

Gender dimorphism of neurodynamic and cognitive functions of sub-elite and elite athletes (on the example of sports acrobatics)

Nataliia Veronika Bachynska¹, Dmytro Anisimov¹, Oleksandr Zhuravel¹, Dmytro Kaznacheiev¹, Vadym Fursa¹, Nataliia Martynova¹, Liudmyla Lysenko²

¹DNIPROPETROVSK STATE UNIVERSITY OF INTERNAL AFFAIRS, DNIPRO, UKRAINE

²NATIONAL UNIVERSITY "CHERNIHIV COLLEGE" NAMED AFTER T.G. SHEVCHENKA, CHERNIHIV, UKRAINE

ABSTRACT

Aim: To evaluate the impact of a specific acrobatic load on the neurodynamic and cognitive functions of acrobats, as well as to study how these functions change depending on the gender, age and level of sports qualification of athletes (sub-elite and elite athletes).

Materials and Methods: Athletes specializing in pair and group acrobatics, of two age categories: 1. Sub-elite - athletes of puberty age, which included: girls (n=32), average age 13.96±1.02 years; boys (n=36), average age 14.88±2.32 years. 2. Youth acrobats (elite athletes): girls (n=30), average age 19.36±2.86 years; young men (n=34), average age 20.38±2.89. The computer program "Diagnost-1" was used in researches.

Results: In female acrobats, the latency period of simple visual-motor information, the latent period of the visual-motor reaction to choosing two out of three stimuli are statistically different from those of young acrobats. Boys acrobats are faster in terms of functional mobility of nervous processes than girls in both age categories (at p<0.05). A greater amount of processed information was found in acrobat boys than in adolescent girls. According to the indicators of cognitive characteristics features of sexual dimorphism between acrobats of different age categories were revealed due to different information processing strategies taking into account sexual characteristics.

Conclusions: Boys-acrobats of puberty and adolescence showed more effective processing of simple and complex visual-motor information compared to girls-acrobats of the same age categories. The indicators of neurodynamic and cognitive functions of young acrobats are better than those of pubescent athletes and different by gender (p<0.05).

KEY WORDS: cognitive functions, sport, sexual dimorphism, technical readiness, acrobatics, neurodynamic indicators

Wiad Lek. 2025;78(1):61-70. doi: 10.36740/WLek/197138 DOI

INTRODUCTION

The problems of sexual dimorphism in sports have received considerable attention in recent years. And currently, this direction in the sport of higher achievements continues to be relevant. Every year there is an increase in the training exertion of female athletes, and in some cases they practically don't differ from those of men [1-3].

The analysis of a number of scientific works on the diagnosis of sensorimotor qualities of athletes of various sports and the prediction of effective sports activity showed that some experts cite examples of studies that showed the leveling of gender differences in female athletes when moving to the stage of higher sports skill [4].

Korobeinikov H., Prystupa Y, Korobeinikova L., Briskin Y. studied the peculiarities of the formation of the psychophysiological organization of the information

processing system in highly qualified athletes in martial arts, game sports and gymnasts [1].

Chernozub A., Kochyna M., Chaban I. et al. note that when comparing the psychophysiological indicators of hand-to-hand fighting athletes in the gender aspect, no reliable differences were found in the indicators of male and female athletes [5].

Other experts claim that changes in both morpho-functional indicators and psychophysiological functions are observed during sports in female athletes [6].

Fedorchuk S., Ivasevych D., Borysova O. et al. investigated the psychophysiological characteristics of handball athletes with different levels of motivation for sports results [7].

Other domestic scientists (Fedorchuk S, Lysenko O, Shynkaruk O.) considered the issues of constructive and non-constructive coping strategies and psychophysiological properties of elite athletes [8]. Vovkanych

L., Dunaets-Lesko A., Penchuk A., Karchmar P. studied the features of sensorimotor reactions of athletes of various sports specializations [9]. Features of psychophysiological status in combination with a number of other factors, such as physical development, technical, general and special physical fitness, features of the training process depending on the stage of multi-year improvement, determine the possibility of forecasting and achieving high sports results.

Studies of psychophysiological indicators allow scientists to qualitatively assess the functional state of the central nervous system of athletes and its changes in different periods of the annual training cycle and stages of multi-year improvement [10].

A high level of speed of sensory information analysis, the strength of nervous processes, lability are important for an accurate assessment of the psychophysiological status of athletes for a scientifically based analysis of their functional readiness and, if necessary, making corrections in the educational and training process [11]. High indicators of efficiency, accuracy, speed of visual signal perception are the basis for achieving high sports results. Sports acrobatics is a complex coordination sport, which is characterized by the speed of thinking and specific technical actions, the ability of acrobats to display their best psychological and physical qualities in the conditions of a stressful situation. In educational and competitive activities, athletes have various mental reactions in case of changes in psychophysiological functions [6, 12].

Therefore, the study of the structure and content of the manifestation of psychophysiological features of acrobats at important stages of sports improvement is significant and provides additional information about the functional state of athletes. The analysis of special scientific and methodical literature and Internet resources showed that the study of psychophysiological indicators for highly qualified athletes in pair-group acrobatics, taking into account sexual dimorphism, is lighting is not enough. This became the goal of our research.

The results of our research of the neurodynamic and cognitive functions of acrobats of different sexes, ages and qualifications when performing a specific load can make a significant contribution to the medical field, in particular in several important aspects:

1. Understanding the physiological and cognitive aspects of sports activities.

Studies of neurodynamic functions, obtained results, help to understand how acrobats of different genders, ages and qualifications (elite and sub-elite) react to complex specific loads. This can help design training methods to improve performance and reduce the risk of injury. Assessment of cognitive aspects of acrobats

in the important pre-competition period for athletes, such as attention, memory and the ability to make quick decisions, allows us to understand how athletes cope with competitive loads (a versatile mixed exercise is a multifunctional acrobatic action) that require a high level of concentration and quick decision-making.

2. Development of individual training programs for acrobats. The results of the neurodynamic and cognitive characteristics of acrobats of different ages, gender and qualification obtained during the study allow for the development of personalized training programs that take into account the individual characteristics of athletes to optimize their training and improve results in competitions.

3. Optimization of sports strategies. The results obtained during the experiment will be able to expand the range of knowledge about neurodynamic and cognitive aspects, which will provide an opportunity for the improved, necessary correction of the technique of performing acrobatic elements, in particular through the understanding of how reaction speed and cognitive load affect the performance of complex elements and acrobatic connections.

Thus, the results of studies of neurodynamic and cognitive functions of acrobats of different sexes in the age categories 12-16 and 17-23 years (sub-elite and elite) can significantly expand knowledge in the field of sports medicine, neuropsychology and cognitive sciences, which will help in further research and development of new training programs, improving safety, and promoting a general understanding of the physiological and cognitive aspects of sports activities.

The essence of the experiment in the study of neurodynamic and cognitive functions of acrobats of different genders, ages and sports qualifications consisted in the following aspects.

Thus, the scientific novelty of our work consists in the study from the standpoint of sexual dimorphism of changes in neurodynamic and cognitive functions of athletes of different sexes and age categories (12-16 and 17-23 years old) of different qualifications (sub-elite and elite athletes) under the influence of a specific load (universal acrobatic force-balance and tempo exercise), which is inherent only to pair-group acrobatics.

An important aspect follows from the above, that the results obtained in other sports cannot be used in the form of automatic data transfer in connection with the specifics of acrobatics. As you know, pair-group acrobatics is characterized by the educational and training process of athletes with a number of personal factors that can individually affect the personal performance of acrobats of different genders and ages. One of the most important factors is the delay in puberty (explained by

Table 1. Comparative characteristics of sensorimotor and neurodynamic indicators of acrobats of different gender before and after a specific exertion (pre-competition period)

Statistical indicators	Sub-elite athletes of puberty age				Elite athletes of youth age			
	To a specific exertion		After exertion		To a specific exertion		After exertion	
	Girls (n=32)	Boys (n=36)	Girls (n=32)	Boys (n=36)	Girls (n=30)	Young men (n=34)	Girls (n=30)	Young men (n=34)
	1	2	3	4	5	6	7	8
Indicators of the latent period of simple visual-motor information, milliseconds								
X±SD	255,70± 3,97	242,57± 6,05	244,02± 3,34	253,44± 6,19	245,00± 3,90	231,60± 6,26	252,45± 3,99	241,54± 8,36
Confidence level (p)	p _{1,2} < 0,05; p _{2,4} < 0,05; p _{3,4} < 0,05				p _{5,6} < 0,05; p _{6,7} < 0,05; p _{7,8} < 0,05			
Indicators of the latency period of the visual-motor reaction of choosing two out of three stimuli, milliseconds								
X±SD	384,70± 3,39	360,28± 6,21	398,61± 3,34	378,75± 4,85	367,38± 3,21	352,84± 5,84	379,16± 3,08	368,98± 5,12
Confidence level (p)	p _{1,2} < 0,05; p _{2,4} < 0,05; p _{3,4} < 0,05				p _{5,6} < 0,05; p _{5,7} < 0,05; p _{6,7} < 0,05; p _{7,8} < 0,05			
Indicators of functional mobility of nervous processes (imposed rhythm mode), seconds								
X±SD	98,81± 7,68	90,00± 2,23	88,87± 5,21	80,51± 2,17	89,44± 6,78	81,87± 2,30	84,07± 4,47	76,35± 2,57
Confidence level (p)	p _{1,3} < 0,05; p _{2,4} < 0,05				p _{5,8} < 0,05			
Indicators of the strength of nervous processes (imposed rhythm, number mistakes)								
X±SD	13,91± 2,55	10,29± 1,62	18,27± 2,82	14,89± 1,98	11,87± 2,28	9,50± 1,31	15,60± 1,84	13,92± 1,74
Confidence level (p)	p _{1,3} < 0,05; p _{2,3} < 0,05				p _{6,7} < 0,05; p _{6,8} < 0,05			
Indicators of the balance of nervous processes, milliseconds								
X±SD	18,03± 2,55	16,8± 1,62	22,93± 2,82	26,36± 1,98	16,24± 2,28	15,62± 1,31	20,83± 1,84	22,42± 1,74
Confidence level (p)	p _{1,4} < 0,05				p _{5,8} < 0,05			

Notes: the differences in the values of the indicators before and after the specific exertion, as well as between girls and boys are reliable according to the Mann-Whitney test (p < 0.05).

the specificity of the selection and loads in the multi-year structure of acrobats' training).

AIM

The purpose of this work is to evaluate the impact of a specific acrobatic load on the neurodynamic and cognitive functions of acrobats, as well as to study how these functions change depending on the gender, age and level of sports qualification of athletes (sub-elite and elite athletes).

TASKS

1. To determine the main neurodynamic indicators of acrobats of different sexes and ages.
2. Assess cognitive functions (attention, memory, ability to make quick decisions).
3. Compare the results among acrobats of different genders, ages and sports qualifications.

4. Evaluation of how a specific load affects various neurodynamic and cognitive aspects in acrobats of different genders, ages and sports qualifications.
5. To identify the relationship between neurodynamic and cognitive functions and specific load (mixed universal acrobatic exercise).

RESEARCH METHODOLOGY

1. Preparatory stage of the experiment: conducting basic tests to determine the level of neurodynamic and cognitive functions before carrying out a specific load.
 2. Evaluation of changes after exercise (re-evaluation) of neurodynamic and cognitive indicators to identify changes compared to initial data.
 3. Comparative analysis of results – analysis of changes in neurodynamic and cognitive functions in different groups before and after performing a specific load.
- On the basis of the received data, it is planned to develop, on a scientific basis, recommendations for opti-

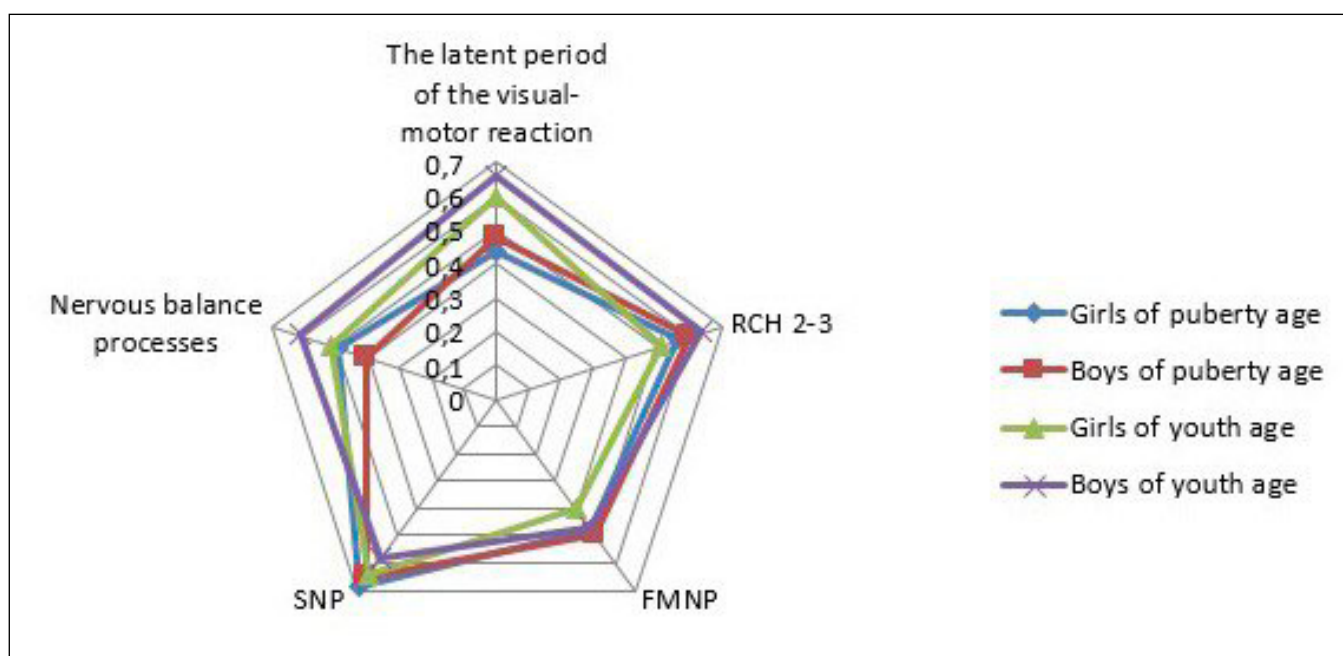


Fig. 1. Reliable correlations between parameters of psychophysiological characteristics and technical readiness of acrobats of different genders and age categories (pre-competition period).

mizing training programs, improving the technique of performing acrobatic exercises.

Thus, the experiment allows for a comprehensive study of the impact of acrobatic loads on neurodynamic and cognitive functions, which contributes to the improvement of understanding and optimization of training programs for acrobats of different genders, ages and qualifications.

MATERIALS AND METHODS

Athletes specializing in pair and group acrobatics, of two age categories: puberty and youth ages, participated in the experiment. The first age category (sub-elite) - athletes of puberty age, which included: girls (n=32), average age 13.96 ± 1.02 years; boys (n=36), average age 14.88 ± 2.32 years. Youth acrobats (elite athletes): girls (n=30), average age 19.36 ± 2.86 years; young men (n=34), average age 20.38 ± 2.89 .

For the reliability and security of the results of our study, the method of stratified sampling (homogeneous groups) was chosen, where the participants of the experiment were divided into groups by age, gender, and level of sports skill. Each of the groups included athletes of the same (from a statistical point of view) level of physical development and sports qualification, which increases the overall reliability, accuracy and use of data in practice, the results can be applied to a larger number of subjects and different situations. In this way, it reduces the bias of the result and the possibility of systematic error. The homogeneity of the sample was

revealed, it is representative of the general population.

The research was conducted in the pre-competition period with the study of individual typological properties of the higher nervous activity of acrobats with the help of the computer program «Diagnost-1» [1, 6, 10, 12]. Sensorimotor reactions of varying degrees of complexity were studied, namely: latent periods of simple and complex reactions, selection of two (RV2-3) from three signals, as well as individual-typological properties of the VND: functional mobility, strength and balance of nervous processes. A comparison of indicators before and after a specific exertion (mixed universal acrobatic exercise) was carried out.

Statistical processing was performed using the STATISTICA 10.0 computer program and MS Excel XP software packages. The main indicators of mathematical statistics were: arithmetic mean (X), standard deviation (SD), standard error of the arithmetic mean (m), Pearson-Brave correlation analysis (r). To study the differences between the indicators used, the non-parametric U-Mann-Whitney statistical test was applied, the level of significance was taken as $p < 0.05$.

ETHICAL STATEMENTS AND PARTICIPANTS

The studies were performed in accordance with all relevant national norms and rules of institutional policy and the National Health Council, according to the Declaration of Helsinki. All athletes and parents of minors gave written consent for the study and were informed of the purpose and procedures of testing and

Table 2. Results of evaluation of cognitive functions of acrobats depending on age, gender and age categories in the pre-competition mesocycle

Indicators	Acrobats of puberty age		Acrobats of youth age	
	Gender			
	Female	Male	Female	Male
	Group 1 (n=32)	Group 2 (n=36)	Group 3 (n=30)	Group 4 (n=34)
Time perception error (s)	9,54±3,74	9,32±4,02	7,25±3,24	7,15±3,56
Confidence level (p)	P _{1,2} >0,05		P _{3,4} >0,05	
Volume of voluntary attention (%)	72,37±7,89	70,98,98±6,28	79,45±6,78	74,39±6,18
Confidence level (p)	P _{1,2} >0,05		P _{3,4} <0,05	
Volume of short-term memory (%)	57,24±5,83	50,36±4,98*	64,87±6,12	56,84±5,78*
Confidence level (p)	P _{1,2} <0,05		P _{3,4} <0,05	
Coefficient of operational thinking (conventional unit)	1,76±0,45	1,23±0,54*	2,35±0,38	1,68±0,67*
Confidence level (p)	P _{1,2} <0,05		P _{3,4} <0,05	

Note: * – the differences compared to the Coefficient of operational thinking (conventional unit) group of female athletes are statistically significant according to the Mann-Whitney test ($p < 0.05$).

of the possibility of withdrawing consent at any time for any reason.

RESULTS

To effectively predict the reliability and success of sports activities, it is important to study the functional state of the central nervous system of athletes. In order to predict undesirable phenomena of emotional overstrain, to assess the emotional stability or, on the contrary, the instability of athletes, the characteristics of the behavior of acrobats in various conditions of training and competitive activities, an assessment of the typological characteristics of athletes was carried out [1, 6].

Studies of psychophysiological indicators were conducted in the pre-competition period after performing a specific exertion- a mixed (universal) acrobatic exercise, which combines force-balance and tempo elements to assess the level of adaptation of the functional systems of the body of acrobats of different sexes to conditions that cause an increase in the intensity of physical and psycho-emotional exertion.

Due to the fact that fatigue develops primarily in the central nervous system, in the process of researching the typological properties of the nervous system, the deterioration of indicators can determine the level of overtraining of athletes. In this case, timely correction of training exertion is extremely important in order to optimize the working capacity of those who are engaged.

Testing of simple and complex speed reaction is important, which allows to reveal the psychological readiness of athletes, which is important for monitoring

and predicting sports results at the same level as technical and physical training. According to the data we obtained, the speed of simple visual-motor information in young men is statistically significantly higher ($p < 0.05$) than the similar indicator in female acrobats (Table 1). This confirms the qualitative uniqueness of the neuro-functional organization of the male and female brain.

Age and sports experience are also important in the study of psychophysiological functions. This is confirmed by our data, where the comparative characteristics of athletes of puberty and youth ages showed statistically significant differences in most indicators of neurodynamic functions ($p < 0.05$).

Analyzing the obtained data, it can be seen that the indicators of the latent period of simple visual-motor information (Imilliseconds), the latent period of the visual-motor reaction of choosing two out of three stimuli (milliseconds) in girls are statistically different from those of young acrobats.

In the group of elite acrobats of youth age, statistically better indicators were found in terms of latent period indicators than in the group of athletes of puberty age ($p < 0.05$), including gender characteristics, which indicates their higher adaptive and compensatory capabilities of the body.

As is known, indicators of the functional mobility of nervous processes are used to characterize rapid changes in the processes of excitation and inhibition and the strength of nervous processes. The strength of nervous processes characterizes the endurance of the nervous system, working capacity, based on the obtained data, it is possible to draw conclusions about

the ability to tolerate both short-term and long-term excitation and inhibition.

Boys were faster according to the indicator of functional mobility of nervous processes than girls in both age categories (the difference is also significant at $p < 0.05$). A greater amount of processed information was found in acrobat boys than in adolescent girls, which corresponds to a higher level of strength of neural processes.

The strength of nervous processes (imposed rhythm, number of mistakes) tends to change this indicator in boys, but in comparison with girls, no statistically significant differences were found ($p > 0.5$).

However, after the specific exertion, the number of mistakes increased compared to the background indicators for both girls and boys (reliable differences were detected with a probability of 95%), which indicates the activation of adaptation processes as a result of performing a mixed exercise as a specific exertion (Table 1).

According to the indicators of the accuracy of reactions to a moving object, boys of puberty and youth have a statistically significant smaller amount of reaction deviations than girls acrobats, i.e. boys have a higher balance of nervous processes (95% probability level).

The next task was to perform a Pearson -Brave correlation analysis between the studied indicators (Fig. 1). A significant number of correlational relationships of psychophysiological characteristics and specific exertion in the form of a universal mixed exercise (points) was revealed.

The correlation analysis showed the informativeness of the values studied between the data characterizing the technical readiness of acrobats (scores) in the form of a universal mixed exercise (performance of a composition with force-balance and tempo exercises) of puberty and youth and psychophysiological indicators. The highest correlations were found between the specific exertion in the form of a mixed exercise and neurodynamic indicators in girls of pubertal age ($r = 0.435 - 0.689$; $p < 0.05$), in boys of pubertal age ($r = 0.405 - 0.652$; $p < 0.05$), in adolescent girls (puberty age) ($r = 0.402 - 0.643$; $p < 0.05$) and in adolescent boys ($r = 0.468 - 0.658$; $p < 0.05$).

According to the indicators of cognitive characteristics, during the research, the features of sexual dimorphism between acrobats of different age categories were revealed, namely: the coefficient of operational thinking (conventional unit) the volume of voluntary attention (%) and short-term memory (%) are statistically significantly better in the group of girls - acrobats of puberty and youth compared to boys and young men of the same age categories ($p < 0.05$) (Table 2).

DISCUSSION

A number of specialists were involved in the research of neurodynamic and cognitive functions of athletes in various sports. In the framework of our work, we will focus on individual publications of scientists, where specialists expressed different views, which were made in research, regarding the issues being studied.

Scientists studied the manifestation of sexual dimorphism of highly qualified judokas: Korobeinikova L., Korobeinikov H., Mishchenko V. et al. [13]. In the course of the experiment of the aforementioned experts, the indicator of the latent reaction time in athletes of different genders didn't have a statistically significant difference. However, it was found that there was a significant difference in terms of bandwidth and impulsivity between groups of judo athletes of different genders.

It was also revealed the presence of a reliable difference in terms of accuracy and stability between judo athletes of different genders. The best indicator of accuracy was found in female judokas, within the framework of these studies, better abilities to perform cognitive tasks that require concentration of attention and the involvement of the thinking function were found.

The stability indicator is significantly better in women, who have higher stability in the implementation of neurodynamic functions. According to the features of the manifestation of the balance of nervous processes, no significant difference between women and men engaged in judo was found. The study of cognitive functions in the above-mentioned groups showed significantly better indicators of short-term memory volume and operational thinking coefficient in women compared to men practicing judo.

Thus, on the example of studies in judo, the authors found that the functional organization of psychophysiological functions in highly qualified judo athletes has different information processing strategies depending on gender. The analysis of neurodynamic indicators in qualified athletes specializing in sports games didn't reveal any significant gender differences.

Research results obtained by specialists Korobeinikova L., Korobeinikov H., Berezhna A., Danko [14] established that the endurance of the nervous system in men is higher than in women practicing judo. At the same time, it was found that the speed of visual perception is better in women, and the efficiency is better in men, which indicates, from the authors' point of view, also the presence of faster perception of non-verbal stimuli in women (this indicates the predominance of non-verbal intelligence).

The data obtained by Korobeinikov H., Prystypa Y., Korobeinikova L., Briskin Y. [1] in athletes of complex coordination sports indicate a probably reduced time of the

motor component of the complex sensorimotor reaction in men compared to female athletes. Also, within the framework of the experiment of the above-mentioned authors, it was found that the values of the complex visual-motor reaction are significantly reduced in qualified sportswomen who are engaged in all-around sports compared to sportswomen who are engaged in complex coordination sports and sports games.

The specialists note that within the limits of the experiment conducted by them, the study of neurodynamic functions testifies to the excellent significance of the time indicator of both simple and complex sensorimotor reactions depending on the type of sport in men and women.

Interesting studies were conducted by Fedorchuk S., Kutsenko T., Yakovenko O., Lysenko O. (2023) [15]. These scientists determined gender differences in the state of psychophysiological functions based on indicators of the reaction to a moving object of qualified rowers with different levels of stress. The authors presented data that male athletes compared to female athletes demonstrated higher response accuracy to a moving object in total and mean deviation time, total delay time, and mean lead time when testing with the subdominant hand, and fewer delay responses during testing dominant hand.

Also, male and female subjects engaged in rowing sports differed in the ratio of the number of anticipatory reactions and the number of delayed reactions during testing with the dominant hand: in men, anticipatory reactions prevailed to a greater extent. The authors explain this by the predominance of visual-spatial coordination functions associated with the right parietal associative cortex in male rowers.

Research by Vilianskyi V., Bachynska N. (2019) [12] on the example of athletes engaged in karate and acrobatics, they showed the following: it was found that between girls and boys in both acrobatics and karate, a reliable difference was found with indicators of the latent periods of simple and complex visual-motor reactions and the strength of nervous processes. Better indicators of the strength of nervous processes and latent periods were found in young men of both sports ($p \leq 0.05$, probability level 90 and 95%).

Psychophysiological indicators of acrobat athletes and those who specialize in karate show better indicators against the background of a certain decrease in the level of neurodynamic characteristics in girls compared to boys.

Compared to acrobats, in karate athletes, the functional mobility of nervous processes is observed by higher values of the strength of nervous processes (at $p \leq 0.05$), that is, lower values of the percentage of false reactions, which may indicate a higher strength of nervous processes, for example, more significant

dynamics of specificity fights. The revealed difference in the speed of reactions between young acrobats and karate players, as well as female acrobats and karate girls, can be explained, for example, by the features of sexual dimorphism, the length of training in these sports, the specifics of training and competition (the difference is significant at $p \leq 0,05; 0,01$).

Sports activity has such an important component as the need for quick decision-making in connection with the specifics of the sport. Therefore, we used the evaluation of the current state of psychophysiological indicators and the control of the dynamics of sensory analyzers and the motor apparatus in research for an objective integral criterion of work and the state of the nervous system of acrobats [16, 17].

Our study showed that the latent period of simple visual-motor information (milliseconds), the latent period of the visual-motor reaction to choosing two out of three stimuli (milliseconds) in female acrobats statistically different from the similar ones in young men (95% probability level), which we deal with a higher level of psycho-emotional stress. This, in turn, can contribute to the development of inhibitory processes and a decrease in the efficiency of the nervous system.

According to the indicators of the accuracy of reactions to a moving object in boys and young men of puberty and youth ages, a statistically significant (95% probability level) smaller amount of reaction deviations was found than in female acrobats, i.e. boys and young men have a higher balance of nervous processes.

According to the obtained data, after performing a specific exertion, the latent period of the visual-motor reaction of choosing two out of three stimuli exceeds the simple visual-motor reaction in adolescent acrobat girls by 38.78%, in boys by 33.00%.

Among young athletes, this difference was 33.41% for girls, 34.53% for boys. We consider the change in sensorimotor reactions in elite acrobats after performing a control exercise within the limits of up to 35% as a marker of mobilization of functional reserves and restructuring of the regulatory mechanisms of the central nervous system in relation to adaptation to a specific load: a control mixed competitive exercise in which force-balance and tempo elements are balanced.

During the individual analysis of the obtained results in three female acrobats and two male acrobats of puberty age, it was found that the indicators of individual psychophysiological indicators decreased by more than 50% after a specific exertion compared to the background ones. This indicates a lack of optimal adaptation to those training exercises that were proposed and performed within the plans.

Exceeding the 35 percent decrease in the number

of accurate actions in spatio-temporal tests towards the deterioration of indicators after a specific exertion may be associated with a decrease in the adaptation capabilities of acrobats to competitive and training activities. Therefore, as methodical recommendations, we proposed the individualization of exertion, regular monitoring of the current condition of acrobats and timely correction of training process plans (can be used as an indicator of detecting low exertion tolerance).

Analyzing the data obtained during the study, it was found that female acrobats need more time to process visual information than male acrobats. In boys, these indicators indicate better possibilities of neurodynamic functions compared to acrobat girls. The detected increase in the number of mistakes in the interpretation of the results of simple and complex visual information after a specific exertion can be explained by an increase in the tone of the sympathetic nervous system.

Gender differences in the cognitive functions of acrobat athletes may be due to differences in the brain physiology of women and men, for example, the distribution of neurotransmitters or the volume of certain brain regions. But in practical activities, it is necessary to take into account the individual performance of each athlete, regardless of gender, taking into account strengths and weaknesses.

Thus, pair-group types of acrobatics contribute to positive adaptation in the vestibular and visual systems. It is necessary to regularly monitor neurodynamic and psychophysiological characteristics both in the preparatory and competitive periods at all stages of multi-year improvement, for timely adjustment of exertions in accordance with changes (indicators) of the functional state of athletes.

Thus, analyzing the data presented by a number of authors in various sports, as well as based on the results obtained by us in this work, it was found that in the majority of studies by scientists, there are gender differences in the neurodynamic and cognitive components of athletes. The absence of gender differences in individual indicators (tests) of neurodynamic functions indicates that the issues under study require additional scientific research and the minimization of factors that may affect the reliability of the results. This can serve as a strong basis for future research and the interest of scientists in a wider study of this aspect.

CONCLUSIONS

1. As a result of the experiment, the influence of specific acrobatic loads on the neurodynamic and cognitive functions of elite and sub-elite acrobatic athletes of different genders was assessed.

2. When determining the main neurodynamic indicators, it was found that in female acrobats, the latent period of simple visual-motor information and the latent period of the visual-motor reaction to the choice of two out of three stimuli were statistically different from those of male athletes (95% confidence level), due to a higher level of psycho-emotional stress. For example, after performing the specific load, in the group of sub-elite athletes of pubertal age, the latent period of simple visual-motor information for girls was 244.02 ± 3.34 , while for boys it was 253.44 ± 6.19 milliseconds (the difference is significant at $p < 0.05$).
3. According to cognitive characteristics during the study, features of sexual dimorphism between acrobats of different age categories were identified ($p < 0.05$) related to gender differences in cognitive functions in brain physiology between women and men (due to different information processing strategies considering gender characteristics): the operational thinking coefficient (conditional units), the volume of voluntary attention (%), and short-term memory (%) were statistically significantly better in the group of female acrobats of pubertal and youth age compared to boys and young men of the same age categories ($p < 0.05$). For example, the volume of short-term memory in female acrobats of pubertal age was $57.24 \pm 5.83\%$, while in male acrobats it was $50.36 \pm 4.98\%$ (the difference is significant at $p < 0.05$); the operational thinking coefficient for female acrobats was 1.76 ± 0.45 , while for male acrobats it was 1.23 ± 0.54 conditional units ($p < 0.05$).
4. In the comparative analysis of the results among acrobats of different genders, ages, and sports qualifications, it was found that in the group of elite youth athletes, the indicators of latent periods were statistically better than in the group of acrobats of pubertal age ($p < 0.05$), including by gender characteristics, indicating their higher adaptive-compensatory capabilities: boys were faster in terms of functional mobility of nervous processes than girls in both age categories (for example, in the group of elite youth athletes, this indicator for girls was 84.07 ± 4.47 milliseconds, while for boys it was 76.35 ± 2.57 milliseconds, the difference is significant at $p < 0.05$). Additionally, male acrobats showed a greater amount of processed information than female acrobats of youth age, corresponding to a higher level of strength of nervous processes. The strength of nervous processes (imposed rhythm, number of errors) showed a tendency to change in boys, but no statistically significant differences were found compared to girls ($p > 0.5$): after the spe-

cific acrobatic load, the number of errors increased compared to baseline indicators in both girls – from 13.91 ± 2.55 to 18.27 ± 2.8 – and in boys of pubertal age – from 10.29 ± 1.62 to 14.89 ± 1.98 (significant differences were found with 95% probability), indicating the activation of adaptive processes as a result of performing mixed exercises as a specific load.

5. The highest correlation relationships were found between specific acrobatic loads in the form of mixed exercises and neurodynamic indicators in girls of pubertal age ($r=0.435 - 0.689$; $p<0.05$), in boys of pubertal age ($r=0.405 - 0.652$; $p<0.05$), in girls of youth age ($r=0.402 - 0.643$; $p<0.05$), and in boys of youth age ($r=0.468 - 0.658$; $p<0.05$).

REFERENCES

1. Korobeynikov G, Prystupa E, Korobeynikova L, Briskin Yu. Otsinka psichofiziologichnykh staniv u sporti: [Evaluation of psychophysiological states in sports]: monograph. L.: LDUFK. 2013, pp.9-10 (Ukrainian)
2. Bachynska NV, Ivchenko O, Boguslavsky V et al. Study of indicators of heart rate variability of acrobats at the stages of long-term training in the aspect of sexual dimorphism. *Acta Balneol.* 2023;65 (3):142-147. doi: 10/36740/ABAL202303102.
3. Bachynska NV, Koshcheev O, Ivchenko O et al. Determination of the degree of manifestation of inversion of sexual dimorphism of female athletes of pair and group types of acrobatics. *Acta Balneol.* 2023;65(6):368-373. doi: 10.36740/ABAL202306104.
4. Negri-Cesi P et al. Sexual differentiation of the brain: role of testosterone and its active metabolites. *J. Endocrinol. Invest.* 2004;27(6):120-127.
5. Chernozub AA, Kochyna ML, Chaban IO et al. Pidvyshchennia efektyvnosti navchalno-trenavalnoi ta zmahalnoi diialnosti sportsmenok, yaki spetsializuiutsia v rukopashnomu boiu, na osnovi vykorystannia indyvidualnykh psichofiziologichnykh osoblyvostei [Increasing the effectiveness of training and competitive activities of female athletes who specialize in hand-to-hand combat, based on the use of individual psychophysiological characteristics]. *Ukrainskyi zhurnal medytsyny, biolohii ta sportu. Seriya «Fizkultura i sport».* 2017;6(9):69-74. doi: 10.26693/jmbs02.07.069. (Ukrainian)
6. Korobeynikov H, Vernydub K, Rossokha H et al. Psichofiziologichni funktsii vysokokvalifikovanykh sportsmeniv riznykh spetsializatsii [Psychophysiological functions of highly qualified athletes of various specializations]. *Moloda sportyvna nauka Ukrainy: zb. nauky z haluzi fizkultury i sportu.* L. 2005;9(1):62–63. (Ukrainian)
7. Fedorchuk S, Lysenko O, Shynkaruk O. Konstruktyvni ta nekonstruktyvni kopinh-strategii ta psichofiziologichni vlastyvoli elitnykh sportsmeniv [Constructive and non-constructive coping strategies and psychophysiological properties of elite athletes]. *Yevropeiska psichiatriia, Elsevier.* 2019;56:306. (Ukrainian)
8. Fedorchuk S, Ivasevich D, Borisova O et al. Psichofiziologichna kharakterystyka stanu sportsmeniv-handbolistiv z riznym rivnem motyvatsii do sportyvnykh rezultativ [Psychophysiological characteristics of the state of handball athletes with different levels of motivation for sports results]. *Sportyvna medytsyna ta fizychna reabilitatsiia.* 2020;(1):33-39. doi: 10.32652/spmed.2020.1.33-39. (Ukrainian)
9. Vovkanych L, Dunaets-Lesko A, Penchuk A, Karchmar P. Osoblyvosti sensomotornykh reaktsii sportsmeniv riznykh sportyvnykh spetsializatsii [Peculiarities of sensorimotor reactions of athletes of various sports specializations]. *Rukhova aktyvnyist, zdorovia i sport.* 2015;2(20):17–26. (Ukrainian)
10. Makarenko MV, Lyzogub VS, Golyaka SK et al. Osoblyvosti vlastyvolei psichofiziologichnykh funktsii u sportsmeniv z riznym rivnem sportyvnoi kvalifikatsii [Peculiarities of the properties of psychophysiological functions in athletes with different levels of sports qualification]. *Sports medicine.* 2008;1:174-180 (Ukrainian)
11. Xu S, Korobeynikov G, Mishchuk D, Lesya K. Osoblyvosti kohnityvnykh funktsii u kvalifikovanykh badmintonistiv [Peculiarities of cognitive functions in skilled badminton players]. *Teoriia i metodyka fizychnoho vykhovannia i sportu: naukovo-teoretychnyi zhurnal.* 2021;(1):9-12. doi:10.32652/tmfvs.2021.1.9-12. (Ukrainian)
12. Vilyansky VM, Bachynska NV. Osoblyvosti psichofiziologichnykh pokaznykiv sportsmeniv vyshchoi kvalifikatsii z urakhuvanniam statevoho dymorfizmu (na prykladi karate ta sportyvnoi akrobatyky). [Peculiarities of psychophysiological indicators of highly qualified athletes taking into account sexual dimorphism (on the example of karate and sports acrobatics)]. *Yedynoborstva.* Kharkiv. 2019;4(14):35-43. (Ukrainian)
13. Korobeinikova L, Korobeinikova H, Mishchenko V, Radchenko Y. Osoblyvosti statevoho dymorfizmu neirodynamichnykh funktsii u dziudoistiv vysokoi kvalifikatsii [Peculiarities of sexual dimorphism of neurodynamic functions in highly qualified judokas]. *Ukrayins'kyi zhurnal medytsyny, biolohiyi ta sportu.* 2017;1(3):220-224.
14. Korobeinikova L, Korobeinikov H, Berezhna A, Danko T. Osoblyvosti statevoho dymorfizmu neirodynamichnykh funktsii u zhinochii borotbi [Peculiarities of paternal dimorphism of neurodynamic functions in women's wrestling]. *Edinbrostva.* 2022;1(23):11-18. DOI: 10.15391/ed.2022-1.02. (Ukrainian)
15. Fedorchuk S, Kutsenko T, Yakovenko O, Lysenko O. Vidminnosti v reaktsii na rukhomiyi ob'iekt u kvalifikovanykh vesliariv z riznym rivnem stresu [Differences in the reaction to a moving object of qualified rowers with different levels of stress]. *Sportyvna medytsyna, fizioterapiya ta erhoterapiya.* 2023. doi:10.32652 /spmed.2022.2.27-32. (Ukrainian)

16. Makarchuk MYu, Chikina LV, Yarchuk PI et al. Vzaiemozviazok mizh stanom psykhofiziologichnykh funktsii liudyny ta yii zdatnistiu oriientuvatsia v prostori ta chasi za riznykh umov vidpovidalnosti za rezultaty diialnosti. [The relationship between the state of a person's psychophysiological functions and his ability to navigate in space and time under different conditions of responsibility for performance results]. *Zhyva fizyka*. 2009;17(1):185-192. (Ukrainian)
17. Yastochkina I. Osobystisna tryvozhnist yak sotsialno-psykhologichna problema. [Personal anxiety as a socio-psychological problem]. *Visnyk Lvivskoho universytetu. Seriiia «Psykhologichni nauky»*. 2020;(6):165–170. doi:10.30970/2522-1876-2020-6-24. (Ukrainian)

CONFLICT OF INTEREST

The Authors declare no conflict of interest

CORRESPONDING AUTHOR

Nataliia Veronika Bachynska

Dnipropetrovsk State University of Internal Affairs

26 Gagarin Avenue, 49005 Dnipro, Ukraine

e-mail: nat3vero@gmail.com

ORCID AND CONTRIBUTIONSHIP

Nataliia Veronika Bachynska: 0000-0002-0448-9187 **A B C D E F**

Dmytro Anisimov: 0000-0003-2893-8343 **B C D**

Oleksandr Zhuravel: 0000-0002-6830-150X **B C D**

Dmytro Kaznacheiev: 0000-0001-5193-7176 **B C D**

Vadym Fursa: 0000-0001-5962-8327 **B C D**

Nataliia Martynova: 0000-0002-8234-3968 **C D**

Liudmyla Lysenko: 0000-0002-3629-3840 **C D**

A – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article

RECEIVED: 14.05.2024

ACCEPTED: 09.12.2024

