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Qualimetry of Psychophysiological Parameters in Aerobic Gymnastics

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Abstract. The article presents the results of psychophysiological study of girls of the Tyumen region national team in aerobic gymnastics. There were three age categories: girls 9–11, 12–14 and 15–17 years old. Diagnostics of psychophysiological states was carried out at the end of the training season using three methods: complex visual-motor reaction, reaction to a moving object, functional mobility of nervous processes. It was determined that most often aerobic athletes have a low level of complex visual-motor reaction, very high functional mobility of nervous processes, as well as a characteristic shift of nervous processes towards inhibition. There is a tendency of increase in the number of athletes with a shift of nervous processes towards excitation with age.

Keywords: psychophysiology, complex visual-motor reaction, reaction to a moving object, functional mobility of nervous processes, sports reserve, aerobic gymnastics, qualimetric approach.

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Квалиметрия психофизиологических параметров в спортивной аэробике

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Аннотация. В статье представлены результаты психофизиологического исследования девушек сборной команды Тюменской области по спортивной аэробике трех возрастных категорий 9–11, 12–14 и 15–17 лет. Диагностика психофизиологических состояний проводилась в конце учебно-тренировочного сезона по трем методикам: сложная зрительно-моторная реакция, реакция на движущийся объект, функциональная подвижность нервных процессов. Определено, что чаще всего аэробистки имеют низкий уровень сложной зрительно-моторной реакции, очень высокую функциональную подвижность нервных процессов, а также характеризуются смещением нервных процессов в сторону торможения с тенденцией увеличения количества спортсменок со смещением нервных процессов в сторону возбуждения с возрастом.

Ключевые слова: психофизиология, сложная зрительно-моторная реакция, реакция на движущийся объект, функциональная подвижность нервных процессов, спортивный резерв, спортивная аэробика, квалиметрический подход.

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Introduction

International anti-Russian sanctions, the consequences of the pandemic, and increased hypodynamia due to widespread digitalization have strengthened the focus of the Russian Government's policy on the formation of a healthy generation, improved identification of talents and support for the ideas of young people in different regions of Russia.

The Strategy for the Development of Physical Culture and Sports in the Russian Federation until 2030 and *The Concept for the Development of Children's and Youth Sports in the Russian Federation until 2030* indicate that the Government of the Russian Federation is extremely interested in the education of an able-bodied, hard-working young generation with the wish to lead a healthy lifestyle. This actualizes the need for constant monitoring of the condition of students and the level of their fitness for the timely regulation of the volume and intensity of training activities, which will ensure the health of the young generation.

The management of sports training used to be carried out by outstanding Soviet scientists, thanks to their scientific research Soviet sports science became world famous. This happened due to the outstanding achievements of Soviet athletes, starting with the first Olympic Games in which the USSR national team participated (Helsinki, 1952), and the fundamentality of pedagogical theories justifying the structure,

contents and components of multilevel sports training, as well as the significance of verifiable and valid ways of assessing quality of sports training.

The key difficulties in assessing the quality of the athletic training process are the extraordinary variety of means and forms of the training process, varying superiority/weighting of different types of training, as well as the diverse conditions for implementing training programs and even the styles of pedagogical activity, often opposingly affecting performance in different sports. Often, many researchers are so interested in only one of the above-mentioned components of training that they do not even make an attempt to apply a systematic approach to the training process using the qualimetry methods.

Qualimetry (the science of measuring quality by quantitative indicators) involves ordering an infinite set of properties of an object or process in the form of a multi-level hierarchical structure – a tree of properties. Qualimetry is based on the need to calculate the coefficient for each property of an object or process, which will allow researchers to take into account the expression of this property and its unequal importance among other properties. The universality of the qualimetric methodology of quality assessment proposed by G. K. Azgaldov has spread its use literally in all spheres of human activity, including sports.

Psychophysiological testing is often used by specialists in extreme spheres of human activity, on whose efficiency the lives of other people may depend (drivers, pilots, employees of law enforcement agencies or energy industry). The qualimetry of psychophysiological training has been previously studied and proven effective by engineering psychologists to ensure the successful piloting with night vision goggles. In addition, the effectiveness of professional psychophysiological training of students as regards physical education has been proved by qualimetry methods.

M. A. Ovsyannikova, E. E. Bindusov, and Z. F. Zvereva concluded that the improvement of reactions to a moving object among students was observed mainly as a result of playing sports rather than doing cyclic and acyclic sports, which is directly related to the specifics of the activity. The results of V. S. Smirnov and V. P. Maltsev found a greater number of 12–13 year old girls with predominant strength of excitation; by the age of 13 there is a slight decrease in the quantitative indicators of accurate and delayed reactions, but the trend remains the same.

In the study of subjective assessment of spatial and temporal characteristics Y. V. Koryagina notes that gymnasts (like wrestlers and boxers) perceive time as something brighter, joyful and coloured, but with a low level of simple visual and auditory sensorimotor reactions.

Foreign researchers are also interested in the peculiarities of psychophysiological states. For instance, the research results of scientists in sports laboratories in France, Canada and the USA experimentally proved the highest level of postural stability of gymnasts in comparison with athletes of other sports, both with the use of vision and without it.

The psychophysiological study of V. Zisi, E. Giannitsopoulou, O. Vassiliadou, E. Pollatou and E. Kioumourtzoglou involved 33 of the best rhythmic gymnastics athletes in Greece and revealed that girls with the highest level of fitness outperformed girls with a slightly lower level of fitness only in memory and self-confidence, while no significant differences were found in simple visual-motor response.

Of particular interest are the studies of famous Romanian experts in the field of aerobic gymnastics, who tried to assess the level of difficulty in performing technical elements, not only from the position of physical development, but also through the psychological subjective opinion about the awareness of the movement itself and its control. As a result, it was found that, more often than not, aerobic athletes show a greater degree of concentration during the execution of the phase of the element with a greater number of errors registered.

Scientists from the University of Sriwijaya (Sumatra, Indonesia) evidenced the efficiency of introducing aerobic gymnastics in schools as part of the subject Physical Education, which allowed children 6–8 years old not only to increase the development of physical qualities, but also succeed in the cognitive development.

Having done a psychophysiological research in aerobic gymnastics, Y. S. Filippova states that most often aerobic athletes are characterized by good attentional set-shifting and increased attention span at the initial stage of training, low personality anxiety and slightly bigger aggressiveness.

The comprehensiveness and significance of the application of reference indicators of athletes' preparedness, including psychophysiological ones, in the long-term training is confirmed in the multiple editions of methodological recommendations of the Ministry of Sports of the Russian Federation and the Federal Medical and Biological Agency, regulating the conceptual apparatus, methodology and principles of development of model characteristics of various aspects of training of highly qualified athletes.

In this article we will present the results of one of the priority components of training in aerobic gymnastics, namely the psychophysiological status of female aerobic athletes and its dynamics due to age-related changes.

The problem of the study lies in the insufficient application of qualimetry methods in psychophysiological training of female aerobic athletes at all stages of sportsmanship development.

The aim of the study is to investigate the psychophysiological status to create model characteristics of female aerobic athletes in accordance with the set age categories of aerobic gymnastics (15–17, 12–14 and 9–11 years old).

Research methods and organization

The psychophysiological study encompassed 38 members of the Tyumen Oblast national aerobic gymnastics team of girls 15–17 years old – 21 % (all of them were awarded the category "Candidate for Master of Sports"), 12–14 years old – 50 % (1-class sports category), 9–11 years old – 29 % of athletes (2-class sports category).

In the sports season 2022–2023, the Tyumen Oblast aerobic gymnastics team girls became silver medalists of the Russian Championship (girls 15–17 years old), winners of the Ural Federal District (girls AGED 15–17 and 12–14) and All-Russian competitions (girls aged 15–17, 12–14, 9–11).

Among sportswomen of 15–17 years old the experience of aerobic gymnastics ranges from 6 to 10 years, and none of the sportswomen has "satisfactory" academic performance, 87.5 % study in grades 9 and 11 of general education school with good marks, 12.5 % – in college with excellent marks. Athletes 12–14 years old have from 3 to 8 years of experience, only 1 athlete has satisfactory school performance, 68 % study in grades 6–8 with good marks and 26 % – with excellent marks. In the age category of 9–11 years all athletes have been training from 4 to 5 years, all of them study in 3–5 grades of secondary school, with 45 % having excellent marks, 55 % – good.

It should be noted that all athletes take part in at least 5 competitions in other cities of the Russian Federation and go to two 10-day training camps during the sports and academic year.

Table 1. Social and demographic characteristics of the study

Age category	Birth year	Number		category	Years of raining	Best result in the season	Class	Marks at school		
		people	%					ex	good	sat
15–17	2006	4	21	CMS	8–10	Russian competition – 2 place	11 and college	1	3	
	2008	4			6–8		9		4	
12–14	2009	3	50	1-class	7–8	Ural Federal District competition, Tyumen Oblast – 1 place	8	1	2	
	2010	4			3–7		7	1	3	
	2011	16			5–7		5–6	3	8	1
9–11	2012	1	29	2-class	5	Tyumen Oblast competition – 1–3 places	5	1		
	2013	6			4–5		4	2	4	
	2014	4			4		3	2	2	

Psychophysiological research was conducted on the basis of the sports club of the Regional Public Organization "Federation of Sports Aerobics of Tyumen Oblast" at the end of the training season 2023 with the use of psychophysiological testing device "UPFT 1/30-Psychophysiologist" and a module of psychomotor tests based on the following methods:

1. Complex visual-motor response to a light stimuli combination.

2. Reaction to a moving object.

3. Functional mobility of nervous processes.

Aerobic gymnastics is a gymnastic sport and in comparison with other sports kinds of gymnastics (sports, rhythmic, aesthetic, cheerleading) is characterized by a high tempo of performance of complex coordination movements throughout the competitive exercise. In addition, competitive disciplines can be both individual and group, consisting not only of elements of complexity, performed by each aerobicist separately, but also rearrangements, interactions, supports together with partners, which requires aerobicists to demonstrate the teamwork skills, rational and optimal decision-making in the shortest possible time.

Complex visual-motor reaction in response to a light stimuli combination (CVMR-LSC) is designed to study the dynamics of nervous processes, functional state, efficiency and different features of decision-making in terms of reaction speed and the number of correct responses to light stimuli. The CVMR-LSC technique presents 30 light combinations to the person tested, of which the first 10 (5 correct and 5 erroneous) are for training, and the remaining 20 (10 correct and 10 erroneous) are for the test itself.

The method "reaction to a moving object" (RMO) is closely related to the methodology of CVMR-LSC. It evaluates the ability of a person to adequately perceive the changing conditions of activity in space and time, as well as to assess the equilibrium of the nervous system by the degree of excitation and inhibition. In total, the technique involves 35 movements of the arrow on the circle (in any direction), of which the first 5 are for training and 30 – for the test. The balance of nervous processes is interpreted by calculating the balance coefficient (BC = ratio of the sum of delay times to the sum of advance times) and then correlating it with tabular data ($0.9 < BC < 1.1$ – balance; $BC > 1.1$ – shift towards excitation; $BC < 0.9$ – inhibition).

In the training process of aerobic athletes, an impressive part of the total time is devoted to technical training (as in any other type of gymnastics), but in addition to improving the technique of execution of individual elements of complexity, technical training in aerobic gymnastics implies constant modernization of the configuration of the competitive exercise. Any of its components (aerobic movement combinations, transitions, interactions, rearrangements) can be subject to changes in a competitive exercise, therefore the effectiveness of the training process is largely predetermined by the aerobic athletes' ability to quickly grasp/perceive and reproduce new combinations of motor movements, which is driven by individual capabilities of perception, attention and thinking, which in turn depend on the mobility of nervous processes.

The technique for assessing the functional mobility of nervous processes (FMNP) was developed by A. E. Khilchenko and modernized by E. G. Cherepanov and K. V. Sugonyaev. The essence of the FMNP technique consists in the speed and accuracy of the subject's motor reactions in response to light signals, in case of a red stimulus it is necessary to press the 'yes' button, green – 'no', yellow – skip (it is necessary not to press the buttons). The FMNP technique is limited in time (120 seconds) and unlimited in the number of stimuli, as the number of stimuli presented will directly depend on the speed and accuracy of the subject's reactions. The time of presentation of the light stimulus decreases by 20 seconds with each correct response and accelerates until the number of errors does not exceed 50 % of the total number of signals.

The description of the results of the psychophysiological study for each technique will be presented from three perspectives:

1. Comparative analysis of performance between aerobic athletes of different age categories (15–17, 12–14 and 9–11 years old).

2. A comparative analysis of the performance of the best aerobicist girls (one from each age category) and the top three highest performing athletes from each age category compared with themselves and relative to other athletes in the same age category. The best aerobicists were selected among soloists of the Tyumen Oblast national team (athlete 1 (A1) in the 15–17 age category, athlete 2 (A2) in the 12–14 age category, athlete 3 (A3) in the 9–11 age category).

3. Comparative analysis of indicators concerning aerobic athletes of each age category.

Results and discussion

The lowest mean reaction time in the CVMR-LSC test was observed in the 15–17 age category and was 583 ms, in 12–14 age category – 658 ms. and in the 9–11 age category – 796 ms. It should be remarked that reaction time exceeding 530 ms. is characterized as a very low reaction speed in accordance with the interpretation of the results of the CVMR-LSC test in "UPFT – Psychophysiologist".

In terms of deviations of the aerobicists' real reaction to the light stimuli combination from the ideal one, the most perfect were the athletes of the age category 15–17 years old, who on average reacted 111 ms earlier or later to the appearance of the light signal, while the athletes of 12–14 years old demonstrated this deviation as 164 ms and girls of 9–11 years old – 205 ms. In terms of 'shortest reaction time' again aerobic athletes of 15–17 years old category showed the best results equal to 430 ms, while aerobic athletes of 12–14 and 9–11 years old category required a minimum of 472 and 553 ms. In terms of the average 'maximum reaction time' in response to the light stimuli combination, 9–11 year old athletes responded the longest, requiring 1228 ms, while aerobic athletes of 12–14 years old and 15–17 years old categories required a maximum of 1016 and 777 ms respectively.

Among the top 3 female athletes from each age category, only the athletes in the 12–14 year old group gave 100 % correct responses, which was better than the 12–14 year old average; the 15–17 year olds gave 95 % correct responses, and the 9–11 year olds gave 90 % correct responses, which was in line with the age category average. The top 3 female athletes in each age category had better average reaction times than their teammates in the same age category, however, in the age category of 15–17 and 12–14 year olds the average reaction time was lower than those of A1 and A2, while in the age category of 9–11 year olds A3 had the best time among both soloists and the top 3 female athletes.

As a result, the comparative analysis of the test results showed that the best aerobic athletes gave more correct reactions in the CVMR-LSC relative to their teammates, athletes 1 and 2 gave 100 % correct reactions, athlete 3–95 %, which is 5 % more (per one correct response) than the average for the relative age categories.

Table 2. Test results of aerobic athletes using the complex visual-motor reaction technique

age category	indicators	right reactions	mean reaction time	Deviation	min	max
15–17	personal	20	661	122	445	889
	$\bar{x}\pm\sigma$ 3 of the best	19±1,7	575±112	101±23	419±89	746±142
	$\bar{x}\pm\sigma$ in the group	19±1,2	583±102	111±36	430±75	777±138
12–14	personal	20	814	92	639	983
	$\bar{x}\pm\sigma$ 3 of the best	20±0	641±187	97±14	468±161	808±193
	$\bar{x}\pm\sigma$ in the group	19±1,4	658±138	164±116	472±131	1016±357
9–11	personal	19	568	134	340	768
	$\bar{x}\pm\sigma$ 3 of the best	18±1,2	690±111	182±43	453±98	990±196
	$\bar{x}\pm\sigma$ in the group	18±1,2	796±227	205±98	553±216	1228±396

Our attention was drawn to the performance of athlete 3 in the 9–11 year old age group, who demonstrated the shortest average reaction time to the light stimulus – 568 ms (93 ms less compared to A1 and 246 ms less compared to A2). She had the best time in the speed of correct answer – 340 ms (105 ms less compared with A1 and 299 ms less compared with A2) and her maximum reaction time was also shorter – 768 ms (121 ms less compared to A1 and 215 ms less compared to A2). Let us recall that aerobic athletes of 9–11 years old age category had the highest values for mean reaction time, minimum reaction time and maximum reaction time.

The longest mean reaction time was demonstrated by A2–814 ms, which prevails over the time values both among the best aerobic athletes of other age categories (A1–661 ms and A3–568 ms) and over the mean reaction time among all aerobic athletes of 12–14 years old ($\bar{x}$ for 12–14–657 ms). It should be born in mind that the spread of time between maximum and minimum reaction times for A1 was 444 ms, for A2–324 ms and for A3–428 ms. Thus, although A2 had the longest mean reaction time, she showed the most stable passing of the test.

Although the athletes showed different degrees of success in passing the CVMR-LSC test, but as a result of interpretation of the obtained test indicators, all 3 athletes had a very low level of reaction speed.

The analysis of the results of the 'reaction to a moving object' test for aerobic athletes showed that, as in the CVMR-LSC method, athletes of 15–17 and 12–14 years old categories have an equal number of normal responses (18), while athletes of 9–11 years old age group gave 5 normal responses to the stimulus behind. Here we can assume that the difference between the number of correct responses in athletes of 12–17 and 9–11 years old categories in the 'reaction to a moving object' test (60 and 43 %) is more significant than in the CVMR-LSC test (95 and 90 %), which can be explained by the lower level of spatial coordination while controlling the arrow's movement in younger children.

It was determined that 15–17 and 9–11 year old aerobic athletes had a significant predominance of delayed reactions, i.e. the athletes' responses were elicited after the arrow had passed the active light signal, over anticipatory reactions (before the arrow had passed the light signal). Athletes of 15–17 and 9–11 years old age groups responded to 63 % of stimuli with delayed reactions; to 36 % for 15–17 and 30 % for 9–11 years old with anticipatory reactions; while athletes of 12–14 years old gave 53 % of delayed and 43 % of anticipatory reactions on average. Here we can say that the majority of athletes 12–14 years old were in a state of balance of nervous processes, while the nervous processes of athletes 15–17 and 9–11 years old were shifted towards inhibition.

Table 3. Results of testing aerobic athletes by the method "reaction to a moving object" (by number of reactions)

age category	indicators	advances	delays	accurate reactions	delays	normal reactions
15–17	personal	0	9	0	21	14
	$\bar{x}\pm\sigma$ 3 of the best	0	11±3	0,3±0,6	18±3	18±6
	$\bar{x}\pm\sigma$ in the group	0	11±4	0,2±0,4	19±4	18±6
12–14	personal	0	14	0	15	18
	$\bar{x}\pm\sigma$ 3 personal	0	14±0,6	0	15±0,6	21±3
	$\bar{x}\pm\sigma$ in the group	0,2±0,5	13±2	0,3±0,5	16±2	18±4
9–11	personal	0	15	0	15	15
	$\bar{x}\pm\sigma$ 3 of the best	0	11±5	0,3±0,6	18±5	15±3
	$\bar{x}\pm\sigma$ in the group	0,4±0,7	9±4	0,2±0,4	19±4	13±3

The most frequently advance responses were given by 12–14 year olds – 13 times, and by 15–17 year olds – 11 times on average, and 9–11 year old athletes found it the most difficult to anticipate the movement of the arrow – 9 reactions.

We can also conclude that athletes are more successful in the CVMR-LSC technique than in 'reaction to a moving object', because according to the results of testing the first technique, athletes gave 95 % (15–17 and 12–14 years old) and 90 % (9–11 years old) of correct responses, while in 'reaction to a moving object' technique only 60 and 43 % (15–17 and 12–14 years old), which is clearly related to the amount of time to show the response, in CVMR-LSC is given 2 seconds to analyze, process and respond, and in 'reaction to a moving object' the time to react is less than 1 second.

The 3 most accurate athletes in each age category were 12–14 year olds with 21 normal reactions, i.e. reactions with a time ranging from –50 ms to +50 ms, which is 4 reactions more than the average for the whole age category. In the 9–11 year olds, the top 3 athletes also showed a higher number of normal reactions (15), but the 15–17 year old girls showed identical performance to the age category average of 18 normal reactions. No anticipatory reactions, i.e. reactions that were given 200 ms or more earlier than the ideal time, were identified among the top 3 aerobic athletes, but in terms of the number of anticipatory reactions, the top 3 athletes in the 12–14 and 9–11 years old age groups outperformed the group averages, while the 15–17 year old athletes matched the group average. The mean of delayed reactions for all top 3 athletes in all age categories was 1 less than the group average, however, only in the 12–14 year olds the top 3 athletes had differences of less than 1 reaction as regards the number of delayed reactions, while the 15–17 year olds had this difference equal to 3 reactions and the 9–11 year olds had the 5 number of reactions.

Among the most effective athletes in all age categories it was revealed that the most correct reactions were given by A2–60 %, which corresponds to the average values for the age category 12–14 years, and A3 showed 50 % of normal reactions, which on the one hand is less than that of A2, but 6 % more than the average for the group of athletes aged 9–11 years, whereas A1 gave 13 % less normal reactions than her peers.

According to the time parameters of the responses, it was determined that athletes of all age categories did not differ significantly in terms of time spent on advanced reaction, but as for delayed responses, it took athletes of 9–11 years old to respond 20 ms longer than athletes of 12–14 and 15–17 years old. On average, the response deviation of athletes in all age categories did not differ significantly (15–17 year olds – 48 ms, 12–14–46 ms, 9–11–53 ms). The mean values of anticipations, delays and deviations from the ideal reaction time of all 3 best

Table 4. Results of testing aerobic athletes by the method 'reaction to a moving object' (by reaction time in ms)

age category	indicators	mean of advances	mean of delays	mean of deviations	mean square deviation
15–17	personal	59	61	60	77
	$\bar{x}\pm\sigma$ 3 of the best	41±16	49±18	46±15	60±15
	$\bar{x}\pm\sigma$ in the group	42±14	52±14	48±13	62±11
12–14	personal	39	54	47	69
	$\bar{x}\pm\sigma$ 3 of the best	31±7	45±13	39±9	56±12
	$\bar{x}\pm\sigma$ in the group	42±10	49±12	46±10	67±15
9–11	personal	41	68	54	77
	$\bar{x}\pm\sigma$ 3 of the best	37±5	63±11	53±5	67±15
	$\bar{x}\pm\sigma$ in the group	45±15	70±12	63±12	73±14

aerobic athletes were closer to the ideal ones than in the groups divided by age categories; while A1 and A2 all had worse values than the group average, only A3 showed better reaction time compared to the group average.

As a result of testing of female aerobic athletes using the method of functional mobility of nervous processes, it was revealed a strong direct correlation of all indicators with the age of the athletes being tested. Thus, 15–17 year old aerobicist girls were able to give a response to 248 stimuli (136 correct, 112 erroneous) in 120 seconds, for 12–14 year old girls this value was 231 stimuli (126 correct, 104 erroneous), for 9–11 years old girl this value was 187 stimuli (102 correct, 85 erroneous). It has been determined that the level of development of functional mobility of nervous processes in 12–14 year old aerobic athletes is very close to the level of development of girls 15–17 years old (the difference between the average values of the total number of stimuli – 17) and is suggestively higher than the level of development of functional mobility of nervous processes in sportswomen 9–11 years old (the difference between the average values of the total number of stimuli – 44).

A1 and A2 demonstrated a very high level of functional mobility of nervous processes (252 and 251). In CVMR-LSC, A3 demonstrat-

Table 5. Results of testing aerobic athletes according to the method "functional mobility of nervous processes"

age category	indicators	total N of stimuli	correct	erroneous	score
15–17	personal	252	138	114	10
	$\bar{x}\pm\sigma$ 3 of the best	263±14	146±8	117±7	10
	$\bar{x}\pm\sigma$ in the group	248±28	136±17	112±11	9
12–14	personal	251	140	111	10
	$\bar{x}\pm\sigma$ 3 of the best	256±15	140±6	115±9	10
	$\bar{x}\pm\sigma$ in the group	231±19	126±11	104±8	8
9–11	personal	192	105	87	5
	$\bar{x}\pm\sigma$ 3 of the best	201±13	109±9	92±5	6
	$\bar{x}\pm\sigma$ in the group	187±17	102±8	85±9	5

Table 6. Qualimetry of psychophysiological status of girls in aerobic gymnastics

test	CVMR				Reaction to a moving object								FMNP			
age category	18+	15–17	12–14	9–11	18+		15–17		12–14		9–11		18+	15–17	12–14	9–11
Qual	speed of complex visual-motor reaction to light stimuli				shifting the balance of neural processes towards								functional mobility of nervous processes			
	low	very low			inhibition				excitation		inhibition		very high		high	low
Quan	average reaction time, ms				average values of deviation of real responses from ideal ones (i) in ms and number of delays (d)								total N of stimuli			
					i	d	i	d	i	d	i	d				
	419	575	641	690	44	7	46	18	39	15	53	18	260	263	256	201

*Quan – quantitative indicators, Qual – qualitative indicators.

ed the best results in terms of mean reaction time, minimum and maximum time, and as for the FMNP technique the number of responses to the light stimulus still corresponded to the level of aerobic female peers, although it exceeded it by 5 reactions (192 and 187 respectively).

As a result, it has been concluded that female aerobic athletes aged 15–17 have very high functional mobility of nervous processes, while those aged 12–14 have high mobility in contrast to those aged 9–11 who have low mobility. Thus, we recommend coaches-choreographers of children 9–11 years old to plan in advance the learning of components of the competitive exercise, or to lay down more hours for the correction of the composition in the competitive period of training.

Having interpreted the obtained results of the study, we proceeded to a comparative analysis with quantitative and qualitative indicators. This study is aimed at the girls of the Russian national team.

The qualimetric analysis showed that girls of three younger age categories had the same level of speed of complex visual-motor reaction in response to light combination – very low, but it should be noted that by quantitative indicators the differences between the reaction speed of girls aged 9–11 and 12–14 years old were 49 ms, between 12–14 and 15–17 years old – 66 ms, between 15–17 and 18 years old and older – 156 ms, and only athletes of the Russian national team and 9–11 years old differed reliably from each other. Thus, the athletes of each age category have differences in the average time of CVMR-LSC and these differences only increase with age.

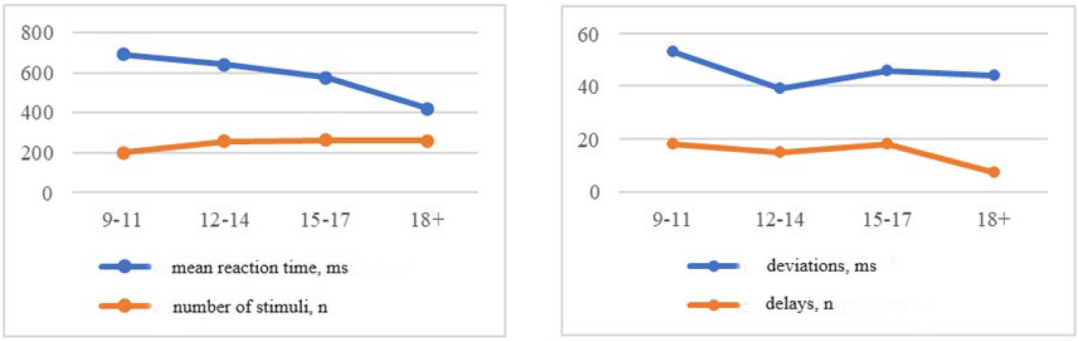
In terms of qualitative indicators of reaction to a moving object, it should be specified that only in the age category of 12–14 years prevail sportswomen with a shift in the balance of nervous processes towards excitation. Similar results were obtained in the studies of N.E. Vysotskaya, A.G. Pinchukova and J.E. Firileva, who explain this jump by the just begun puberty of girls 12–14 years old. At the same time, by quantitative indicators of average deviations in time of real reactions from ideal ones, no reliable differences were found among sportswomen of all age categories ($p>0.05$), but the girls of the Russian national team had a noticeably lower number of delayed reactions ($p<0.05$) compared to the athletes of younger age categories, who had no reliable differences among themselves ($p>0.05$).

As a result of mathematical and statistical analysis of the total number of stimuli presented in the method of functional mobility of nervous processes it was determined that the reliability of differences exists only between the indicators of girls 12 years old or older and girls 9–11 years old ($p<0.05$), the indicators of girls 12–14, 15–17 and 18 years old and older had no reliable differences ($p>0.05$). Aerobicist girls 12 years old and older are characterized by a high degree of mobility of nervous processes, which is consistent with the statements of E.P. Ilyin, V.V. Troshin and Yu. Troshin and Yu.S. Filippova about predisposition of people with mobile nervous system to the most effective recovery after submaximal physical load.

In addition, it was found that by the age category of 15–17 years the average reaction speed improves by 17 % (from 690 to 575 ms) (Fig. 1A), which correlates with the results of research on age-related psychophysiological changes in children in the scientific works of V.K. Balsevich, who pointed out that by the age of 15 the quality of response improves significantly, which leads to increased stability.

It was learned that the trends in the time of deviation of the real reaction from the ideal one and the number of delayed reactions are identical. Thus, by the age of 12 years, there happens a decrease in the mentioned indicators (from 53 to 39 ms and from 18 to 15 reactions), and by the age of 15 years there is a slight improvement (from 39 to 46 ms and from 15 to 18 reactions), which then decreases again in the age category of 18 years and older to 44 ms and 7 delayed reactions (Fig. 1B).

The dynamics in the total stimuli number while determining the degree of functional mobility of the nervous system of female aerobic athletes consists in a significant surge in values by 12–14 years of age (by 55 stimuli) and their insignificant changes with age (by 18 years of age by 4 stimuli).



A B

Fig. 1. Quantitative indicators of psychophysiological statuses of female aerobic athletes depending on age category A – CVMR-LSC and FMNP; B – reaction to a moving object

Conclusion

According to the results of CVMR-LSC testing, there was clearly observed an inversely proportional dependence of each indicator of reaction speed to the age of aerobicists, i.e. the older the athlete, the faster she is able to give a correct response (the mean reaction time of girls in 15–17 years old age group – 582 ms, 12–14 years old – 657 ms, 9–11 years old – 796 ms). As for the number of correct responses to the light combination, athletes 15–17 and 12–14 years old coped with the task more successfully (19 correct responses in each group) than athletes 9–11 years old (18 correct responses).

Interpretation of the results obtained after passing the 'reaction to a moving object' test presented that among aerobic athletes of 15–17 years old 75 % of girls have a shift of nervous processes towards inhibition and 25 % have a balance of nervous processes, among 12–14 years old the shift towards inhibition falls on 73 % of athletes, balance of nervous processes – on 21 % and towards excitation – 5 %, among girls of 9–11 years old only one has a balance of nervous processes, the rest have a shift of nervous processes towards inhibition.

Within the group of sportswomen of 15–17 years old 88 % of girls have very high functional mobility of nervous processes and 12 % – average, in the group of sportswomen of 12–14 years old the majority of girls (53 %) also have very high and 47 % high mobility of nervous processes, in the group of sportswomen of 9–11 years old 18 % demonstrate high mobility, 36 % – average and low, and 9 % – very low mobility of nervous processes.

Therefore we have found model characteristics of psychophysiological preparation of female aerobic athletes, which correspond to a low level of complex visual-motor reaction to the light combination, have a very high functional mobility of nervous processes, and demonstrate a shift of nervous processes towards inhibition.

The device of psychophysiological testing "1/30- Psychophysiologist" is one of the leading mobile diagnostic tools with the possibility of interpreting the results already stored in the database, but not appropriate for interpreting the results of athletes in aerobic gymnastics. Therefore, on the basis of the developed model characteristics and additional psychophysiological tests to increase the number of subjects in the future we will develop norms of quantitative indicators of girls and boys in aerobic gymnastics in accordance with age categories, which will lead to more effective management in the training process at all stages of sports training.

The obtained results of the study will expand the data bank of psychophysiological indicators of aerobic athletes from 9 years and older. This will serve as a basis for the qualimetric substantiation of the training management efficiency in aerobic gymnastics and information system aimed at personalizing the training process in gymnastic sports.

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