with a high level of motivation to achieve success; ** - p <0.05, in comparison with athletes with an average and above average levels of motivation to achieve success.

first and second groups.

Features of the mental state of athletes were assessed using the methods "Stress Test" and the "Luscher color test".

The average values of the indicators according to these methods are presented in Table 3.

The average values of the indicators of the "Luscher color test" showed that significant differences were noted between the first and second groups in terms of performance: fatigue, deviation from autogenous norm, heteronomy and autonomy. There is a tendency to reliability of differences in the indicators of anxiety and eccentricity.

Also, reliable differences between the first and third groups were determined for the indicators: concentricity and heteronomy. Reliable differences between the second and third groups in terms of the deviations from the autogenous norm and concentricity were determined (Table 3).

The values of the fatigue index in the first group of

athletes are lower than in the second group. This is the best indicator. The remaining indicators show an average level.

The analysis of the indicators of the "Stress test" testifies to significant differences in the stress-resistance index between the first and third groups. Higher rates are observed in the first group, with a high level of motivation to achieve success. In terms of throughput, there are higher rates: between the first and third group; between the second and third group. Higher rates are observed in athletes of the third group – judo athletes with low and below average levels of motivation to achieve success (Table 3).

In judo athletes of the first group (performance of strenuous activity) the obtained data testify to: higher resistance to the action of aversive (irritating) stimuli; high ability to maintain the maximum level of efficiency. Athletes of the third group (performing combined monitoring and discrete control actions) determine: higher level of distribution of visual attention between dynamic objects; higher processing speed of continuously incoming non-verbal information; higher level of coordination of movements (Table 3).

By the index of impulsivity, reliable differences between the first and second groups are determined. The lower rates were revealed in the athletes of the first group – athletes with a high level of motivation to achieve success (Table 3).

Discussion

Thus, a high level of motivation to achieve success in athletes is provided by the activation of neurodynamic, cognitive functions and the level of light resistance. In athletes with high level of motivation to achieve success, the values of neurodynamic functions predominate: endurance of the nervous system and speed of visual reactions. This circumstance as a whole reflects the general trend in the formation of motivation in combats [3, 17].

At athletes with an average level of motivation to

Table 3. The mental state of high qualification judo athletes with different levels of motivation (median, lower quartile, upper quartile)

Indicators	High level of motivation to achieve a success, first group (n=9)	Average level of motivation to achieve a success, second group (n=10)	Motivation to avoid a failure, third group (n=6)
Luscher color test (LCT)			
Efficiency, standard unit	12,00; 11,00; 12,00	8,00*; 7,00; 11,00	11,00; 10,00; 12,00
Tiredness, standard unit	2,00; 1,00; 2,00	3,00*; 1,00; 4,00	3,00; 0,00; 5,00
Anxiety, standard unit	0,00; 0,00; 1,00	2,00т; 1,00; 3,00	1,00; 0,00; 5,00
Autogenous norm deviation, standard unit	12,00; 10,00; 16,00	16,00*; 12,00; 16,00	14,00**; 8,00; 16,00
Eccentricity, standard unit	10,00; 8,00; 11,00	8,00т; 6,00; 9,00	11,00; 8,00; 12,00
Concentricity, standard unit	9,00; 8,00; 10,00	8,50; 6,00; 10,00	5,50***; 4,00; 9,00
Vegetative coefficient, standard unit	13,00; 10,00; 16,00	15,00; 13,00; 19,00	16,00; 12,00; 26,00
Heteronomy, m	7,00; 7,00; 10,00	6,00*; 4,00; 7,00	7,00*; 6,00; 8,00
Autonomy, standard unit	10,00; 9,00; 11,00	11,00*; 9,00; 12,00	10,50; 9,00; 12,00
Stress test			
Stress tolerance, standard unit	95,09; 86,47; 114,94	94,38; 88,28; 104,12	91,87*; 81,98; 102,11
Capacity, standard unit	1,09; 0,95; 1,23	1,15; 1,08; 1,23	1,28***; 1,19; 1,40
Abando, standard unit	(-0,07); (-0,11); (-0,03)	(-0,04)*; (-0,09); (-0,03)	(-0,06); (-0,10); (-0,03)

Notes: * -p <0.05, in comparison with athletes with a high level of motivation to achieve success; ** - p <0.05, in comparison with athletes with an average and above average levels of motivation to achieve success

success, significantly higher values of neurodynamic parameters are revealed: endurance and stability of the nervous system; balance of nervous processes; throughput of the visual analyzer. In judo athletes with the predominance of motivation to avoid failure, significant differences are revealed by some neurodynamic indicators: the frequency of touching; duty cycle in tapping test conditions; accuracy of the balance of nervous processes. This circumstance indicates a special coping strategy in conditions of psycho-emotional tension in judo [18].

In athletes with high level of motivation to achieve success, prevail the following values of cognitive functions: accuracy and effectiveness of verbal perception. In judo athletes with an average level of motivation to achieve success, the accuracy and effectiveness of nonverbal perception is significantly higher compared to a group of athletes of high level of achievement motivation.

Athletes with an average level of motivation to achieve success identified higher values: productivity; speed, accuracy and effectiveness of verbal information. Athletes with a predominance of motivation to avoid a failure have preference for other groups in the speed, efficiency and stability of the processes of thinking and processing information.

Thus, the thesis about the optimality of motivation of the failure avoidance (the coping strategy) is partially confirmed. Such strategy makes it possible to minimize exhaustion of vegetative resources in conditions of extreme sports activity [19, 20].

The mental state of judo has its own characteristics. Mental efficiency is significantly higher in the group of athletes with a predominance of motivation to achieve success in comparison with a group of judo athletes of average level of motivation. It is revealed that in this group of judo athletes the state of relative comfort is associated with the search for support among others and orientation toward internal beliefs [21].

Athletes with average levels of motivation to achieve success and avoid a failure are significantly lower than the indicator of overall mental performance and discomfort in comparison with other groups.

Athletes with high level of motivation to achieve success revealed high stress resistance. The speed of response to stress factors is greatest in a group of athletes with a motivation to avoid failure. The impulsiveness index (not preparedness of actions and the assumption of errors) is significantly higher in the group of athletes with an average level of motivation.

The result is consistent with the early studies. It was found that achieving a certain level of stress resistance is achieved due to the tension of vegetative regulation [22].

Conclusions

1. High level of motivation to achieve success in judo athletes of high qualification is provided by activation of neurodynamic, cognitive functions and level of light resistance.
2. Judo athletes with predominance of motivation to avoid a failure form a coping strategy to prevent psycho-emotional stress. Such strategy helps to minimize the exhaustion of vegetative resources in conditions of extreme sports activity.
3. The presence of mental state relatively to comfort in judo athletes of high level of motivation to achieve success involves the search for support among others and orientation toward internal beliefs.
4. Judo athletes with high level of motivation to achieve success revealed increased stress resistance. In the group of athletes with the presence of motivation to avoid failure established the best response to stress factors.

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Conflict of interest.

The authors state that there is no conflict of interest.

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Cardiovascular and Energy Requirements of Parents Watching Their Child Compete: A Pilot Mixed-Methods Investigation

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Abstract

Purpose: Researchers have extensively documented the cardiovascular and metabolic demands for sports participation. To date, researchers have ignored the same requirements of competitor's parents. Hence, our purpose was to document parent cardiovascular and metabolic responses to watching their child compete while also paying particular attention to their thoughts before and after the competition. Achievement Goal Theory (AGT) drove interpretation of parent thoughts.

Material: Parents wore a device, made by Firstbeat Technologies, which continuously monitored heart rate. The parents wore the device the night before the competition to be acclimated to the technology and during the event until later in the day. Parents also completed two open-ended questions, one before the tournament and one after the contest.

Results: Before the contest, the dad expected that his son won the event (Croatian National Championships for juniors). Conversely, the mother's expectations centered more on her son's enjoyment and competing to the best of his abilities. Parents had differing cardiovascular and energy requirement responses to watching their son compete. In addition, post-competition reflections differed as the father expressed disappointment whereas the mother expressed sadness.

Conclusions: The data presented are unique and a first in the sports literature. The parents varied in the intensity of their cardiovascular responses and calories burned while watching their son compete. The father's cardiovascular response over the course of watching was that of an aerobic workout. Whether this pattern is unique or universal are a critical research question. Last, AGT appears relevant when assessing the parent's expectations.

Keywords: achievement goal theory, qualitative research, heart rate monitoring, youth sport.

Introduction

Researchers have extensively documented the physiological demands of competitive sports participation. Sports scientists have been able to increase documentation with the advent and continual upgrading of wearable technologies. For instance, these sports scientists have documented the physiological responses of athletes competing in team sports such as handball [1], and soccer [2]. Likewise, they have published on the physiological requirements in individual sports such as judo [3], table tennis [4], and hard and clay surface tennis [5]. Researchers have even examined the physiological responses of top-level European basketball referees [6]. From this body of literature, sports scientists researched and provided training programs that best prepare athletes and referees for the physiological demands of many sports.

Though indeed, the athletes and referees' physiological states are most important for bettering training with the goal of performance enhancement as well as injury prevention, there are others involved in the competitive process, namely spectators. Indeed, in youth sport, the spectators relate to the youth participants – namely parents. Researchers have reported that parents serve a vital role in athlete development [7], a source of youth enjoyment [8-10], and express a broad range of verbal reactions during sporting contests [11-12]. Given the importance of parents to the youth sports experience, it is surprising that researchers have not examined the physiological responses and thus demands of spectating their children.

In addition to uniquely measuring parent physiology while watching their child compete, we sought to gain insight into their expectations and reactions to their child's participation in this prestigious event. For decades, researchers have examined the dichotomous and contemporary variants of Achievement Goal Theory (AGT) in competitive sport. Large-scale meta-analyses on perceived goal orientation climate [13] and the individual orientation perspectives [14-17] exist. AGT helps in describing, explaining, and predicting behavior, thoughts, and emotions in the competitive sports environment. The key to this investigation is the tie between AGT and physiological reactions as documented recently [18].

From the dichotomous perspective, the two dominant climates and individual orientations are task or mastery and ego or performance. Improvement motivates individuals endorsing or supporting a task or mastery orientation. Conversely, an ego-oriented person or climate strives to win and is motivated to attain high normative standards of ability. Meta-analytic of the dichotomous AGT framework from the climate [13] and individual [17] are consistent in that the task orientation is consistently small to moderate in meaningfulness correlated with intrinsic motivation, positive emotions, and such desired achievement context variables. The ego orientation or climate is routinely viewed less favorably in youth sports context is in reality consistently unrelated or at best

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modestly related to undesirable achievement correlates (i.e., negative emotions). Hogue and colleagues [18] experimentally demonstrated that ego-involving climates caused heightened salivary cortisol response in middle school children. They interpreted salivary cortisol as indicating higher stress because of the ego environment.

When thinking of actual sports performance, only Lochbaum and Gottardy [15] have summarized the AGT literature and sports performance. Their quantitative review concerned Elliot's [19-20] approach-avoidance framework. While the dichotomous task and ego distinction relate to how competence is defined, the approach-avoidance dimension relates to how competence is valenced. An approach valence indicates a behavior initiated by a positive or desirable event or possibility such as excited to improve (mastery-approach goal) or win (performance-approach goal). In contrast, an avoidance valence indicates a behavior initiated by an adverse or undesirable event or possibility such as hoping to avoid getting worse (mastery-avoidance goal) or getting beat (performance-avoidance goal).

Results based on Lochbaum and Gottardy [15] random effects model indicated that the performance goal contrast (i.e., being more excited to win than hoping to avoid losing) had the most substantial facilitative impact on performance (effect size of .73) followed by the mastery and performance-approach goals. Both of the avoidance goals performance and mastery had small non-significant and detrimental effects on performance. Thus, it is possible that performers perceive a performance or an ego climate as stressful though also beneficial to the real outcome. Indeed, in youth sports, parents are key players in creating climate perceptions.

Purpose, materials, and methods

Our purpose was to document the physiological state of parents watching their child participate in a highly competitive environment, the Croatian National Championship while trying to gain insight into the parents' expectations and reaction to their child's experience. Based on the AGT framework, the literature base, and the competitive environment, parent expectations and responses to their son's competitive experience were *a prior* interpreted within an AGT context. We expected a higher expectation of winning to be associated with a heightened physiological response.

Two parents, a mother, and father of the same adolescent were the participants in this pilot investigation. The mother at the time of the data collection was 41 years of age and 158 cm tall, 60 kg in body weight. The father was 44 years of age and 175 cm tall, 78 kg in body weight. Both parents self-reported being moderately physically active and supportive of their son's National Team aspirations.

Parents self-reported their year of birth, height, and weight. To measure the physiological processes involved in spectating, both parents wore the Firstbeat Technologies Bodyguard 2 device (https://www.firstbeat.com/en/wellness-services/individual-wellbeing/). The Bodyguard 2 records heart rate at 1 ms intervals (1000 Hz) at a sampling rate of 12.5 Hz. The Bodyguard 2 measured the participants' R-R intervals. The Firstbeat analytics allow for calculation of oxygen consumption and energy expenditure that were important for this investigation. In addition, the device is sensitive to movement data (i.e., steps). The company designed the Bodyguard 2 for long-term uninterrupted measurements with a 20-day storage capacity with only little needs for recharging. The participants as would anyone wearing the device attached it to their skin with two chest electrodes.

To gain a better understanding of the physiological responses, both parents completed two open-ended questions. The first question concerned their expectations for the day. Specifically, the question was "Please give a short description of your expectations regarding today's competition." Parents answered this question 2 hours before their son's first judo fight. The second question concerned a retrospective report on the entire competition. The exact question was "Please describe your day, give us some thoughts about today's competition, and describe how you felt during today's competition." The parents completed this second open-ended question 4 hours after their son's last fight.

The article's second author purposefully approached the two parents as potential participants. The second author knew that their son would be competing at a National Championship event. Given the son's competition history, the second author anticipated that he would have many fights and that the parents would be engaged (i.e., attending the competition). The son competed in five judo fights (won, lost, won, won, lost) from 9:38 am until 12:20 pm. The last fight was a bronze medal fight, which he lost and thus finished fifth. The second and third author obtained University of Zagreb human subject approval. Both parents consented to participate. The second author provided each parent with a Bodyguard 2 device, electrodes, and the wear instructions. Parents wore the device continuously from 20:00 pm the night before the competition until 17:00 pm the day of the tournament. The second author collected the technology, and uploaded the data directly to the Firstbeat SPORTS software. As previously mentioned, the parents completed two open-ended questionnaires. The parents wrote their answers directly into a Google form document. The second authors texted the link to both parents.

The research utilized a mixed-method approach. As described by Creswell [21], a mixed-method approach involves both qualitative and quantitative data that the researcher integrates. The notion is a more in-depth analysis of the research topic is accomplished compared to just one of the approaches [22]. In our research, parent physiological reactions were quantitative data and parent expectations and responses to the day were qualitative data. For the two open-ended questions, the second author, and a colleague individually translated the written answers into English. Though qualitative interpretive approaches exist, the research team read the responses and discussed the themes present. As mentioned in the introduction, the

research team *a priori* decided on an AGT focus.

Results of the research

Quantitative data. Figure 1 (father) and 2 (mother) are the Firstbeat Technologies printouts of the parent heart rates and energy expenditures. We placed the markers (F1, F2, etc.) and results (W, L) for each fight on the graphs. Visually, it is clear that the mother's highest reactions and energy expenditures were during the fights whereas the father's most significant reactions and energy expenditures were after each fight. The second fight was the most demanding on both parents because they had to wait to see if their son could get back into the competition based on his opponent's next fight. This result also meant that he could no longer enter the finals nor win the gold or silver medal at the National Championships. In total, he had five fights from which he won three and lost two. The second lost match was the fight for the bronze medal so at the end he finished in the fifth place.

At no time did the parents run around or engage in any intentional physical activity. The data presented relate to speculation only. As found in Table 1 and based on age-predicted maximal heart rate, we provided the heart rate zones for differing levels of cardiovascular physical activity. The mother and father's results were different as the father's heart rate activity was sufficient to be rated as aerobic based training (i.e., minutes accumulated of at least 30 percent of predicted maximal oxygen consumption). The father amassed 50 minutes of classified moderate-to-vigorous physical activity. On the other hand, the mother's heart rate patterns were insufficient for a training effect. The mother gathered 24 minutes of classified moderate physical activity. Figure 3 (father) and Figure 4 (mother) provide a breakdown of energy sources, carbohydrates or

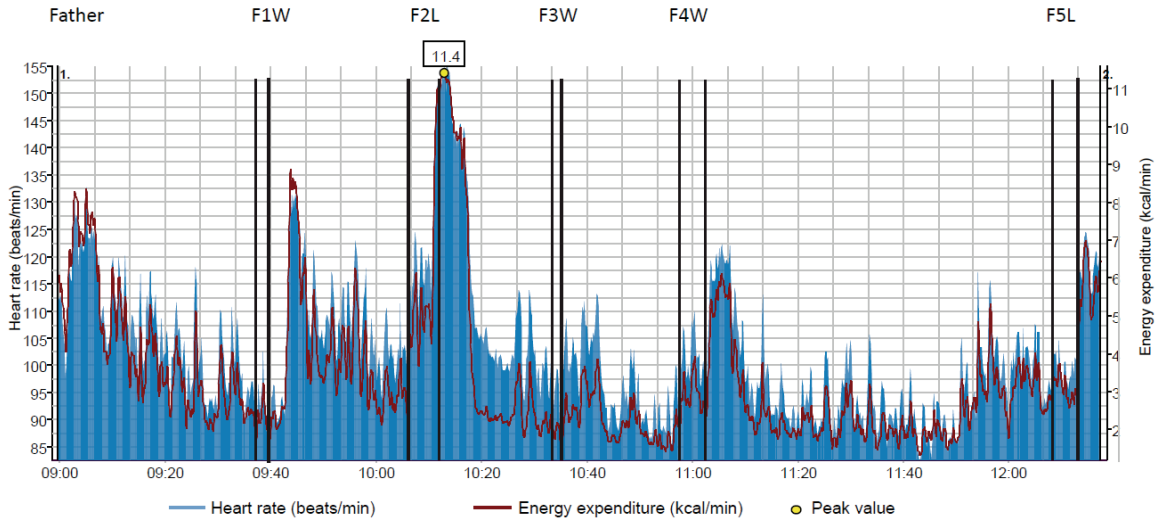

Figure 1. Cardiovascular and energy expenditure patterns of father immediately before, during, and immediately after watching son compete

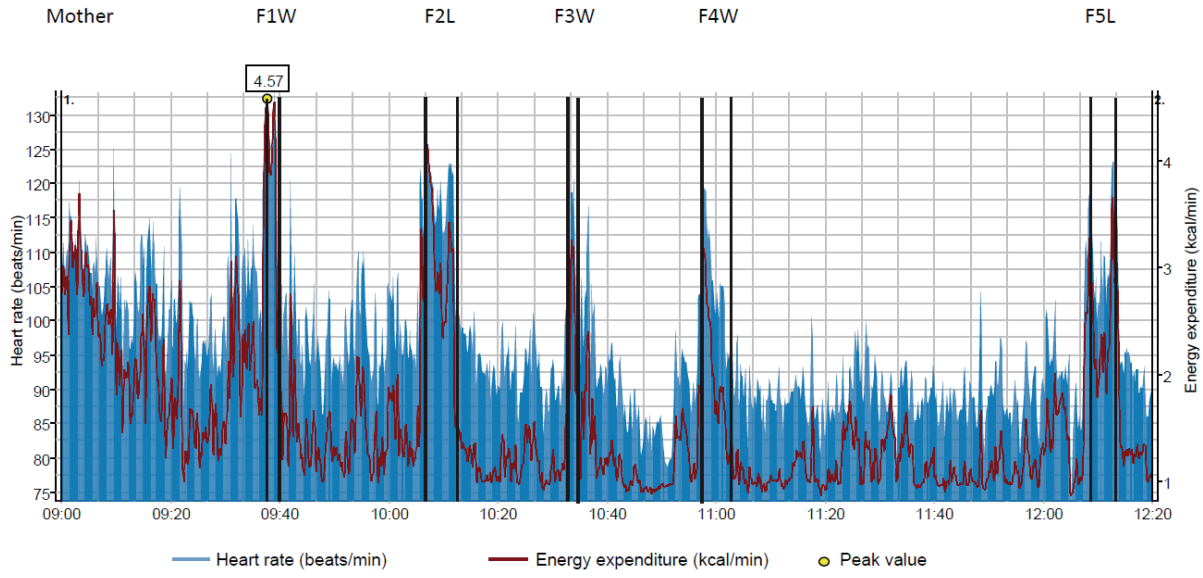

Figure 2. Cardiovascular and energy expenditure patterns of mother immediately before, during, and immediately after watching son compete

fats. Both parents utilized both energy sources nearly in equal proportions.

Qualitative data. The first open-ended question asked was "Please describe your expectations for today's competition." The father's answer was short. It was *"Victory"* whereas the mother wrote more.

I know that my son is capable, that he can and wants to do it. I expect that he shows that and that his confidence will be at that level so, in the end, he is satisfied with what he achieved.

The second question asked was "Please shortly describe how your day went, describe your thoughts about today's competition and describe you felt during it." The father's response was a series of descriptive words and was as follows:

It was Saturday, it was a hard day, without rest, uptight and intense. Competition: stifling, hard chairs, stinking

Table 1. Descriptive data for time before, during, and immediately after competition for each parent

Variables	Mother	Father
Average HR (bpm)	96	103
Lowest HR recorded	75	82
Highest HR recorded	134	154
High intensity zone (min)	0	0
Anaerobic threshold (min)	0	3
Aerobic zone 2 (min)	1	6
Aerobic zone 1 (min)	23	41
Training effect (Firstbeat defined)	1.5 (facilitated recovery)	2.5 (maintained aerobic fitness)
Calories (kcal) from fat	161	343

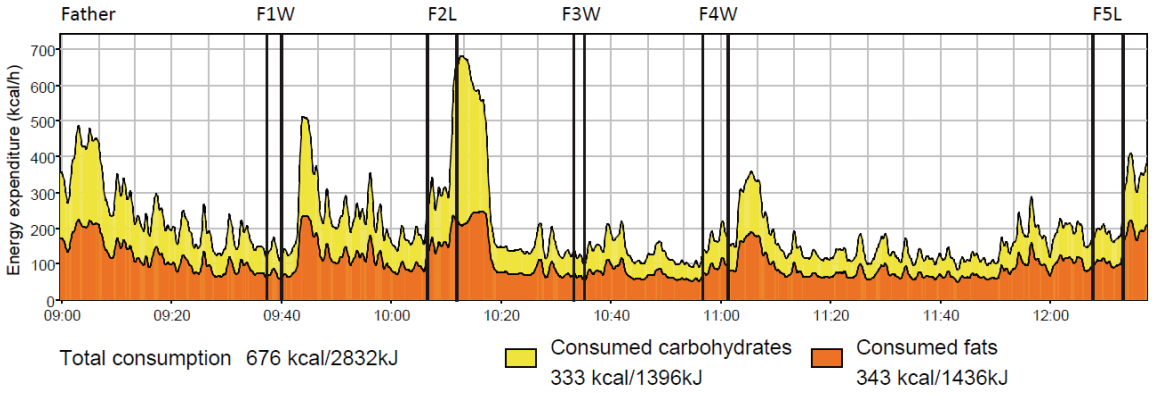

Figure 3. Caloric energy sources and totals of father immediately before, during, and immediately after watching son compete

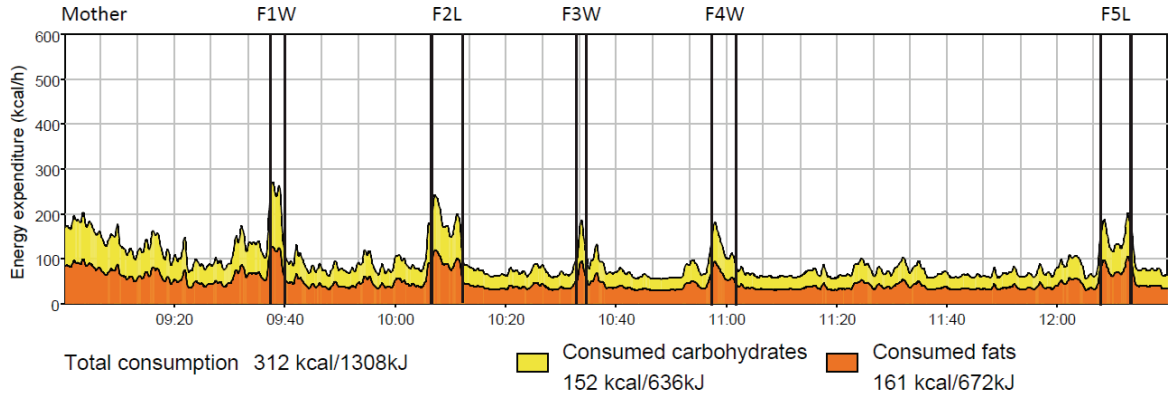

Figure 4. Caloric energy sources and totals of mother immediately before, during, and immediately after watching son compete

kimonos, waiting, disappointment, moving on.

Again as with the first open-ended question, the mother wrote a good deal more than her husband.

I enjoy spending time with my kids, and I love when I am involved in their sports activities, like today. I am very excited because I know that my son wants to win a medal and I also have the same expectations. At the end of the competition, I am sad because I think my son is sad. I try to hide my emotions because I am afraid that it will make him even sadder. When we came home, I closed myself in the bathroom pretending I was doing the laundry, cried and then calmed myself. Afterward, we all went to a restaurant where we talked a lot, got angry, made up and then decided we are ready for new battles.

From an AGT perspective, the father expressed a strong ego goal orientation with his emphasis and reflections on wanting to win and being disappointed in his son's losing. Though the mother's open-ended answer before the event seemed to convey a task goal orientation, her son doing his best, she expressed her expectation was congruent with her son, to win a medal. This expectation again was the only one the father expressed.

Discussion

This mix-methods approach with physiological data is unique to the literature. Dorsch and colleagues [11] used a mixed-methods approach with many sources of qualitative data and quantitative observational data. We sought to expand the research base by quantitatively documenting parent cardiovascular and metabolic parameters in and around their son's competition. Given physiological reactions without context are without meaning and open to a great deal of interpretation, we qualitatively investigated before and after the sporting event the mother and father's expectations and reactions to their son's competition. The cardiovascular and thus metabolic patterns differed remarkably and consistently between father and mother. The father reacted to the match outcome whereas the mother was engaged in the fight and seemingly physiologically disengaged between fights. The qualitative answers provided clues into the differing cardiovascular patterns. When combined, the quantitative and qualitative results are worthy of discussion and future lines of research.

Though biased in that two of the three authors favors AGT across our careers, AGT fit the open-ended responses [19-20]. Both the father and mother at some point expressed winning as the goal or expectation. The father indeed expressed winning as the only goal, and this perspective seemed to dictate his physiological reactions. The father's results are in line with Hogue and her colleagues' [18] experimental investigation of the impact of goal climate on middle school students' stress response. An ego-involving climate leads to greater salivary measured cortisol in the middle school-aged participants. The mother interpreted her goal to be congruent with her son. As mentioned in the introduction, the research community far too often paints the performance- or ego-orientation as detrimental. The negative emotions expressed are consistent with meta-analytic research. Though small in meaningfulness, researchers have reported that the ego goal and ego climate correlate with the expressed negative emotions. The negative feelings seemed in direct response to losing. Asking the parents their reactions between each fight would help understand the full pattern of emotions across the competition experience.

As with any investigation, limitations exist. Given our research was a pilot in nature, the main limitation is sample size though the study itself seems unique to the youth sports literature. This restriction provides future research directions. For instance, a more substantial sample or repeated measures design with the same parents or set of parents across many competitions will aid this research topic. The event itself was a major competition and potential stepping stone for the adolescent. He needed a third-place finish to continue on his positive trajectory within the Croatian National Judo system. He, unfortunately, did not achieve the bronze medal. Whether the parent, especially the father's, cardiovascular and metabolic patterns are consistent could only be answered with repeated measurements across competitions of varying importance. Future research looking to capture the adolescents' expectations will aid in better understanding of parents' expectations and post-competition reactions.

Conclusions

1. The power of wearable technology influences future research directions. In the present investigation, the parents wore the Firstbeat Body Guard 2 device. This device provides a great deal of information concerning stress, sleep, physical activity, and recovery. Wearing the device for several days before as well as after the competitions is a potential area of future research.

2. We can envision this line of research moving from descriptive such as describing parent and even child sleep and stress patterns leading up to competition and the days afterward to randomized interventions for sleep and stress management. We believe that a mix-methods approach should guide future research as it has in the past (e.g., Dorsch et al., 2015).

3. The used technology in this pilot investigation provided unique data. Importantly, the participants reported no lifestyle barriers to wearing the technology or complaints about the technology being a nuisance.

4. The open-ended questions provided insight and complimented the wearable technology data. Incorporating qualitative methodology is vital for future wearable technology research measuring stress, sleep, and recovery analytics.

Conflict of interests

The authors declare that there is no conflict of interests.

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Analysis of the functional state of students in the process of healthy training exercises in different phases of the ovarian-menstrual cycle

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Abstract

Purpose: to substantiate the application of a rational program of health-training sessions in the educational process of physical education of students in different phases of the ovarian-menstrual cycle.

Material: in study participated students (n=127), who did not have deviations in health (the main medical group). According to the results of the tests were determined: heart rate; blood pressure; vital capacity of the lungs. To determine physical performance was used Harvard step-test. Physical exercises from the main means of health fitness were used differentially and dosed.

Results: It was established that the consideration in the phases of the ovarian-menstrual cycle of indicators of the functional state, changes in well-being and working capacity give an opportunity: planning loads in the training process; adjustment of volume and intensity of loads. We recommend to schedule the load of our program as follows: in the menstrual phase – the development of flexibility (moderate load); in the postmenstrual phase – development of coordination, overall endurance; in ovulatory – speed development; in postovulatory – development of special endurance; in premenstrual – the development of strength, flexibility. In the postmenstrual and postovulatory phase, a high level of physical working capacity, functional state of the cardiopulmonary system has been registered. It also has a positive effect on body weight correction in the women students.

Conclusions: When developing programs of health training sessions with women students it is necessary to take into account the phases of the ovarian-menstrual cycle.

Keywords: physical education, functional state, health training sessions, students, ovarian-menstrual cycle.

Introduction

The process of physical education of student youth attracts the attention of many specialists in the field of physical culture and sports. In recent years, significant changes have been made both in physical education disciplines and in the methods of teaching them [5, 8, 13, 31]. Particular attention deserves physical education of students. For the correction of the functional state of students exist a large number of authoring techniques using various means of recreational physical culture [6, 8, 9, 32].

It was considered the approaches to the organization of the training process of women. They were based on the differentiation of volume, intensity and direction of training loads in accordance with the functional capabilities of the organism in different phases of the ovarian-menstrual cycle (OMC) [7].

It was developed an author's program of rehabilitation of obese students and low level of physical fitness [6]. The author applies differentiated classes for improving aerobics and taking into account the phases of the OMC. There are number of scientific studies that address the issues of building a training process for athletes based on the ability to work in different periods (phases) of specific biological cycle. Fundamental works are considered those [17, 19, 25], in which the functional status of athletes was studied during specific biological cycle.

The authors [26] considered the connection of the psycho-physiological state and the manifestation of high-speed abilities of high-grade water polo players. The biological cycle of hormonal changes in their organism was taken into account. Another study [24] examined the effect of the training process of high-skilled athletes (judo) on the psychophysiological state of athletes in various phases of the OMC.

Studies by other scholars [18, 23] also confirmed the need to take into account the biological cycle of women during the training of qualified athletes [14]. An analysis of such studies indicates their relevance. An analysis of scientific papers shown that most studies devoted to questions that examine the effects of various kinds of stress on the body of women athletes of high qualification.

To a lesser extent is studied the question of building a health-training process for girls, especially during specific biological cycle. For athletes, there are certain conditions for performing any physical activity in the adverse periods of the ovarian-menstrual cycle. For students, such conditions require some adaptation. Students feel more significant functional and psycho-physiological stress, which affects their mental and physical ability to work [8, 10, 13].

The results of many studies indicate that hormonal changes in OMC reflected in the mental and functional state of women. They are also displayed at the level of their special ability to work [20, 22].

Despite a significant number of works [23, 27, 29] during conducting classes with students do not take into account the peculiarities of the biological function of their organism.

Hypothesis. It is assumed that taking into account the peculiarities of the female body (phases of the ovarian-menstrual cycle) in the process of health-training sessions will contribute to the improvement of the functional state

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of the students and the growth of their capacity for work.

The aim of the work is scientifically substantiate the application of rational program of health-training sessions in the educational process of physical education of students in different phases of the ovarian-menstrual cycle.

Materials and methods.

Participants: In study took part 127 students aged 17-19 years old of Sumy State University. All students belonged to the main medical group (not having health abnormalities) and were divided into experimental and control groups. All students agreed to participate in the experiment.

Organization of research. The study was conducted between September 2015 and January 2017. At the beginning of the study was conducted: questionnaires, analysis of the functional state of students. The level of their physical capacity is also determined. During the testing, we were guided by the recommendations of leading specialists in the field of physical education [11]. The results were recorded in general protocol and subject to statistical processing.

From the indicators of functioning of the cardiovascular system were determined: the frequency of heart rate (heart rate, beats per min. [1]), blood pressure – systolic (BPS, mm Hg) and diastolic (BPD, mm Hg) by Korotkov method. The Vital capacity (VC, ml) was determined using the spirometers of the computer complex NS-psychotest. The students had to complete three attempts. The best attempt was to set off. To determine physical performance was used Harvard step-test [11].

To determine the phases of the OMC was used the calendar method. For this, the next stage of ovulation was determined by measuring basal body temperature. In our studies, body temperature was measured in the oral cavity, under the tongue with a closed mouth (sublingual or oral temperature, Tor). It is recommended to breathe through the nose for maximum reduction of vibrations through inhaled air. Measurement was carried out at the same time of day using the same type of thermometer. For a state of relative rest, the oral temperature was taken as a comfortable level of 36.6±0.10°. Registration Tor was conducted in the dynamics of all experiments using the digital thermometer firm "Microlife" (Switzerland). The thermometer allows you to measure the temperature of the oral cavity in 1–3 min (at the sound signal of the thermometer). The measurement accuracy of the instrument is ±0.10. According to the results of observations, a schedule was constructed. Its evaluation was carried out in accordance with the known laws: a day before ovulation, the temperature is slightly reduced; during ovulation the temperature rises by 0,3-0,6 and remains at this level until the end of the cycle [25]. During the study, the timing of the onset of menstruation and its duration were fixed.

Students of the experimental group were engaged in complexes of health-training exercises, which were assigned individually and corresponded to the phase of OMC. Students of the control group were engaged in the proposed programs of health-training classes without taking into account the phases of the OMC. The loading was carried out taking into account the functional state of the students. Differentiated used and dosed physical exercises from the main means of health fitness (fitbol aerobics, pilates, stretching, body-art, mind-body).

Statistical analysis: For the treatment of the results of the study it was used: descriptive statistics, sampling method, the criterion of consistency Shapiro-Wilky, Student's criterion and dispersion analysis [4]. The main statistical characteristics of the sample were determined: the arithmetic mean of the sample ($\bar{x}$); standard deviation (S); representative error (m). The reliability level was set at P=0,95 (level of significance p=0,05). Some results were obtained at higher levels of significance p=0,01 and p=0,001. In conducting complex pedagogical and biological studies with the participation of students, the Ukrainian legislation on health protection, the Helsinki Declaration of 2000, and the directive No. 86/609 of the European Society regarding the participation of people in medical biology research were observed.

Results.

It was found that the formation and course of the menstrual cycle is in most students within the limits of the physiological norm. The regularity of the cycle lasts from 21 to 27 days noted by 69% of the respondents. In 18% of girls the cycle is not regular. 14% of students do not control the duration of the cycle. The evaluation of the duration of the menstrual cycle revealed a higher proportion of shorter, prolonged and overly prolonged menstrual cycles in 57% of students. In 43% of students the structure of the duration of the menstrual cycle was more favorable.

An important informative indicator is the presence and intensity of a painful sensation before and during the lunar period [3, 7, 14]. An analysis of the survey of students for the presence of pain in the middle of the menstrual cycle showed that in general, they were noted by 47% of students. In 37% of the pain arose periodically. Regular pain sensation appeared in 15.2% of students. At the same time, students note the restrictions on physical activity, or generally avoid exercises.

The students' state of health before the occurrence of menstruation is characterized by the following: the presence of headaches is observed in 23%; 44% of students increase fatigue; 33% of students report increasing irritability. Ovulatory, premenstrual, and menstrual days are considered days of biological stress [25, 27, 28].

The obtained data indicate that during the planning of practical classes on the physical education of students, it is imperative to take into account the phases of the OMC. One of the most promising areas in the physical education of students can be the development and implementation of health fitness techniques: regulated physical activity in accordance with the periods of the health-training process of occupations. During conducting classes we must take into account the phases of the ovarian-menstrual cycle.

In the least favorable phases (premenstrual, ovulatory, menstrual) the volume and intensity of the load decreased. Classes on the proposed methods corresponded to the periods of the annual cycle of training [14, 16, 21]. This approach during the construction of health training sessions contributed to a more rational distribution of loads of different orientations and better adaptation of the body of students to training loads.

In order to determine the functional state of students studied the state of the cardiovascular and respiratory systems. The obtained data are one of the main indicators of functional capabilities and adaptation of the body to physical activity. The average student heart rate was 74,20±0,29 beats per min. $^{-1}$. This is somewhat higher than the norm and indicates signs of tense work of the cardiovascular system. Observations show that there is a direct relationship between pulse and physical activity [1, 29]. An analysis of the cardiovascular system performance at the end of the study showed that the mean heart rate of the students of the experimental group in a resting state was from 66,23±5,01 beats per min. $^{-1}$ to 68,26±2,27 beats per min. $^{-1}$. These indicates compliance with the norm. All these contributes to the purposeful use of the selected means and methods to improve the overall level of physical fitness and functional capacity of the body of students.

To determine the functionality of external respiration, we studied the indicators of the vital capacity (VC). We used the spirometry method. The obtained data indicate that the respiratory function of the thoracic cells of the students corresponds to the average functional level (3,401±0,30 ml/kg).

The decrease in the level of general physical activity is observed during the training of the majority of students [2, 12, 15, 30]. It should be noted that performance varies in different phases of the biological cycle [3, 7]. At the beginning of the study of students' physical working capacity it was found that their physical capacity meets the low level. The results of the study of physical working capacity in students of the experimental group changed from 53,2±0,15 up to 68,04±2,48 standard units ($p<0,001$). The indices of Harvard step-test in the control group improved from a low level of 51,06±0,18 up to 58,18±2,30 standard units ($p<0,05$). The data of the Student t-criterion is reliably ($p<0,001$) confirm a significant increase among the results of the students of the experimental group. To a lesser extent was recorded the growth of these rates in the control group of students. The smallest values of the indices of Harvard step-test are recorded in the ovulatory (III) and menstrual (I) phases. The highest values are recorded in the postmenstrual (II) and postovulatory (IV) phases of the OMC. It was found that physical working capacity in the students of both groups changed wavelike throughout the menstrual cycle.

The construction of a health-training process in accordance with the menstrual cycle is necessary to ensure proper alternation of work and rest. The actions of the main loads on the body of students were planned by us in accordance with the phases of the OMC. This contributed to the rational use of the internal capabilities of the body to achieve optimal effect in the transfer of loads and provided the necessary match between the processes of fatigue and recovery [16, 23, 26]. At the beginning of the pedagogical study, students were encouraged to learn how to identify and record the phases of the OMC. Students learned to assess their condition and body reactions to different loads. The girls conducted a "well-being diary".

On the basis of the data we have developed a table in which the characteristics of the phases of the OMC and recommended training load for the annual mesocycle are given (Table 1).

Consideration in the phases of the ovarian-menstrual cycle of indicators of the functional state, changes in well-being and working capacity give an opportunity: planning loads in the training process; adjust the volume and intensity of loads.

The loadings according to our program are recommended to build by the following ways: in the menstrual phase – the development of flexibility (moderate load); in the postmenstrual phase – development of coordination, overall endurance; in ovulatory – speed development; in postovulatory – development of special endurance; in premenstrual – the development of force, flexibility. It should be noted that the functional state of students of the experimental group significantly changed during the OMC ($p<0,05$). In the postmenstrual and postovulatory phase, a high level of physical working capacity, functional state of the cardiopulmonary system has been registered. It also has a positive effect on body weight correction in the students.

The use of differentiated health fitness in the experimental group and the consideration of the biological cyclicity of the functions of the female body allowed effectively influence the functional characteristics of the students. It positively affected their physical capacity and functional status.

The obtained data of the pedagogical experiment confirmed the effectiveness of the proposed program of health-training classes in most of the studied indicators.

Discussion.

The development and scientific substantiation of the physical education program classes with students requires solving a number of problems. There must be an appropriate organization and methodological support for the classes. Students need to develop knowledge about healthy lifestyles and personal hygiene. After all, according to the analysis, there are students who do not control their cycle. Such students do not follow their state of health at different phases. The given problem can be solved, if to use organizational-activity approach to the process of employment: to create a certain interrelation of the teacher and students; change the forms of classes and their sequence.

There are studies that provide data on the impact of training sessions with various elements of fitness aerobics on the reproductive system of students [20, 18]. The authors note the need to take into account and regulate

Table 1. The general structure of the loads according to the periods of annual cycle according to the phases of the ovarian-menstrual cycle

Phases of cycle	Duration (days from the cycle start)	Training loadings Periods of annual cycle	Characteristics of physical and mental working capacity Appropriate development of physical qualities
Menstrual I	3-5 (from 1 to 5)	Medium (renew period)	Medium level of physical working capacity: recommended such exercises as development of flexibility of temperate force (pilates, mind-body). Low indices of working capacity
Postmenstrual II	7-9 (from 6 to 12)	Extensive (main period)	High level of physical working capacity: development of general tolerance, force, speed-force abilities, flexibility (body-art, feetball, stretching). High indices of working capacity
Ovulatory III	2-4 (from 13 to 15)	Medium (renew period)	Low level of physical and mental capability: recommended the reduction of volume and intensity of loadings. Development of tolerance (pilates, mind-body)
Postovulatory IV	7-9 (from 16 to 24)	Extensive (main period)	Gradual increase of physical working capacity; development of aerobic working capacity force, speed (speed force), (pilates). Mean value of mental working capacity
Premenstrual V	3-5 (from 25 to 28)	Short (supporting period)	Medium level of working capacity: development of aerobic working capacity, flexibility, force, coordination abilities (pilates, body-art)

the intensity of physical activity in different phases of the OMC.

Closer to the discussed problem belong the study of N.V. Sizova [20]. The author shows the changes that arise in the cardiovascular and respiratory systems of students during the pursuit of health-improving aerobics. In this paper, the conclusion is made on the obligatory accounting of the intensity of physical activity in different phases of the cycle.

Currently, there are studies that provide information on the features of conducting lessons for various wellness fitness programs with students. But these studies are fragmentary and need further study. At the present stage, "soft fitness" is a special attention among girls and women: pilates, mind-body, body-art. In the process of health training sessions with students we used the proposed techniques. Our goal was to improve their functional state, physical and mental performance in different phases of the OMC. The loads were planned according to the annual cycle of classes or mesocycles. Our analysis allows us recommend mandatory planning of health training sessions in all mesocycles during the school year. Classes should be conducted taking into account microcycles in accordance with the phases of the OMC: in the favorable phases (postmenstrual and postovulatory) apply the load of the main period; in the unfavorable (menstrual, ovulatory) load of the recovery period; in the premenstrual phase of the load supporting period. According to these phases, the classes use different types of soft fitness. Under favorable conditions – fitbol aerobics, step aerobics, combination of various aerobic species. In unfavorable conditions – pilates, stretching, mind-body and body-art.

The data obtained by us confirm and supplement the research results of other scientists regarding the consideration of the biological function of the female body in the development of programs for physical education [10, 13, 20].

Comprehensive student surveys show the high effectiveness of the developed organizational and methodological approaches: training by the fitness programs pilates, mind-body, body-art and taking into account the phases of the OMC and the periods of the annual cycle of health-training sessions.

Conclusions

1. The effectiveness of the proposed methods of training was confirmed by the results of improvement of the main studied parameters in students of the experimental group: an increase in the level of functional status, improvement of physical and mental performance, optimization of OMC (relief of pain, decrease of irritability), increased interest in classes.

2. When developing health-training programs of classes with students it is necessary to consider the following: the phases of the ovarian-menstrual cycle; periods of the training process.

Conflict of interest:

The authors state that there is no conflict of interest.

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Factorial structure of aerobics athletes' fitness

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Abstract

Purpose: The purpose of the research is to develop an algorithm of teams' formation in sport aerobics and to define factorial structure of athletes' fitness.

Material: in the research sport aerobics' athletes (n=19) participated. All athletes are members of Kharkiv national team (Ukraine). All athletes underwent complete medical examination. The functional condition of an organism (arterial blood pressure, indicators of a variability of the *rhythm* of the heart, treadbahn testing), psycho-physiological state (time's determination of simple and complex reaction) were defined. The physical development and physical fitness and stability of vestibular system were also defined. The factorial and cluster analysis were used.

Results: The algorithm of teams' formation in sport aerobics is developed for performances in various competitive categories. The algorithm contains all stages of standard procedure of the factorial and cluster analysis. In the factorial analysis the individual factorial values were also defined.

Conclusions: The obtained data are recommended to be used at teams' formation for performances in various competitive categories: team formation for pair and group performances. The general and individual factorial structure of athletes' complex fitness is defined. It is possible to select athletes with similar qualities and with different qualities for the mixed performances. The determination of individual factorial structure of fitness permits to estimate objectively variants of athletes' formation in groups.

Keywords: individualization, algorithm, aerobics, factorial, cluster.

Introduction

The aerobics is a difficult and emotional sport. In aerobics are used elements from artistic and rhythmic gymnastics and acrobatics. A lot of attention is paid to choreography. In programs of mixed pairs, trio and group more attention is paid to interaction between partners. The following categories of performances are provided in aerobics: individual male, individual female, mixed pairs, trio and group (5 athletes). The aerobic dancing (aerodance) and the gymnastic platform (aerostep) are also used. The versatile character of sport aerobics creates certain difficulties in planning of training process. The big complexity is also caused by optimum selection of athletes for group performances.

In scientific literature nowadays a lot of attention is paid to aerobics as mean of health promotion and improvement of people's functional condition.

Shypulo I.P. [1] proved the increase of aerobic exercises' efficiency of girls' motor fitness at the extracurricular institutions. The author defined the most informative indicators of girls' physical fitness. The analytical graphic model for forecasting and carrying out the quantitative and high-quality control of girls' fitness level is created. The author concluded about possibility of results forecasting of aerobics exercises. The method of aerobics exercises which consists of five stages is recommended to perform. Its main feature is constant objective control of exercises' efficiency.

Beliak Yu.I. et al. [2] offered the dispensing method of physical activity in aerobics classes for students. The energetic value for each zone of loads intensity was determined on the basis of correlation between the heart beats rate and consuming of oxygen. The evaluation component of this dispensing method of loads permits to use it computer programs. It can be also easily modified for load distribution on other types of recreational fitness.

Bryukhanova N.A. et al. [3] revealed reaction of students' heart rate on the increasing of musical speed. The authors recommend to use the increasing of intensity only in limited scope during trainings: the increasing of musical speed up to 142-145 beats per minute or heights of the step platform up to 20 centimeters.

Gurieieva A.M. et al. [4] described the factor structure of girls' physical condition at the beginning of academic year. The authors offered rational balance of physical skills' development methods necessary for recreational aerobics' program creation. The authors managed to define the most important factors influencing on the girls' health condition of the first year of study. The factor analysis

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permitted to specify the correlation of methods which are intended for physical skills development.

Golod N.R. [5] selected basic provisions of the comprehensive program of physical rehabilitation for students of special medical group. The program of rehabilitation included: change of lifestyle; morning hygienic exercises; kinesiatrics (yoga, functional training); aerobic exercises (swimming, Nordic Walking, jogging, recreational aerobics); massage.

Thus, a lot of scientific researches devoted to recreational aerobics are closely intertwined with problems of sport aerobics. Therefore they can be applied in the training process of athletes in sport aerobics. However there are not many scientific researches devoted to the problems of sport aerobics.

Chen L.Y. [6] offered the method of motor actions' reconstruction in aerobics based on three-dimensional vision of motor action. The author offers to use the computer visual recognition technology for extraction of specific point of athlete's body image. It gives the opportunity to obtain the main features of athlete's body shape. Then the evaluation of motor action from the four points in the three-dimensional space is done. The results of modeling testified that offered method can improve considerably the motor action's evaluation efficiency and its correction in the course of training.

Fan C. [7] demonstrated that one of basic elements in sport aerobics is jump. At the same time the jump's height, speed of jumping squat and position of the athlete in space are also important. The author offered the jumps training technique in aerobics which involves using of special exercises for increase the ability of body control in space.

Hu C. F. et al. [1] point that the main sense of aerobics consists in manifestation of beauty of art and the motor action. The aerobics gives the chance to enjoy the beauty of motor compositions.

Jiang G. P. et al. [2] investigated jumps with obstacles in sport aerobics. The authors have determined that in a phase of take-off there are two peak phases of manifestation of the maximum strength of a hip and a shin. The peak phase of hip muscles' tension is appeared in a preparatory phase of a jump, and of shin muscles' tension is appeared in a take-off phase. In phase of action in the air the various segments of a body exert various impacts on the effect of the turn. In a landing phase the maximum rotary moment of a coax is much more, than at other joints. The author recommends using the obtained data in training technology of jumps in aerobics.

Li A. [10] analyses the physiological and psychological features of high-class athletes in sport aerobics who were traumatized. The author developed the scientific basis of training process in sport aerobics and rehabilitation after sport injuries. The author specifies that reasons of sport injuries are difficult and multifaceted. The author analyzed the psychological reasons of sport injuries. It gives the opportunity to facilitate the effective rehabilitation of athletes.

Li C. et al. [11] carried out the factorial analysis of anklebone injuries' reasons in sport aerobics training. The authors suggest reducing of unnecessary classes of aerobics for training process' optimization.

Huang W.Y. et al. [12] studied athletes' heart rate variability in aerobics with use of the telemetric monitor of heart rate continuous registration (Polar RS800). The conclusion was drawn that age, professional qualification, heart rate and gender influence on athletes' heart rate variability during increase of loads.

Sang G.Q. [13] conducted a sociocultural research of aerobics development. The author specifies that aerobics is a new type of the sport program. The aerobics acquired high popularity grace to its unique modern attractions. The author researched correlation between aerobics and modern society and analyzed different types of the social and economic factors appeared with aerobics development based on careful examination of spiritual and cultural elements in aerobics development and its social impact.

Shi W.Y. [14] conducted researches on development and application of aerobics training courses. The author testified that hyper media technologies in sport aerobics training courses have strong impact on study. Technologies contain the multimedia material oriented on target functions of sport practice training. Such material promotes the correct organization of educational information. Such approach is useful for sport practice.

Wang M. [15] analyzed correlation between efficiency of study in strength exercises and level of athletes' physical fitness. Normalization of athletes' technical actions in aerobics is closely connected to the level of their physical fitness. It is appeared in technical elements when athletes execute falling. The correlation between strength training and athletes physical monitoring is analyzed. It can be used for increase the strength opportunities and physical fitness.

Zarebska A. [16] revealed that dancing aerobics provides sufficient incentives for increase in explosive strength. It influences on jumps' height. The author revealed the genetic conditionality of jumping ability's training effect.

Yan F.F. [17] offered method of decorating the complete sets of competitive aerobics in trio (one of categories of sport aerobics). The author demonstrated influence of performances in trio on development of competitive aerobics. The results testify that the competitive aerobics has the following aspects: sportswear, temperament, body shape, physical trait and others.

Xiang F.F. et al. [18] analyzed the importance of strength for keeping the body position in space. The authors offer cautions concerning strength training in aerobics. In aerobics the speed, rhythm, amplitude, athlete's body center of gravity are important. The pose can reflect art achievements of athletes. The athlete's pose influences on general judicial evaluation. The authors analyzed importance of strength development from the point of view of body's position.

In other researches it is possible to select solutions of the following problems of athletes fitness: programs' development directions permitting to keep physical shape

effectively [19]; differentiation of relocation methods in dancing games [20]; motivational aspects of success achievement [21, 22]; mechanical parameters of jumps [23] influence of interval fitness program and interval study program on aerobic and anaerobic physiological indicators [24].

Developing of athletes training programs presuppose such elements in sport aerobics: optimization of physical activities [25] and didactic basics of a training [26, 27]; choice of adequate tests and pedagogical control [28, 29]; periodization of training process [30] and competitive activity [31, 32]; factors of athletes success [33, 34] and choice of optimum parameters of the movement [35, 36].

Thus, there is a problem of training creation process in sport aerobics. The greatest attention is paid to physical training of athletes, problems of traumatism and rehabilitation after injuries, to the analysis of biomechanical structure of various movements, to use of interactive technologies. However, the problem of individual approach and a teams' formation for group performances in various competitive categories of sport aerobics is less researched. Thus, in modern sport aerobics the principles of athletes division according to groups for teams' formation have descriptive character. There is no emphasis on quantitative models. Also the principles of mathematical and statistical modeling aren't applied. In literary data there are no accurate recommendations about aerobics athletes training in respect of individual psychophysiological opportunities and typological features.

The purpose of the article is to develop an algorithm of teams' formation in sport aerobics and to define factorial structure of athletes' fitness.

Material and methods

Participants. in a research the athletes (n=19) from the sport aerobics national team (Kharkiv, Ukraine) have participated.

Organization of a research. The following methods were used: methods of functional definition of athletes' organism condition (arterial blood pressure, indicators of variability of the heart's rhythm, treadbahn testing) psycho-physiological methods of research (time's determination of simple and complex reaction in various modes of signaling); methods of physical development's definition and physical fitness; method of vestibular tolerance's definition.

The variability of the heart's rhythm was used for the analysis of vegetative regulation of heart activity.

The record of a signal was carried out on the portable cardiographic equipment «Cardiolab +», (Computer electrocardiograph «Cardiotest» permits to register 12 channels standard ECG, ECG in the lead system by Neb and Frank. For the indicators' analysis is used Dialog box «Complex» Dialog box «Lens» http://www.dx-sys.com.ua/en/products/). Its basis is made by 3; 6; 12 channel cardiograph + the Cardio CE phonocardiograph + on the basis of a notebook (or the personal digital assistant) PAQ 3870. The Polar model monitor of heart rate continuous registration with appropriate software was also used. The record was realized for 5 minutes in lying position after 5-minute rest.

The subsequent processing of cardiointervals permitted to define a row of statistical characteristics of variability of the rhythm of the heart [37]:

As indicators of heart beats rate we found:

1. Mo (mode of RR-intervals' duration) the most frequent interval between teeth RR (sec.);
2. AMo (amplitude of mode of duration of RR-intervals) – percentage of intervals' quantity (the most frequent) to the total quantity of the measured intervals (in our case we used 50 RR-intervals) (%);
3. Δx – variation range of RR-intervals' duration: there is difference between the highest and the least value of RR-intervals (sec.);
4. Index of tension (conv. un) of regulatory mechanisms (IT) we found by formula:

$$IT = AMo / 2Mo \bullet \Delta x \quad (1),$$

Where Δx – is the value of variation range of RR-intervals' duration (sec.);

Mo – mode of RR-intervals' duration (sec.);

AMo – amplitude of mode of duration of RR-intervals (%).

In the analysis of heart rate indicators we were guided by the fact that indicators of a heart rate reflect a different contribution of sympathetic and parasympathetic branches of the autonomic nervous system to the process of heart activity regulation. The mode of RR-intervals' duration (Mo) indicates resultant effect of regulatory influences. It reflects the steadiest functioning level in these conditions. The variation range reflects the range of possible deviations option of casual process. The variational range is defined by expressiveness of respiratory oscillations of a heart rate. Therefore this index is considered as the indicator of activities of an closed-loop control. The amplitude of mode of duration of RR-intervals (AMo) permits to judge about activity of closed-loop control. Thus, increase of AMo duration of RR-intervals and IT witness about tonus increase of sympathetic branch of the autonomic nervous system. Increasing of variation range of RR-intervals' duration witnesses about increase of parasympathetic branch influence of the autonomic nervous system [37].

In our research was also conducted testing by time's definition of simple and complex reactions to sound and visual stimuli. Time of complex reaction was determined by testing with feedback. In a testing of time's definition of difficult visual and motor reaction with feedback were determined: time of latent period reaction; average quadratic deviation; quantity of mistakes; time of the minimum exposition; time to reach to the minimum exposition [38].

Our research carried out the testing to define the time of simple and complex reactions to sound and visual stimuli. Time of complex reaction was determined by testing with feedback. Time of the latent period of reaction, an average quadratic deviation, and quantity of mistakes, time of the minimum exposition and time of reach the minimum exposition were defined by time definition of complex

visual and motor reaction with feedback [38].

The vestibular stability was determined with the help of Barany mechanical chair. Rotation of chair was ensured by hand during 20 sec at speed of 2 r.p.sec^{-1}. After every 2 sec. we registered heart beats rate (HBR) with the help of photoelement equipment. HBR was also registered after rotation during 10 sec., after every 2 sec. Increase of HBR before and after rotation was considered as proper reaction to rotation. It is activation of sympathetic branch of autonomic nervous system. Decreasing of HBR before and after rotation was considered as inappropriate reaction to rotation. It is activation of parasympathetic branch of autonomic nervous system (motion sickness). In case of data analysis the HBR indicators on the 2nd sec after the beginning of rotation were selected. The indicators after rotation were also selected [37].

Statistic analysis. Digital material was processed by means of traditional methods of mathematical statistics. The arithmetic average value X, an average quadratic deviation of S (a standard deviation) was determined by each index. The factorial and cluster analysis of testing indicators were also carried out. The factorial analysis of testing indicators was carried out during the primary materials processing. The obtained data processed by means of Excel and SPSS software. Differences considered reliable at significance value of $p<0,05$.

Results

We developed an algorithm of definition of individual factorial structure of athletes' fitness for teams' formation for competitive categories in sport aerobics.

The algorithm consists of the following stages:

- conducting of athletes' testing, which includes set of tests (not less than 10);
- definition of the general structure of athletes' fitness. Definition of major factors and drawing up their characteristic;
- determination of individual factorial values structure of athlete's fitness. It is necessary to notice that this stage is extremely seldom applied in sport's scientific researches. As a rule, most of researchers define the general factorial structure of athletes' fitness. However determination of individual values of factorial structure of fitness is important for creation a better understanding of athlete, planning of his training, selection of partners etc;
- carrying out the hierarchical cluster analysis of testing indicators. Selection of teams in sport aerobics on the basis of the groups formed as a result of the cluster analysis;
- drawing up characteristics of the formed groups of athletes. Creation of programs for performances in various competitive categories. Development of training programs.

We investigated the factorial analysis of indicators for definition of the general and individual structure of athletes' fitness as one of fundamental components of this algorithm.

In structure of athletes' complex fitness 4 major factors were defined: Cattell's method was used. For the characteristic of each factor its indicators were analyzed.

The first factor consists of following indicators (28,6% of general total dispersion) (tab. 1): HBR on the 2nd sec at rotation on Barany's chair (r = 0,95), HBR in 90 sec of rest after performance of a standard load on the treadbahn (r = 0,94), HBR after the rotation on Barany's chair (r = 0,93), an indicator of HBR average value in heart rate (r = 0,95), HBR in 10 sec after rotation on Barany's chair (r = 0,88), HBR of the rest (r = 0,68).

The first factor consists of indicators reflecting the level of a regulation of vegetative balance from the central nervous system (CNS). The increasing of HBR (at rest, an average value in heart rate, at the beginning and after the rotation on Barany's chair) is pointed to activization of sympathetic branch of the autonomic nervous system.

The increasing of HBR in response to rotation demonstrates proper response of the vestibular system to rotation. It is followed by activization of sympathetic branch of the autonomic nervous system. On the other hand, increasing of HBR of rest and HBR average values in heart demonstrates activization of sympathetic branch of the autonomic nervous system. It can reflect the insufficient level of athletes' functional training. In our case increasing of HBR at rest can be regarded as fast activization of power supply systems of muscular activity in response to the beginning of testing. Testing is perceived by an organism as a stimulus. The organism reacts to this stimulus as well as to muscular work.

Such fast activization of power supply mechanisms, fast getting "degree of readiness" demonstrates adequate regulation of vegetative balance from a CNS. Also it demonstrates high reactivity of sympathetic branch of the autonomic nervous system.

This factor included indicators of nervous processes mobility (time to reach to the minimum exposition of a signal, time of the minimum exposition of a signal) (r =-0,57;-0,53). It is established that indicators of nervous processes mobility correlate with indicators of activity of sympathetic branch of the autonomic nervous system. It can be explained with the fact that also the activity of sympathetic branch of the autonomic nervous system is necessary for implication of nervous system mobility. Based on the above stated, the first factor was called "sympathicotonia" (fig. 1).

The second factor consists of the following indicators (28,5% of general total dispersion): age (r =-0,92), body weight (r = 0,85), wrist strength (r = 0,81), back strength (r = 0,72), body length (r = 0,68) (tab. 1). Indicators of the second factor mainly reflect the level of development of strength abilities and absolute strength. An exception is the indicator of age which joined the second factor with negative coefficient of interrelation. It can be explained with the fact that in our research young athletes were stronger. The indicator of strength of a nervous system (quantity of mistakes at execution of the test on speed of reaction with feedback) (r =-0,55). It is determined that the indicator of strength of a nervous system correlates with indicators of physical strength. Athletes have strength of a nervous system and physical strength as integrated

implications of the general psychophysical structure of organism. Based on the above stated data, the second factor was called "Strength" (fig. 1).

The third factor included indicators (9,4% of general total dispersion): average value of time reaction to a sound (r =-0,94), jump height (r = 0,75), an error of reproduction of intervals of 1 sec time (r =-0,74) (tab. 1). The indicators characterizing the speed of reaction and explosive strength were part of the second factor. Therefore the third factor was called "Speed" (fig. 1).

The fourth factor included only two indicators (9,2% of general total dispersion): coefficient of heart rate variations) and average value of time of reaction of the choice (r = 0,64), choice reaction time indicators, quantity of mistakes, the general time of execution of the test and time of an exit to the minimum exposition of a signal when testing in the feedback mode (r = 0,57-0,51) (tab. 1).

The obtained data witness that the increasing of activity of parasympathetic branch of the autonomic nervous system reduced the speed of reaction of choice. It is natural reflection of ability to the general relaxation of an organism. In this regard the fourth factor was called "parasympathicotonia" (fig. 1).

The table 1 and the figure 1 witness that major impact to total dispersion is made by the first and second factors. It is logical to conclude that indicators of nervous system reactivity and indicators of strength abilities development are the most significant in structure of athletes' fitness. Indicators of high-speed endurance and ability to relax are less significant. It is expressed in a parasympathicotonia.

Further the individual factorial structure of athletes' fitness was defined. The percentage values of each factor's display at each athlete (tab. 2) were defined for this purpose.

The table 2 and the figure 2 demonstrate that all athletes have different display of various factors. It witnesses about existence of essential individual differences. It has to be shown in various styles of performances and necessity of application of individual programs of athletes' training. It is possible to define athletes with major display of a factor 1 – "sympathicotonia" (athlete № 6), with the major display of a factor 2 – "Strength" (athlete № 3), with major display of a factor 3 – "Speed" (athlete № 2), with major display of a factor "parasympathicotonia" (athlete № 9) (fig. 2).

Table 1. The matrix of indicators' components of qualified athletes (man) testing * (n = 19)

Indicators	**№ of factors, contribution in general dispersion**			
	1 **28,6%**	**2** **28,5%**	**3** **9,4%**	**4** **9,2%**
HBR in rotation on Barany chair, rates per min^{-1}	0,95			
HBR of renewal after 90 sec after work, rates per min^{-1}	0,94			
HBR after rotation on Barany chair, rates per min^{-1}	0,93			
Mo RR-intervals, sec	0,89			
HBR after 10 sec after rotation on Barany chair, rates per min^{-1}	0,88			
HBR at rest, rates per min^{-1}	0,68			
Choice reaction time with feedback, msec	-0,57			
Choice reaction time with feedback, total time of test execution, sec	-0,53			
Choice reaction time minimum time of signal exposition, msec	-0,51			
Age (years)		-0,92		
Body mass (kg)		0,85		
Wrist strength, kg		0,81		
Back strength, kg		0,72		
Body length, cm		0,68		
Choice reaction with feedback, mistakes, quantity		-0,55		
Time of reaction to sound (msec)			-0,94	
High jump from the spot (cm)			0,75	
Mistake in reproduction of time interval's 1 sec, sec			-0,74	
Variation range of RR-intervals, sec				0,96
Choice reaction time, average values, sec				0,64

* Note: the rotation of matrix is carried out by Varimax method.

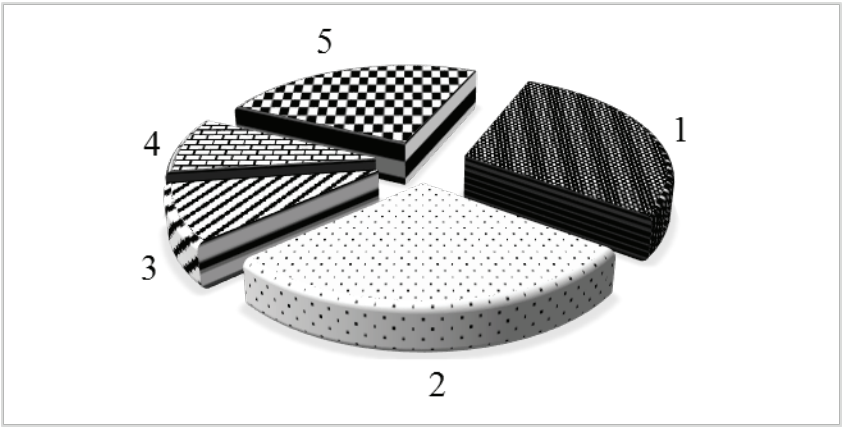

Fig. 1. Factorial structure of athletes' fitness (n=19) (4 factors are defined): 1 – Factor of "Sympathicotonia", 28,6%; 2 – Factor "Strength", 28,5%; 3 – Factor "Speed", 9,4%; 4 – Factor of "Parasympathicotonia", 9,2%; 5 – Other factors, 24,3%

Table 2. Individual display of factors in structure of athletes (male) fitness' (% of the maximum display of factor in selection) (n=19)

Athlete's №	Factors			
	Sympathicotonia	Strength	Speed	Parasympathicotonia
1	88,89	32,22	61,11	52,22
2	77,78	11,11	100	77,78
3	66,67	33,33	33,33	33,33
4	63,33	47,78	58,89	61,11
5	55,56	78,89	55,56	94,44
6	92,22	44,44	66,67	55,56
7	100	46,53	77,78	66,67
8	41,11	55,56	42,22	88,89
9	54,44	66,67	44,44	100

For combined performances it is possible to select athletes with similar qualities (representatives of one cluster) and with different qualities (representatives of different clusters). For example, the athlete with the major display of a factor "Strength" can be combine (to make a team of athletes) to athletes with the major display of a factor of Sympathicotonia. Also it is possible to combine such athlete with others depending on tasks of the performance program. The athlete with the major display of a factor "Strength" will perform successful in programs with keeping of other athletes. Thus, determination of personal factorial structure of athletes' fitness permits to evaluate objectively options of athletes completing in groups. It gives the opportunity of effective teams' formation for competitive performances in different categories.

Discussion

The analysis of literature and own results of the research revealed that this research is the first from the point of view of theoretical and methodical bases development of teams' formation for performances in different competitive categories; integral training of athletes in sport aerobics. Nowadays there is insufficient quantity of scientific research in the field of individual approach to the training process in sport aerobics. At the same time authors concern the research and development of separate parameters of athletes training. The authors do not consider process of team's formation and integral preparation from the point of view of the analysis of a wide complex of fitness indicators [39]. That's why the subject and object, the purposes and tasks of research are new and relevant.

Prior to this research of teams' formation for performances in different competitive categories and integral training of athletes were considered only as peripheral issue. The teams' formation did not consider the principles, an algorithm, and analysis tools of indicators and specific techniques of training process optimization. From this point of view our research is new. Our research is important not only for the theory and practice of sport training. This research is also important for other sciences connected with a study of the person – pedagogics, psychology, psycho-physiology, etc.

In our work the process of teams' formation is based on determination of individual factorial structure of each athlete's fitness. Therefore creation of an algorithm of teams formation in sport aerobics is a new problem, developed for the first time. The carried-out analysis of scientific literature data [39] determined that most of authors consider the principle of team's combination and individual fitness as one of the main principles. At

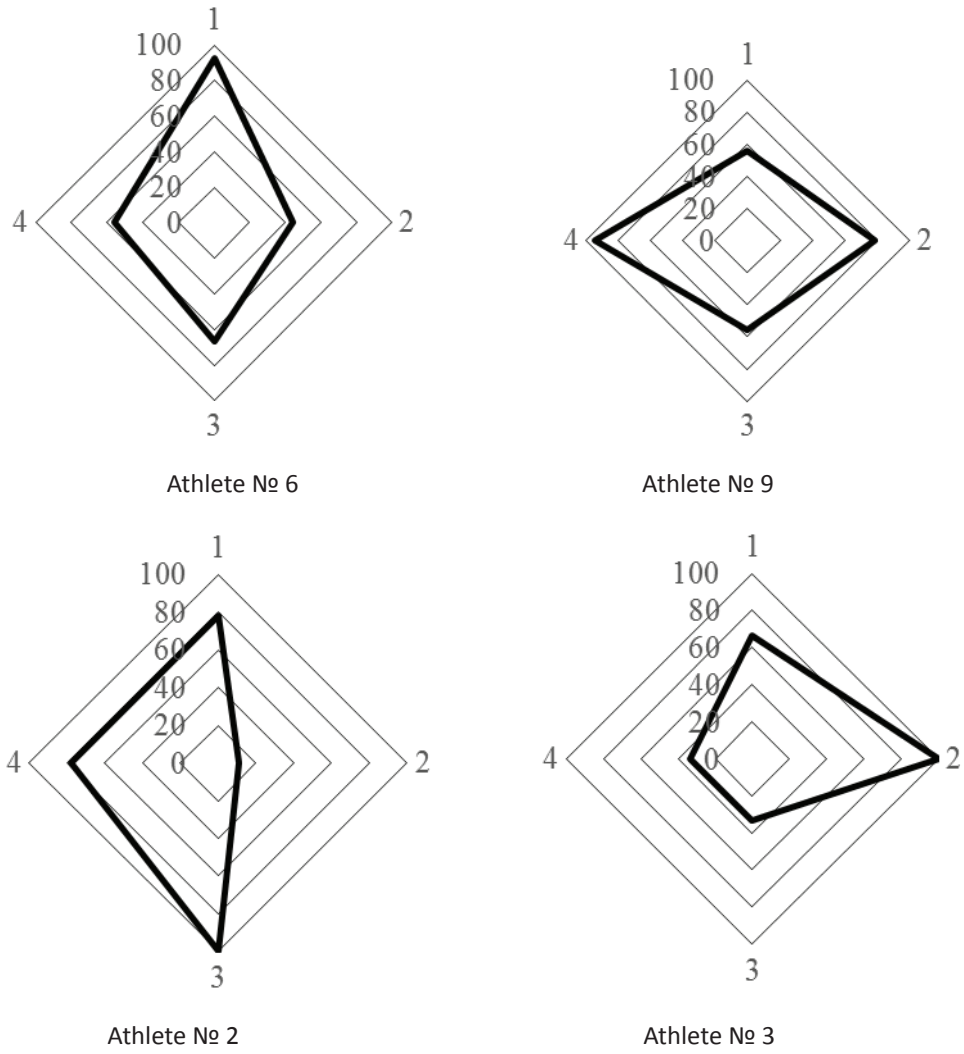

Fig. 2. Personal factorial structure of the functional and psychophysiological capabilities at athletes: 1 - Factor of "Sympathicotonia"; 2 - Factor "Strength"; 3 - Factor "Speed"; 4 - Factor of "Parasympathicotonia".

the same time, in cyclic sports there are already some scientific works concerning to concrete recommendations about creation of educational and training process for each athlete. In sport aerobics there are only a few theoretical, methodical and organizational bases of team and individual approach combination to the training process of athletes.

That's why our research has a new direction. In this case the principle of combination of team and individual training of athletes becomes a system which has the structure, algorithms and mathematical apparatus.

From the analysis of scientific literature data [40, 41] was revealed that the problem of individual distinctions has rich history and is beyond far the theory and a technique of physical training and sport. From this point of view our work is expansion and addition of available knowledge of individual human nature. Our research gives the chance of application of athletes' specific features for creation of various groups depending on tasks of educational and training process [42].

In our research the methodology for individualization in game sports is used [43, 44]. From this point of view the system of a team's combination and individual approach to process of athletes training in aerobics is expansion and addition of results of other researches [45-48]. In our research the approaches to the training process' planning are presented with consideration of specific features of factorial structure of athletes' fitness, their psycho-physiological and functional features.

In sport aerobics athletes form groups for performances in various competitive categories. The success of performances at competitions depends on optimum selection of structure of such teams. It should be noted that in recommendations for training of athletes in aerobics questions of individual athletes' distinctions aren't revealed (psychological, physiological, psycho-physiological). This question is important for ensuring success of performances at competitions. Therefore the offered methods of the leading factors' definition are represented the new approach to individualization fitness' problem.

On the basis of generalization of scientific literature data, results of own experiments and carrying out the general theoretical-analytical research we have developed

the general scheme of ways of team's combination and individual training of athletes. Such scheme is already used in game sports [25]. It looks as follows.

The first direction of this series of researches provides creation of an algorithm of mathematical systematization and processing of a wide range of the indicators reflecting the separate parties of athlete's fitness and condition. This direction considers a condition of the athlete or group of athletes in separate time point.

This direction supposes the determination of group and individual structure of athletes' fitness. Then by means of the cluster analysis athletes form groups by fitness similarity.

The second direction of scientific providing of fitness process' individualization is connected with the analysis of the factors causing individual dynamics of athletes' competitive effectiveness. This direction presupposes the creation of regression models of dynamics regularities of athletes' competitive efficiency and application of these models for the forecast of competitive result and management of educational and training process. In our research this direction is reflected in individual approach to the training process creation in a year cycle. We considered increasing and decreasing of competition form's level.

The third direction of researches is connected with development of the interactive technologies [41] permitting to increase the various aspects of training process to qualitatively new level.

On the basis of researches' results of three directions are created the team and individual programs of athletes training.

Thus, the training of athletes in aerobics is based on the system approach. It is extension of scientific literature data and for the first time obtained data in sport aerobics.

Conclusions

1. The algorithm of teams' formation in sport aerobics for performances in various competitive categories is developed. The factorial and cluster analysis were used in this approach. The algorithm contains all stages of the standard procedure of the factorial and cluster analysis. In the factorial analysis individual factorial values for creation of complete characteristics of each athlete were revealed. The general and individual factorial structure of complex fitness of athletes is defined.

2. For the combined performances it is possible to select athletes according to the similar and different qualities. Determination of individual factorial fitness' structure permits to evaluate objectively options of athletes groups' formation. It permits forming effective team for competitive performances in various categories.

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• the research work of Ministry of Education and Science of Ukraine for 2013-2014. «Theoretical and methodical bases of application the information, pedagogical and medical-biological technologies for formation of healthy lifestyle» (№ of the state registration 0113U002003);

• the research work of Ministry of Education and Science of Ukraine for 2015-2016. «Theoretical and methodical bases of means application the information, pedagogical, medical-biological orientation for motor and spiritual development and formation of healthy lifestyle» (№ of the state registration 0115U004036).

• the research work of Ministry of Education and Science of Ukraine for 2017-2018. «Theoretical and methodical bases of application of information, medical-biological and pedagogical technologies for realization of individual physical, intellectual and spiritual potential and formation of healthy lifestyle» (№ of the state registration 0117U000650).

Conflict of interests

The author declares that there is no conflict of interests.

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Hygienic aspects of physical education and health of schoolchildren

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Abstract

Purpose: to analyze the state of physical education in secondary schools of Ukraine and to observe hygienic requirements during physical education lessons.

Material: the study was attended by schoolchildren (n=40, age – 12-13 years) and schoolchildren of specialized sports classes (n=40, age - 14-16 years). Studied: the level of physical health; functional state of the respiratory and cardiovascular systems; the state of energy supply of children's organism; the influence of mobile games on the functional capabilities of the body of children. To study the effects of physical exercises on the development of the muscular system of children, excretion of creatinine with urine was studied.

Results: high levels of physical and functional status of young players are noticed. These data are significantly higher than similar data from their peers from non-sports classes. In the course of systematic training and competitions, excretion of creatinine decreases at the end of the season to 0.8 g/l. These changes point to a decrease in energy resources and are consistent with a decrease in the rapid qualities of young players (as a measure of overall physical fitness). In this group of pupils, there were 2-4% lessons in the classes: mostly because of colds. In schoolchildren of ordinary schools, indicators of physical development and functional status were significantly worse. The indicators of the lung capacity were 3500-3800 ml. The distance of 30 m children ran for 5,5±0,4 seconds. The index of the brush dynamometer was 35±1,8 kg. The results of the recovery of the heart rate after the metered loading were from 2 to 3 minutes. There is a shortage of body weight in 12% of schoolchildren. There is an overweight in 1,8% of schoolchildren.

Conclusions: in the structure of children's morbidity a high level of respiratory diseases, gastrointestinal tract, and eyes is allocated. Therefore, when taking physical training, such data should be taken into account. It is also necessary to take into account the level of individual somatic health, which leads to a safe area of intense motor activity.

Keywords: schoolchildren, life capacity of lungs, dynamometry, Skibinski index, creatinine, phosphorus.

Introduction

The problem of physical education of children and adolescents and its hygienic aspects have practical and scientific significance. Strengthening of health, raising the level of physical fitness of children and adolescents of school age is one of the most acute problems of our state's social policy. Improving the health of schoolchildren in most cases is determined by the level of development of physical qualities, the formation of which takes place in physical education lessons. In recent years, no significant positive changes have taken place in this school in the school system of physical education [2, 3]. Physical culture is a means of upbringing and improving the physical training of schoolchildren. Physical culture is also: the main factor in the restoration and strengthening of health during the formation and formation of the body; a source of general and mental performance improvement [36, 37, 42]. The state of health of children and adolescents should be considered as a criterion for their readiness to perform labor and social functions [8, 15, 30].

The physical culture phenomenon by force and ability to influence the preservation and strengthening of human health is one of the most significant [15, 34]. Therefore, the professional knowledge, functions and activities of the physical education teacher should be aimed at maintaining the health of students.

The study of a number of authors [8, 19, 41] indicates that the choice of means and regulation of physical activity in physical education and fitness classes should be consistent with somatic health and physical fitness of schoolchildren. Attempts were made by many domestic and foreign scholars, specialists, managers and individual educators [18, 28, 35]. In school practice, there is a significant deviation from the target settings of physical education and bringing them to purely normative approaches. This worsens the health of schoolchildren and contradicts the idea of forming a harmoniously developed personality [10, 43, 44].

The basis of education and training, a co-ordinating and integrative component of the entire activity of the teacher of physical education at school is a lesson. Features of organization and conducting a lesson in physical culture are determined by the state program. Improving the software for the subject "Physical culture" is one of the main ways to improve the quality of the physical culture lesson. In recent years, many studies have taken into account the hygienic requirements for the process of physical education of schoolchildren. These requirements are based on the physiological laws of the influence of motor activity on the body. Requirements are devoted to the problem of improving the normative and software of physical education of schoolchildren. In the educational process, new curricula for schoolchildren in 1-4 and 5-9 grades are introduced. The organization of the educational process of physical education, taking into account the region of residence, is of great importance. This applies to rural areas where socio-economic and environmental conditions differ from urban living conditions [5, 20, 27, 40].

A special concern for society is the state of health of children. 30-40% of schoolchildren found nasopharyngeal

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disease; in 20-40% of breach of posture; in 50% defects of vision [14, 24, 29, 48]. The reasons for the unsatisfactory state of health of schoolchildren of secondary schools and the level of their physical preparedness is the lack of scientifically substantiated system of physical education of schoolchildren [3, 33, 42]. This is due to the fact that the integral concept of this system has not been developed, the ways of its restructuring have not been defined [3]. The modern science of physical education requires the transition from traditional means of gathering information about the physical condition of schoolchildren to comprehensive monitoring. One such information is the creation of an automated system for integrated control of the physical condition of schoolchildren. The purpose of such a system is to identify the differences in physical fitness, individual and personal properties of response to external factors and physical activity [18]. Foreign publications cover the use of new technologies and the creation of a data bank on this basis on the physical condition of the child. Such a base is used for the planning of physical activity, the development of individual programs for independent classes [31, 39, 45, 47].

The social adaptation of the schoolchildren is an important problem. Adaptation is possible only with a high level of health. This requires the creation of a health-saving educational technology in high school [4, 6, 32, 49]. An important task of the teacher of physical culture is to make active independent motor activity conscious, purposeful. It is necessary to focus on the elements that contribute to: the formation of the need for schoolchildren to improve their health; healthy lifestyle and physical fitness; formation of interest in the use of physical exercises. For the improvement of the educational process at the lessons of physical education, the gender issue is important [16, 38, 46]. In fact, there are no methodical recommendations for teachers, where would be given recommendations on differentiated physical education of boys and girls. We are convinced that in the process of physical education we need to develop a concept of a gender approach aimed at forming a physical culture among schoolchildren. The first step may be to conduct classes individually for boys and girls from the first class. But this innovation requires significant financial costs. Therefore, in today's conditions, taking into account the motivational priorities of girls and boys, it is important to take into account the physical education lesson. This approach makes it possible to select exercises that call and support interest in the lesson [16]. Sanitary and hygienic requirements for the organization of physical education lesson and physical education at school include a number of important provisions: analysis of the results of medical examination; hygiene conditions of the place of the lesson; analysis of the effectiveness of physical education in school according to the incidence of schoolchildren; observance of the sequence of classes and their combination with other lessons in the schedule of the school day and the week [21]. But very often the hygiene requirements for a physical education lesson are not fulfilled, which has negative consequences. In particular, this refers to a combination of the schedule with other lessons (the first lesson of physical culture on Monday).

An important factor in health promotion is to go in for sports in out-of-school period. In senior form about 55% -70% of schoolchildren think so. One of the important reasons may be the impossibility of paying for classes [16]. There is a fairly high percentage of schoolchildren who do not want to go in for sports. It is known that it is the level of individual somatic health that determines the safe zone of intensity of motor activity during exercises.

An aim of the study is to analyze the compliance with hygiene requirements and to generalize the state of physical education in secondary schools of Ukraine, to evaluate the functional condition of schoolchildren in Lviv.

The task of the work is to analyze the functional state and physical preparedness of the schoolchildren under the influence of mobile games: in physical education lessons [26] and in training sessions in Children's and Youth Sports School [22].

Material and methods.

Participants: schoolchildren of secondary schools № 43 and № 55 (n=40, age - 12-13 years), schoolchildren of specialized sports classes of Children's and Youth Sports School № 4 (n=40, age - 14-16 years).

Organization of research. We studied: the level of physical health; functional state of the respiratory and cardiovascular systems; the state of energy supply of children's organism; the influence of mobile games on the functional capabilities of the body of children.

Measurement of indicators: height, body weight, Skibinski index, lung capacity, PWC_{170}, maximum of oxygen consumption, anaerobic exchange threshold [23].

To study the effect of physical exercises on the development of the muscular system of children aged 12-13 years old, we studied excretion of creatinine in urine. The studies were conducted using a set of reagents for the determination of creatinine in human urine (Filisit Diagnostics, Dnipropetrovsk).

The studies of creatinine were carried out by a colorimetric method by the Jaffe reaction [13].

To detect the rate of inclusion of the creatine phosphokinase mechanism of energy supply when performing physical exercises in children aged 12-13 years, we studied the excretion of inorganic phosphorus with urine.

The purpose of the pedagogical experiment was to determine the effectiveness of our practical recommendations, which were based on the use of mobile games during lesson and out-of-class time. The pedagogical experiment lasted from December 2014 to May 2015. In total we were offered 60 mobile games. Our proposed mobile games are classified: the intensity of the load [games of low intensity – heart rate (heart rate) to 130 beats/min.]; medium intensity – heart rate from 130 to 154 beats/min.); high intensity – heart rate 155 to 174 beats/min.) [17]. In the preparatory part, medium intensity games were used; in the main were used games of high

and medium intensity (depending on the tasks set); in the final part, were used low intensity games. This approach made it possible to bring the cardiovascular system closer to the baseline level. At each lesson, played 3 to 4 games.

We used mobile games: at physical culture lessons; during big breaks; during morning gymnastics; in extended-day groups; in out-of-class time. In particular: low and medium intensity games were used during the morning gymnastics; low and medium games were used during the big breaks; in middle-aged and high-intensity games in the extended-day groups at out-of-class time.

On the directivity conducted the pedagogical experiment has comparative and consistent aspects. It occurred in a homogeneous group of subjects. According to the aim the experiment was ascertaining and forming. According to the condition of conducting the research, the experiment was natural. Schoolchildren of the control group of the Lviv Secondary School № 43 were engaged in the common methodology.

Statistical analysis: we determined the following indicators: arithmetic mean – M; standard deviation – ±δ; mean deviation error – ±m; the validity of the discrepancies according to the Student's t-test. The level of significance was taken at least $p<0,05$.

Results

At the beginning of the research (Fig. 1-A), in girls, the vital capacity of the lungs was 1720-1754 ml ($p<0,05$), in boys – 1795-1850 ml ($p<0,05$). These figures are below the age-old norm. In girls at the end of the research (Fig. 1-B) these indicators increased by 51-170 ml. It brought them closer to the age norm. The boys also showed a tendency to increase by an average of 205 ml.

The results of the Skibinski index determination at the beginning of the study in boys and girls indicate that the respiratory and cardiovascular function can be assessed as "satisfactorily" (correspondingly 20 and 18 units). At the end of the study, the average values of the Skibinski index have a positive tendency for the growth of pupils of both sexes.

The excretion of creatinine with urine in children aged 12-13 years at the beginning of the study was 0,29-0,0 g/day (41%-43% of the norm). At the end of the study (Fig. 2-A), the following results were obtained: 0,35-0,39 g/day (50%-56% of the norm).

After the physical culture lesson, the magnitude of excretion of creatinine at the beginning of the study was 0,34-0,35 g/day. At the end of the study, the results were 0,42-0,51 g/day (60%-70% of norm) (Fig. 2-B).

Excretion of phosphorus with urine at the beginning of the study was 0,64-0,66 g/day (58%-60% of norm) (Fig. 3-A). After the physical culture lesson at the beginning of the experiment, the amount of phosphorus was 0,72-0,74 g/day (66-67% of norm) (Fig. 3-B). At the end of the study, the results were 0,75-0,80 g/day (68%-73% of norm) (Fig. 3-A, 3-B). Thus, the use of a selection of mobile games points to positive changes in the excretion of creatinine and phosphorus in schoolchildren 12-13 years [17].

Also the indicators of physical development and functional state of schoolchildren in the city of Lviv were studied: the first group – Children's and Youth Sports School (football); the second group – schoolchildren from ordinary non-sport classes. Age of adolescents – 14-16 years. Table 1 shows the physical and functional status of schoolchildren-athletes

From Table 1 data highlights the high physical and functional status of young players. These data are significantly higher than similar data from their peers from non-sports classes. Recovery of heart rate (HR) to baseline values after dosed loading (20 squats for 30 seconds) in this group of schoolchildren was on average 1 min.–1 min. 30 sec. Indicator of general physical fitness in the run of 30 meters was 4,5-4,9 seconds. As an indicator of the intensity of energy metabolism, excretion of creatinine was studied. Determination of creatinine in the urine of the control group of schoolchildren was 1,35 g/l. In the

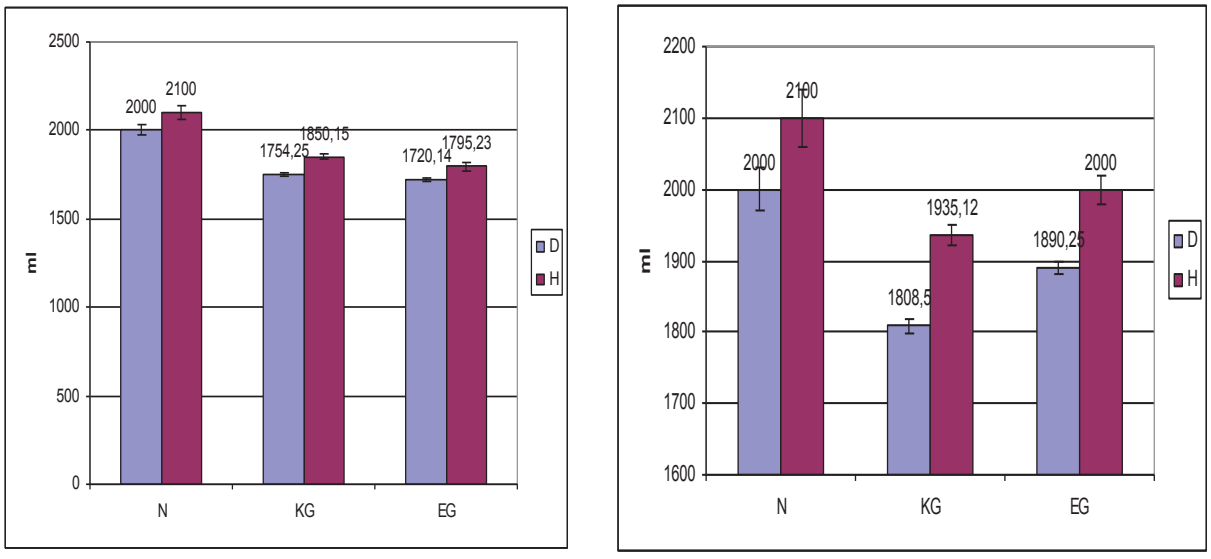

Fig. 1. The magnitude of the vital capacity of the lungs in children aged 12-13 years at the beginning (A) and at the end (B) of the study (n=40): D – girls, H – boys, N – norm, KG – control group, EG – experimental group, ml – milliliters.

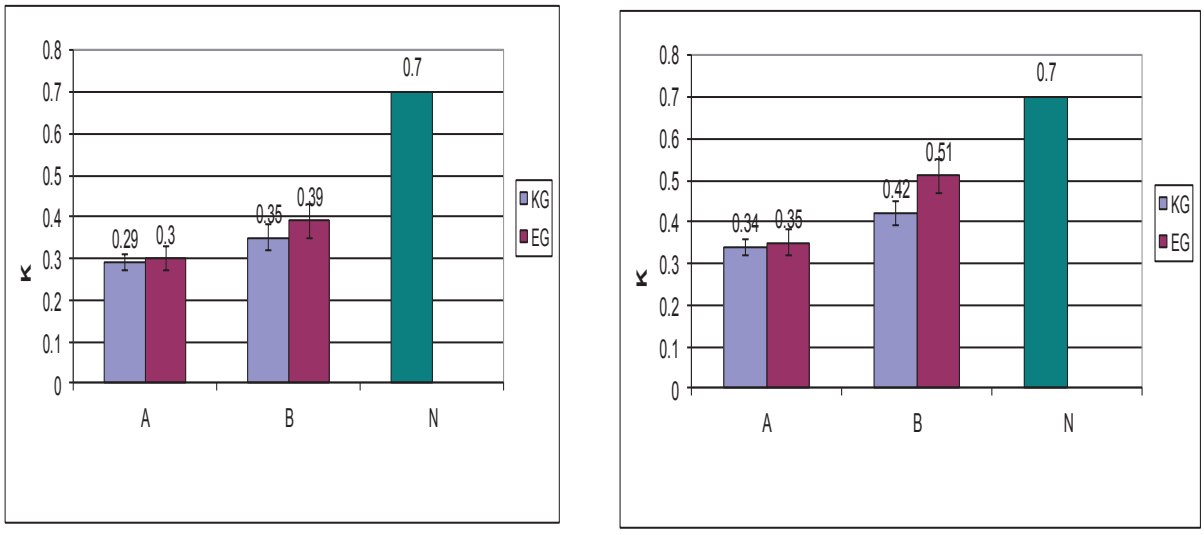

Fig. 2. The magnitude of creatinine excretion (F – g/day) in children aged 12-13 years in rest (A) and after physical culture lesson (B) (n=40): A – at the beginning of the study, B – at the end of the study, N – norm, KG – control group, EG – experimental group.

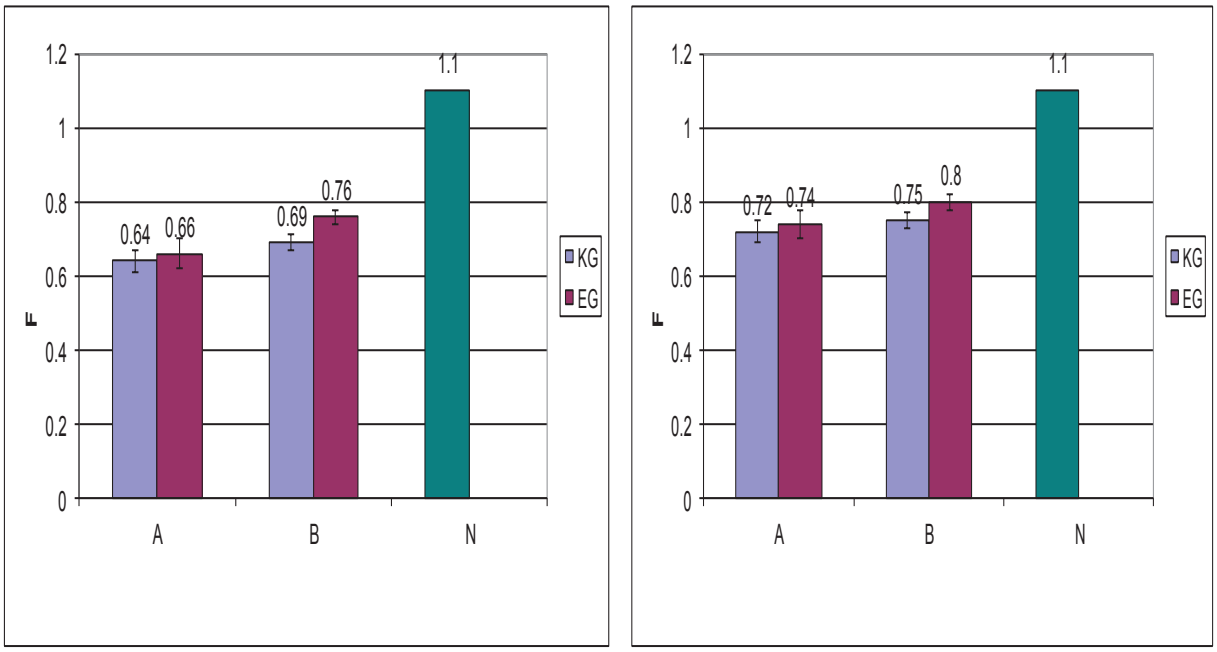

Fig. 3. The magnitude of phosphorus excretion (F – g/day) in children aged 12-13 years in rest (A) and after physical culture lesson (B) (n=40): A – at the beginning of the study, B – at the end of the study, N – norm, KG – control group, EG – experimental group.

course of systematic training and competitions, excretion of creatinine decreases at the end of the season to 0,8g/l. These changes indicate a decrease in energy resources and are consistent with the decrease in the high-quality qualities of young players (as a measure of overall physical fitness) [19]. In this group of schoolchildren, there were 2% to 4% of pupils: mostly because of colds. Such a small number of missing classes by schoolchildren is due to the fact that the trainers of the Children's and Youth Sports School select children according to certain criteria.

In schoolchildren of the ordinary schools, indicators of physical development and functional state were significantly worse. Indicators of vital capacity were 3500-3800 ml. The distance of 30 m children ran for 5,5±0,4 seconds. The index of the brush dynamometer was 35±1,8 kg. The results of the recovery of heart rate after a dosage loading were from 2 to 3 minutes. In 12% of schoolchildren, there is a shortage of body weight, and 1,8% of excess weight.

In the structure of the morbidity of this group is released a high level of diseases of the respiratory system, the gastrointestinal tract, eyes. Missing classes were observed in 22% of schoolchildren. Therefore, when taking physical training, such data should be taken into account. It is also necessary to take into account the level of individual somatic health, which determines the safe area of intense motor activity and is a criterion for the effectiveness of these activities.

Table 1. Indicators of physical development and functional state of schoolchildren-athletes of 14-16 years

№	Type of preparedness	Control indexes	Indexes of preparedness at the age of		
			14 years	15 years	16 years
1.	Physical development	Body weight (kg)	55,9 ±3,2	55,9±2,8	65,5±2,5
		Height (cm)	165,0±2,3	170, ±3,1	176,0±1,2
		Vital capacity (ml)	3900-4100	4500-4600	4800-5000
		Deadlift (kg)	100-120	120-140	150-160
		PWC_{170} (kg m/min./kg)	1400-1600	1600-1850	1800-2000
2.	Functional state	Maximum of oxygen consumption (ml/kg/min.)	50-54	54-56	55-57
		The threshold of anaerobic exchange (heart rate)	145-155	155-160	160-170

Note: PWC_{170} – a test for the determination of physical working capacity, in which the heart rate reaches 170 beats per minute.

Discussion.

In today's conditions, when conducting a physical culture lesson, motivational priorities are important, which make it possible to select exercises that cause interest in the lesson and increase its effectiveness [10, 16, 21]. Therefore, with the consent of the administration of education in the above mentioned schools, the physical culture lesson was diversified by mobile games, which is a new educational methodical form. This form of the lesson stimulated schoolchildren and during the experiment they showed higher possibilities for the functional state of the body compared with the study of the physical health of schoolchildren in Ukraine by other authors [8, 14].

The literature did not address the question of assessing the functional state of schoolchildren according to biochemical indicators during the lessons. This approach made it possible to evaluate the energy capabilities of the organism, to show their changes in the direction of improvement during the school year. Therefore, the results of these studies indicate the ability to recommend mobile games to be included in the school curriculum as a form of exercise in a physical education class.

Studies of most authors show a positive effect in post-exercise physical culture and recreational stresses [24]. These studies have established a positive health effect on the functional parameters of the cardiovascular, respiratory and muscular systems. Comparing these data with the indicators of physical development and functional state of schoolchildren trained at the Children's and Youth Sports School, it was clearly established significantly higher functional capabilities of schoolchildren-footballers.

Lampinen E.K. et al studied the differences in physical activity between Finnish girls and boys and children from different socio-economic backgrounds [38]. The authors found that the level of socio-economic preconditions affects the physical activity of children. Tambal K.D. et al highlight the most relevant gender and age differences for the protection of children and adolescents [46]. The authors emphasize that schools should make efforts to improve the level of preparation of schoolchildren through the curriculum of physical culture. These approaches coincide with our results.

Gordon B. et al. presented models for teaching personal and social responsibility of schoolchildren [32]. Zhang T. et al. developed a theoretical model of social and environmental self-realization of schoolchildren in physical activity [49]. The authors note the need for improvement in schoolchildren: physical fitness, development of motor skills, participation in physical life. These results support and coincide with the results of our research.

We were also the first to investigate the excretion of creatinine as a measure of overall physical fitness. The results obtained in such a comprehensive approach to the analysis of physical education classes in schools give grounds to assert that it is necessary to involve schoolchildren not only in extra-curricular physical education and wellness activities, but also in specialized training sessions at the Children's and Youth Sports School.

Conclusions

1. Studies have established that the improvement of methodical forms of motor activity at the lessons of physical culture improves the indicators of physical development and functional state of schoolchildren.

2. A significant increase in muscle mass and better training of the body of the schoolchildren during systematic sports activities, as evidenced by the excretion of creatinine, has been established.

Conflict of interests

The author declares that there is no conflict of interests.

The prospect of further research is the study of biochemical parameters, functional state, physical preparedness and health of schoolchildren during systematic physical education classes.

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Restoration of ankle joint, quality of life dynamics and assessment of achilles tendon rupture consequences

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Abstract

Purpose: to investigate the dynamics of restoration of the amplitude of motion in the ankle joint, the quality of life and to assess the effects of the breakdown of the Achilles tendon.

Material: patients (n=59, of which n=30 – the main group and n=29 – the control group) were examined at 4, 8 and 16 weeks after surgery. Indicators registered with the help of: goniometry; the Achilles tendon Total Rupture Score; the scale of an assessment of consequences and results of Leppilahti implications.

Results: the decrease of the total amplitude of the motion in the ankle joint takes place due to the deficiency of the amplitude of the dorsal flexion. At the end of the study the dorsal flexion rates were significantly better among the patients of main group. In particular, its deficit was 3.2 ± 1.85° in the main group and 6.8 ± 2.06° in the control group. The final total score Me (25; 75) was also better according to the questionnaire of the Achilles tendon Total Rupture Score: 82 (78; 84) points against 74 (72; 77) points ($p < 0.01$). An assessment of consequences according to the Leppilahti score was 83.8 ± 8.58 points in the main group and 70.7 ± 10.58 points in the control group ($p < 0.01$).

Conclusions: means of physical rehabilitation help recover the amplitude of movement in the ankle joint, improve the quality of life and the effects after the rupture of the Achilles tendon. The correct methodological approach and combination of tools further improves the results.

Keywords: physical rehabilitation, therapy, functional abilities, recovery, Achilles tendon, physical activity, physical exercises, quality of life.

Introduction

Injuries and damage of ankle joint are commonly belong to the injuries of the musculoskeletal system. The part of them makes from 6 to 21% of the total number of traumas of the musculoskeletal system or 40-60% of the number of the lower limb injuries [6, 15]. Damage of the tendon-ligament apparatus of the tibia is a major cause to consult a doctor [5]. Subcutaneous rupture of Achilles tendons occupy a leading position and make up 47% of tendons and muscles rupture [7, 8].

The rupture of the Achilles tendon is a sudden and severe trauma, which reduces the quality of life. In the biomechanics of the patient's step there is no phase of rupture and shock. It is the result of a violation of the link of transmission of muscle contraction. Also, the rhythm of walking is disturbed, and motor activity is sharply reduced [10]. Hypokinesia and immobilization cause changes in skeletal muscle, lowering the amplitude of motion. They lead to negative morphological and physiological changes [25] and reduce the functional capabilities of the body systems.

The restoration of the normal function of the operated limb is a long process, which includes the adaptation of the ends of the tendon, the normalization of neuro-trophic disturbances and the restoration of motor skills [2, 11]. Available knowledge of the biology of the tendon and regeneration regulation mechanisms are of great importance in surgery and rehabilitation [14].

Physical rehabilitation is an important moment for achieving optimal functional restoration of the entire limb [26]. Optimization of recovery and working capacity become even more important in sport [3]. However, it is noted that until recently attempts to optimize the postoperative regime after surgical treatment of the tendons' rupture were quite empirical. The main reason: from the side of the time characteristics and the gradation of the mode of physical exercise lacked clear conceptual foundations [12].

The biggest difference between protocols of postoperative rehabilitation takes place in the early postoperative period. Such differences are observed in methods of influencing the tendon in the early stages of healing (during the first three-six weeks) [9, 24]. One note that early mobilization is the most common way of managing postoperative tendons [16, 20, 23, 24]. It is also preferred in studies: longitudes for immobilization (with the possibility of movement in the volume of 20° and walking the day after the operation) [13]; early axial loading [18, 19]; early loading of the tendon [23]. Sufficiently detailed protocols for functional management of patients are presented in the works of Nilsson-Helander K. [21] and Nicklas Olsson [22].

Aim of the study is to identify the features of recovery of the functional indexes of the ankle joint, the quality of life and to assess the consequences after physical rehabilitation at the rupture of the Achilles tendon.

Material and methods

Participants. The materials of the work were obtained during the research on the basis of the State Institution "Institute of Traumatology and Orthopedics of the

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National Academy of Sciences of Ukraine" and the Consultative-Diagnostic Center of Shevchenko District (Kyiv). Patients (n=59) aged 34 to 57 years (including 67.8% men and 32.2% women) participated in the study. Patients were referred for surgery with a diagnosis of "Achilles tendon rupture" for years 2014-2016. Patients were divided into the main group (MG; n=30) and the control group (CG; n=29). The main group was engaged in the developed rehabilitation program, and the control group in the standard.

Organization of research. The developed rehabilitation program include renewed and expanded complexes such as: isometric and ideomotor exercises; exercises in the pool; varieties of walking; special active exercises for restoration of the amplitude of motion; for the restoration of the plantar flexion strength. in the addition to the developed program were include corrective exercises, exercise with fitball, exercise bicycle, platform BAPS, round-bottomed shoes, physiotherapy methods, massage. In the period after the operation, three periods are allocated: immobilization – 4 weeks (duration of the physical therapy from 15 minutes to 30 minutes 2-3 times a day); the period of partial immobilization – 4 weeks (up to 40 minutes twice a day); the period of restoration of strength endurance and strengthening of the musculoskeletal system of the shin – 8 weeks (up to 45 minutes, 1-2 times a day).

It was used: goniometry of plantar and dysplastic phlegm of the ankle joint (4, 8 and 16 weeks after surgery); assessment of quality of life according to Achilles tendon Total Rupture Score (8 and 16 weeks after surgery). It was conducted the evaluation of the results of patients' treatment according to Leppilahti scale: consists of seven points, six of which have a maximum score of 15; one point is maximally estimated at 10 points [17] (16 weeks after the operation).

Statistical analysis. Materials of the study were worked out in the program of statistical analysis – IBM SPSS 21. Mathematical processing of numerical data was carried out using methods of variation statistics. The analysis of the correspondence of the type of distribution of the quantitative indices of the normal distribution law was checked by the criterion of Shapiro-Wilka (W). For quantitative indices with normal distribution, the average ($\bar{x}$) and the mean square deviation (S) were determined. For quantitative indices with distinctions from normal distribution were additionally determined the median (Me) and the upper and lower quartiles (25%, 75%). The Wilcoxon criterion (for independent groups) was used to assess the significance of the difference between the baseline and control groups.

Results

The results of the statistical analysis of the obtained goniometric indices revealed the peculiarities of their dynamics and the existence of significant differences between the groups (Table 1). According to the results of the angle of planter flexion at the time of four weeks after surgery, the differences between the MG and CG were found ($p<0.01$) to be significant (Table 1). The average results were 29.1±1.19° in the MG and 28.1±1.13° in the CG. The subsequent examinations in eight and sixteen weeks did not reveal significant differences ($p>0.05$) in terms of the angle of planter flexion (Table 1). The average results in patients of the MG were 36.5±2.61° for eight weeks and 39.6±4.27° for sixteen weeks after surgery. In patients of the CG, these results were 35.8±3.08° and 39.1±4.12° respectively.

So, the dynamics of the deficiency of the amplitude of plantar flexion in the MG was as follow: in four weeks – 11.5±3.64°; in eight weeks – 4.2±2.58°; in the sixteen weeks 1,0±1,60°. Among the control group, the deficit of plantar flexion was: in four weeks 12.3±3.90°; in eight weeks – 4,5±2,06°; in the sixteen weeks 1,2±1,30°.

According to the results of the statistical analysis of the obtained indicators of the angle of the dorsal flexion,

Table 1. Statistical indices of goniometry in the dynamics of restorative treatment, degrees

Indicators	Group	Result of healthy lower limb	Time after surgery		
			4 weeks	8 weeks	16 weeks
			Me (25; 75)		
Angle of plantar flexion	MG	41 (39; 45)	29 (29; 30)	37 (35; 38)	40 (37; 43)
	CG	41 (39; 43)	28 (27; 29)	36 (35; 38)	40 (36; 41)
	p	>0,05	<0,01	>0,05	>0,05
Angle of dorsal flexion	MG	15 (13; 18)	-15(-17; -15)	6 (5; 7)	12 (10; 13)
	CG	14 (13; 18)	-15(-16; -15)	4 (3; 5)	9 (7; 10)
	p	>0,05	>0,05	<0,01	<0,01
General amplitude	MG	56 (52; 64)	14 (12; 15)	43 (40; 44)	43 (48; 56)
	CG	55 (52; 60)	12 (11; 13)	41 (38; 43)	49 (43; 52)
	p	>0,05	<0,05	<0,05	<0,05

Note: p – the level of reliability.

at the time of four weeks after the operation between the groups was not found any significant differences (p>0,05) (Table 1). The average results of the MG were 15.7±1.16°. The average results of the CG were – 15.5±1.05°. In the eight weeks after the surgery the analysis of the results of the index of the dorsal flexion angle revealed a significant difference between the groups (p<0.01). At this stage, the average values were: in the MG and CG 6.0±1.10° and 4.1±1.34° respectively. A statistically significant difference was maintained at the time of the final survey (p<0.01). The average values are set at 11,9±2,15° in the MG and 8,4±1,97° in the CG.

So, the dynamics of the dorsal flexion amplitude deficiency in the MG was as follow: in four weeks – 30.8±2.64°; in eight weeks – 9,2±2,65°; at sixteen weeks 3.2±1.85°. Among the control group, the deficit of plantar flexion was as follow: in the four weeks 30.7±2.80°; in eight weeks – 11,0±2,81°; in sixteen weeks, 6.8±2.06°.

According to the results of the overall amplitude index, for all three examinations of the operated limb, it was found a statistically significant difference (p<0.05). In the main group, the overall amplitude was: in the period of four weeks 13.47±1.98°; in eight weeks – 42,5±3,12°; at sixteen – 51.6±5.98°. Among patients of the CG, the following values were recorded: 12.5±1.62°, 39.9 ± 3.70° and 47.4±5.46° respectively.

In all three surveys the percentage of decrease in the total amplitude of the motion in the ankle (its deficiency) was statistically significantly different between the groups (Table 2). So at the time of the survey in four weeks after the surgery, the deficiency of the general amplitude was: in the MG 75,4±2,55%; in the CG – 76.9±2.39%. In eighth week after the surgery, this indicator improved and made up: in the MG 22,7±6,03%; in the CG 27.1±4.49%. At the final stage, the percentage reduction in the overall amplitude was: in the MG 6.8±4.28%; in the CG – 13,7±3,64%.

It should also be noted that the withdrawal of the ankle joint at 0° was observed on average: among the patients from the MG – by 11.7±1.12 days after the removal of gypsum immobilization [at Me (25; 75) – 12 (11; 13) days]; among the patients of the CG – 13.2±1.62 days (Me (25; 75) – 13 (12; 14)). The difference between this indicator was statistically significant (p<0.01)

The dynamics of quality of life are the main criterion for the effectiveness of physical rehabilitation [4]. The dynamics of quality of life was studied on the results of the questionnaire (Table 2), which is related to the symptoms and level of physical activity of patients.

The dynamics of Me (25; 75) indicators of the total quality of life score have the following features. The first application of the questionnaire in the eight weeks after the surgery has statistically better results in the MG. In the CG, the scores are lower (p<0.01), the value of Me (25; 75) is: in the MG – 41 (38; 44) points; in the CG – 36 (34; 39) points. The following and final questionnaires revealed that, at the sixteenth week after the surgery, the results of the general score increased in the groups of patients. The results remained significantly different (p<0.01) with the advantage in the main group (Table 5.6). Indicators of Me (25; 75) after the completion of the course of physical rehabilitation are as follow: in the MG – 82 (78; 84) points; in the CG – 74 (72; 77) points.

For evaluation of the results of treatment and consequences it was used the Leppilahti at al. Scale of assessment of the results of patients' treatment [17].

According to the pain in the Scale of assessment both groups have high score (Table 3). The statistical difference in pain was not established (p>0.05). Note that the average score was: in the MG – 14.3±1.73 points; in the CG – 13,8±2,18 points.

The indicator of the MG and CG significantly differed from the point of the scale of "stiffness" (p<0.01). The statistical results were better in the MG (Table 3). The average value is set at the level: in the MG – 14,7±1,27 points; in the CG – 12.6±2.54 points.

The statistical analysis of the subjective characteristic of the force of plantar flexors (the III point of the scale) established the existence of a significant difference between the results of the groups (p<0,01). Thus, the patients of the MG have significantly better results (Table 3). In addition, the average value was: in the MG – 8.7±2.92 points; in the CG – 6.7±2.42 points.

The statistical analysis of observations according to the "restriction in shoes" revealed a significant difference between the groups (p<0.01). This fact confirms the presence of better scores among the patients of the MG (Table 3). Also the higher was an average score of the patients of the MG – 8.7±2.25 points. The CG had 6.9±2.47 points.

The "amplitude" point reflects the degree of difference between the ranges of the ankle joints on the healthy and injured limbs of the patient. The "amplitude" point significantly differed (p<0.01) in the MG and CG (Table 3). Note that the average value was: in the MG – 13.2±2.45 points; in the CG – 10.0±3.27 points.

The point "subjective treatment result" indicated satisfaction with the result of treatment by the patient himself. This point had statistically significant difference between the average results of groups of patients (p<0.01). Note that the average score was: in the MG – 14.2±1.90 points; in the CG – 12,1±2,51 points.

According to the results of the "isokinetic strength" the statistical difference was also better in the MG (p<0,05). The average values of the indicator in the groups of patients were: the MG – 10,2±2,78 points; the CG – 8,6±2,27 points.

The total score by the Scale of assessment [17] was also significantly (p<0.01) better among the patients who have reducing treatment on the developed program. Note that the average values in the groups were: in the MG – 83.8±8.58; in the CG – 70,7±10,58 points.

In addition, in the distribution of the total score of the scale (according to Leppilahti at al. [17]) were revealed the peculiarities in the gradation (Figure 1): more than 90 points – excellent result; 89-75 points – good, 74-60 – satisfactory; less than 60 – unsatisfactory. Among the patients of the CG predominate the score as "excellent"

Table 2. Statistical indicators of quality of life (Achilles tendon total Rupture Score) in the dynamics of rehabilitation, scores

Index	Group	Time after surgery 8 weeks Me (25; 75)	16 weeks
Total score	MG	41 (38; 44)**	82 (78; 84)**
	CG	36 (34; 39)	74 (72; 77)
Limitation at force	MG	4 (3; 4)**	7 (7; 8)*
	CG	3 (2; 3)	7 (6; 8)
Limitation through tiredness	MG	4 (4; 5)*	8 (7; 8)*
	CG	4 (3; 4)	7 (7; 8)
Limitation through immobility	MG	5 (4; 6)**	8,5 (8; 9)**
	CG	4 (3; 5)	7 (6; 8)
Limitation through pain	MG	5 (4; 6)*	8 (7; 9)**
	CG	4 (3; 5)	7 (7; 8)
Limitation in everyday activity	MG	7 (6; 7)**	9 (8; 9)**
	CG	6 (4; 7)	8 (7; 8)
Limitation in walking on uneven surface	MG	5 (4; 6)*	8 (8; 9)**
	CG	4 (3; 5)	7 (7; 8)
Limitation in fast stair climbing	MG	3 (3; 3)	9 (8; 9)**
	CG	3 (3; 3)	8 (7; 8)
Limitation in running	MG	1 (0; 2)	8 (7; 8)**
	CG	1 (0; 2)	7 (7; 8)
Limitation in jumping	MG	1 (0; 2)	8 (7; 8)**
	CG	1 (0; 2)	7 (7; 8)
Limitation in hard physical activity	MG	6 (6; 7)	8 (8; 9)
	CG	6 (6; 7)	8 (8; 9)

Note. * - the difference between the indicator is statistically significant comparing to the control group at the level p<0,05; ** - p<0.01.

Table 3. Statistical measures by the Scale of assessment (by Leppilahti at al. [17]) after rehabilitation, scores

Index	Group MG Me (25%; 75%)	CG
Pain	15 (15; 15)	15 (15; 15)
Stiffness	15 (15; 15)**	15 (10; 15)
The strength of plantar flexors (subjectively)	10 (5; 10)**	5 (5; 10)
The restriction in shoes	10 (5; 10)**	5 (5; 10)
Amplitude	15 (10; 15)**	10 (10; 10)
Subjective result	15 (15; 15)**	10 (10; 15)
Isokinetic strength	10 (10; 10)*	10 (5; 10)
Total score	85 (80; 90)**	70 (65; 80)

Note. * - the difference between the indicator is statistically significant compared to the control group at the level p<0,05; ** - p<0.01.

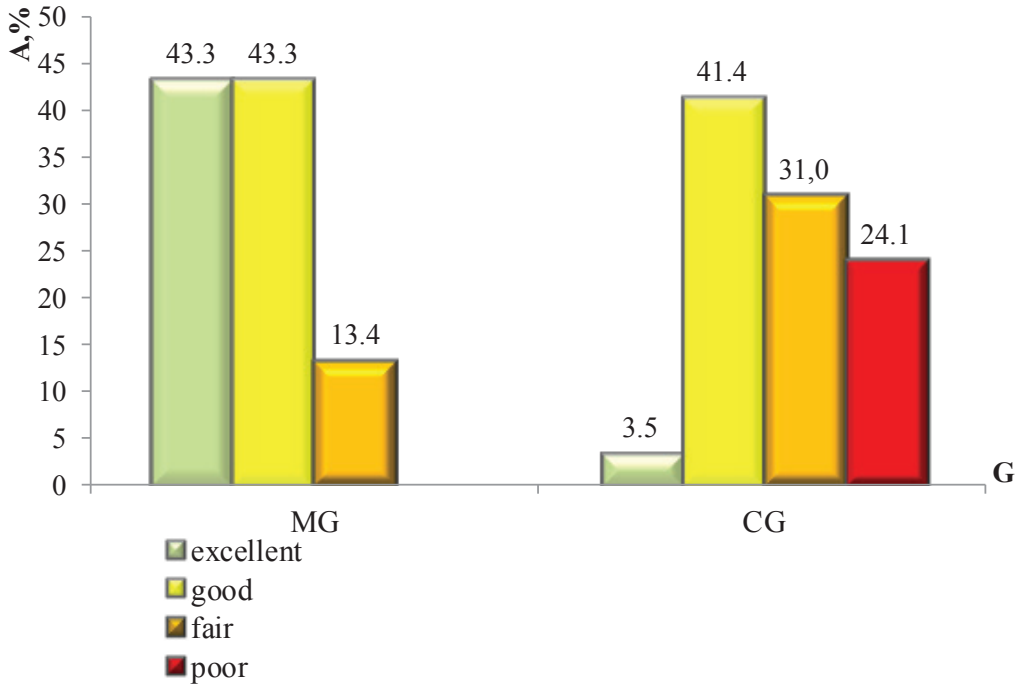

Fig. 1. Distribution of the total score of the scale for the evaluation of the results of patients' treatment with Achilles tendon ruptures (according to Leppilahti at al. [17]) according to the gradation of the results: A - percentage of patients,%; G group; MG – main group; CG – control group; excellent – excellent result (excellent); good – good result (good); fair – satisfactory result (fair); poor – unsatisfactory result (poor).

and "good" (by 43.3%). Other patients (13.4%) had satisfactory treatment results. Among the patients of the CG, the distribution of indicators was worse. In the CG only a small percentage of patients (3.5%) were rated "excellent". The largest proportion of patients in the CG was rated "good" (41.4%).

An essential proportion (31%) of patients of the CG received satisfactory result. In the CG, an unsatisfactory result was 24.1%. There was no satisfactory result in the MG.

Discussion

The obtained results point to the possibility of improving the effectiveness of physical rehabilitation in the application of a more intense program. However, the algorithm for rehabilitation should never be transformed into a template. When creating a rehabilitation program, one should give preference to a method that can restore the performance of the patient with the lowest risk and in the shortest time with the best anatomical and functional result.

The dynamics of the indicators shows that the level of restoration of the functional state of the joint and modern methodological approaches to the construction of the rehabilitation program affect the quality of life of the patient.

The conducted research and the obtained results confirm statistical data on the dynamics of goniometric indices during restorative treatment. Thus, in the work of Ayub Hussein Mussa [1], it was reported that the athlete group did not differ from the control group of athletes after the surgical treatment of the Achilles tendon and the course of accelerated and intensive rehabilitation (the standard rehabilitation program was used). But according to the index of dorsal flexion there were significant differences between the groups of athletes. Thus, in this study the groups of athletes had similar dynamics in goniometry indices.

The research of Lantto I. [16] concerned the evaluation of long-term results (11.0±0.9 years) of the usage of various protocols of monitoring patients in the early postoperative period. The author found that the average score on Leppilahti scale was: in the group with early mobilization and use of the brace – 92.9±5.6; in the group with immobilization in a stretched state – 93,6±7,2 points. No statistical differences were found.

Willits K. et al. [27] investigated patients who had surgical intervention and conservative treatment. In two years after the acute rupture of Achilles tendon according to Leppilahti scale the indicators were as follow: 82 points – among patients who had surgical intervention; 83 points – among patients in the group of conservative treatment. These values are considered good, but not different.

Thus, the study of the effectiveness of surgical treatment, and rehabilitation measures should take into account biomechanical parameters and quality of life of patients.

Conclusions

The rupture of the Achilles tendon and immobilization after surgical treatment lead to a decrease in the amplitude of the dorsal and plantar flexion, quality of life.

A condition for improving the dynamics and results of the recovery process in patients after the Achilles tendon ruptures is: modern methodological approaches in the organization of the rehabilitation process; taking into account the philosophy of the international classification of functioning and methods of determining the SMART goals; appropriate combination of means.

The restoration of the amplitude of the dorsal flexion is more slowly than planar. The dynamics of restoration of functional indicators of the lower limb and quality of life was significantly better among patients undergoing rehabilitation course on the developed program.

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Conflict of interest

The authors state that there is no conflict of interest.

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