

## Assessment of psychophysiological characteristics in water skiing athletes using the Bos-Test Software and hardware system

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### Abstract.

**Purpose:** Modern sports require ongoing research into the psychophysiological characteristics of athletes across various disciplines, including water skiing. Analyzing these results helps develop a clearer understanding of athletes' psychophysiological profiles. **Object.** This study evaluates indicators of simple visual-motor reaction, complex visual-motor reaction, reaction to a moving object, and performance on the tapping test. **Participants and Research Methods.** The study involved 9 athletes aged 7–9 years who practiced water skiing in the Dnipropetrovsk region. Written informed consent was obtained from all athletes' parents. The research was performed at the Dnipro Children's and Youth Sports School of Water Skiing and Wakeboarding. Testing to determine psychophysiological characteristics was conducted at the scientific laboratory of the Ukrainian State University of Science and Technology, Scientific and Educational Institute Prydniprovsk State Academy of Physical Culture and Sports. During the study, methods of theoretical analysis and generalization of scientific and methodological literature, pedagogical testing, pedagogical analysis, and testing of psychophysiological indicators using the software and hardware complex «Bos-test» were used. **Results.** The research showed that athletes exhibited high mobility of nervous processes, a high level of nervous processes, and a high level of interdependence between the average reaction time and the total number of errors. It was also determined that the indicators of the latent period of the left hemisphere's reaction are more stable compared to the right. In athletes, the processes of inhibition of the nervous system prevail, and the performance of the nervous system is determined at an average level. **Conclusions.** The planning and construction of the training process in complex coordination sports require an understanding of the psychophysiological characteristics of athletes. These characteristics can serve as individual criteria for predisposition to a specific type of sport. Due to the rapidly changing situations during the training and competitive process in water skiing, athletes are required to respond quickly and make decisions. These indicators play a very important role in the individual planning of the training process for young athletes. The conducted research allowed for the assessment of the psychophysiological characteristics of athletes engaged in water skiing. The obtained results allow for a focus on improving individual indicators based on the results of psychophysiological testing.

**Keywords:** water skiing, psychophysiological testing, athletes.

### Introduction.

Water skiing is a non-Olympic sport that has been gaining increasing popularity in worldwide in recent years (Daipaha et al., 2022; Thye et al., 1991). The initial training stage in water skiing occurs at the age of 7-9 years. According to Smirnovsky et al (2022) psychophysiological characteristics of athletes are among the most informative criteria of athletes' giftedness at the initial stages of long-term training. At this age, children's talents and abilities are revealed, and their health is strengthened. Young athletes master the basics of water skiing techniques, and their physical qualities are being developed. Therefore, at this age, it is very important to determine the psychophysiological features of children who are starting to engage in water skiing. Over the years of water skiing's existence, a training system has been formed that includes both training and competitive activities. This system includes physical, technical, psychological, integral, tactical, and ideomotor types of training (Suárez-Iglesias et al., 2024; Bray-Miners et al., 2012; Lance, 2024).

Experts note that sports mastery in water skiing is determined not only by well-developed physical qualities. The level of central nervous system activation, reaction speed, decision-making in complex situations, stress resistance, the degree of development of anticipation processes, and the type of nervous system are also of great importance (Suárez-Iglesias et al., 2024; Woodgate et al., 2021; Leggett et al., 1996). At this stage of

preparation, identifying the individual characteristics of children and their psychophysiological characteristics provides an understanding of how to structure the training process further for each athlete individually (Bray-Miners et al., 2013; Suderman et al., 2023). As the results of the analysis of scientific and methodological literature show, scientists have long been studying the psychophysiological features of athletes of various qualifications and specializations. Smirnovska et al. (2017) were engaged in determining the role of individual psychophysiological characteristics in the training system of water polo athletes; Korobeynikov et al. (2018) assessed the psychophysiological state of highly qualified wrestlers. Repko et al. (2018) compared the psychophysiological states of fencers, swimmers, and basketball players, Smirnovskyi (2017) assessed the psychophysiological characteristics of qualified fencers in splits. Podrigalo et al. (2023) conducted an analysis of the psychophysiological characteristics of taekwondo athletes.

As noted in his research by Borysiuk et al. (2022), a reduction in the duration of phases responsible for reaction speed contributes to a decrease in MT response time, which in turn leads to more effective motor activity. Janicijevic et al. (2022) in his research notes that athletes demonstrate better reaction time indicators compared to athletes who do not engage in sports. O'Sullivan et al. (2022) states that the functional reaction time of para-taekwondo athletes is significantly worse compared to athletes without disabilities. Quinzi et al. (2022) in his research studied the cognitive sensorimotor characteristics and reaction accuracy of athletes from various sports, such as badminton, martial arts, and climbing, and noted better reaction speed and fewer errors in them. In the studies by Tomic et al. (2021), it is noted that athletes engaged in football have better reaction speed compared to those who do not engage in sports.

According to the authors (Mullins, 2007; Korobeinikova et al., 2024; Borisova et al., 2019). They can also characterize the state of the functional system of the body, which is responsible for the level of technical preparedness of athletes. Also, during intense training activities, the assessment of an athlete's psychophysiological functions can be an indicator of the development of fatigue and overstrain in athletes (Raab, 2022; Zamirovna et al., 2021). The research results by Yao Q. (2022) indicate that reaction speed can be improved through the rational structuring of the training process. The authors (Tsatsiashvili et al., 2023; Katashinskaya et al., 2022; Halian et al., 2023) continue the thought of Yao Q (2022) and emphasize that the assessment of the psychophysiological characteristics of young athletes allows for the correct planning of the training process.

*The aim of the study is to assess the psychophysiological characteristics of athletes in water skiing using the software and hardware complex «Bos-test».*

## **Materials and Methods.**

*Participants.* The study involved 9 athletes aged 7-9 years, who are engaged in water skiing. Written consent was obtained from all parents. The study was conducted in accordance with the provisions of the Helsinki Declaration 'Ethical Principles for Medical Research Involving Human Subjects' and the 'Universal Declaration on Bioethics and Human Rights' on the principles of voluntariness, anonymity, and trust.

*Study organization.* The research was conducted at the Dnipro Children's and Youth Sports School for Water Skiing and Wakeboarding. Testing to determine psychophysiological characteristics was conducted at the scientific laboratory of the Ukrainian State University of Science and Technology, Scientific and Educational Institute Pridneprovsk State Academy of Physical Culture and Sports using the 'BOS-TEST-Professional' software and hardware complex. During scientific research in the laboratory, the functional state of the central nervous system of athletes and their changes in various psychophysiological states were assessed. During testing, significant attention was paid to the indicators of the latent period of simple and complex visual-motor reactions, the accuracy of reaction to a moving object with the determination of the number of anticipatory and delayed reactions, and the average deviation in reaction to a moving object. The dynamics of hand movement endurance in young athletes were studied using the tapping test method.

### *Testing Procedure*

#### Simple visual-motor reaction level (SVMRL)

The subject was sequentially presented with green light signals. Upon the appearance of the signal, the subject should press the button as quickly as possible, trying not to make mistakes (mistakes are considered as premature button presses and missed signals). The light signal was given at quite random moments in time so that a reflex to the time was not developed, yet regular enough for each subsequent signal to be expected. The interval between signals ranged from 0.5 to 2.5 seconds. The first 5-7 signals were 'trial' ones, intended for the adaptation of the subject and were not recorded. The number of proposed signals in one examination was 70, with a minimum of 30.

#### Level of complex visual-motor reaction (LCVMR)

During this test, the subject must react as quickly as possible to the presentation of a spotlight, which may flash green, red, or blue. The athlete had to press the button in response only to a stimulus of one color. In this testing, not only was the time of signal appearance random, but also its color.

Reaction to a moving object (RMO)

The reaction to a moving object involves performing a responsive movement (pressing a button on the instrument panel) to a specific signal – the convergence of moving objects at a single point. In this case, the respondent is required to stop the arrow moving around the dial at a specific mark. The subject, observing the movement of a point object, stopped the movement of the point object at the moment when its position was expected to coincide with the mark. Then the error of non-coincidence of the point object and the mark is calculated – the error time of delay with a positive sign or advance with a negative sign, and after a set time, the movement of the point object is resumed.

Tapping test

The subject must press a key on the computer keyboard as frequently as possible for 30 seconds. The number of dots placed is counted.

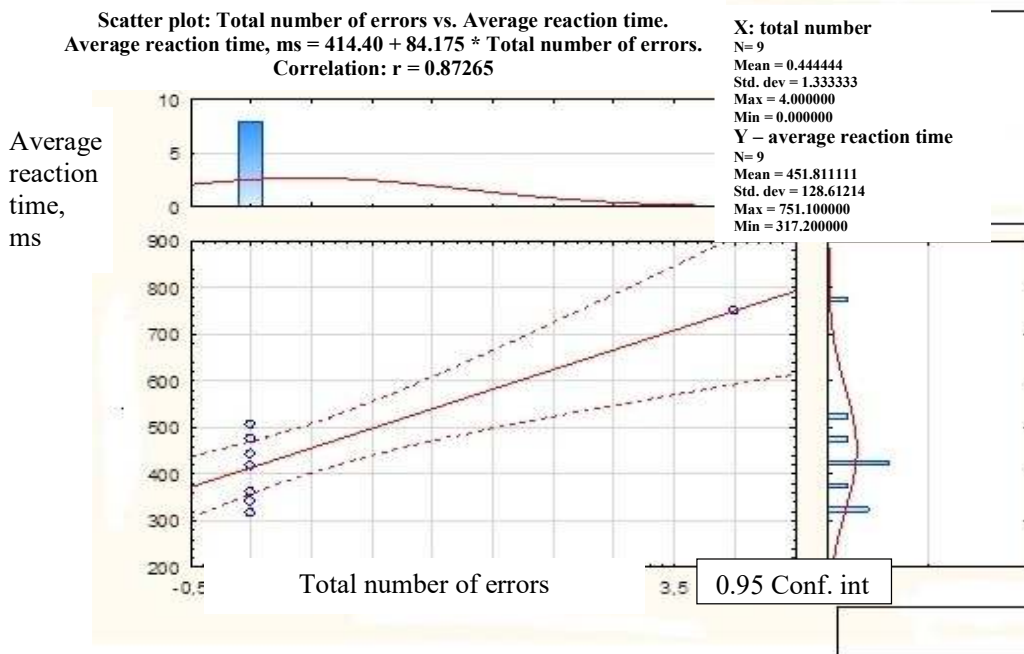
*Statistical analysis.* Statistical data processing was conducted using non-parametric mathematical statistics methods with the help of the STATISTICA 10.0 statistical package.

To describe all empirical data, the arithmetic mean ( $\bar{x}$ ), standard deviation (SD), median (Me), minimum value (Min), maximum value (Max), and in some cases the 25th (Q1) and 75th (Q2) quartiles were used –  $\bar{x}$  as they are much less dependent on extreme values or skewness in the data set than the mean and standard deviation.

**Results.**

To diagnose interhemispheric asymmetry during the testing of a simple visual-motor reaction, the task was proposed: right eye, right hand, and left eye, left hand. The results of the diagnosis are shown in Fig.1. The average SVMRL indicator, namely the reaction speed of athletes to a visual stimulus, indicates high mobility of nervous processes in both hemispheres of the brain. A high standard deviation was detected during the testing of the left hemisphere. The indicator of the average number of errors (left eye, left hand) indicates a high level of nervous processes, as it reflects the characteristics of attention concentration.

The results obtained when constructing the scatter plot during the testing of the left hemisphere (Figure 1) showed that the correlation between the total number of errors and the average reaction time was at the level of  $r = 0.87265$ .



**Figure 1.** Scatter diagrams of SVMRL when testing the left hemisphere

In Table 1 the correlation relationships between the parameters are presented. A high correlation was found between the total number of errors and the average reaction time ( $r=0.87$ ), a moderate correlation was established between the indicators of average reaction time and the overall level of functional state ( $r=0.64$ ).

A weak correlation was obtained when comparing the indicators of the total number of errors and the overall level of functional state ( $r=0.25$ ). A high inverse correlation was obtained between the indicators of error-free level and average reaction time ( $r=-0.87$ ), stability of reaction and overall level of functional state ( $r=-0.86$ ). No high or medium correlations were found between the indicators obtained during the testing of the right hemisphere.

**Table 1. Correlation between variables SVMRL during testing of the left hemisphere**

Variable	Total number of errors	Error-free level	Average reaction time, ms	Reaction stability	Overall level of functional state
Total number of errors	1,00	-1,00	0,87	0,027	0,25
Error-free level	-1,00	1,00	-0,87	-0,027	-0,25
Average reaction time, ms	0,87	-0,87	1,00	-0,38	0,64
Reaction stability	0,027	-0,02	-0,38	1,00	-0,86
Overall level of functional state	0,25	-0,25	0,64	-0,86	1,0

The obtained SVMRL test results allowed us to state the predominant activity of the left hand and left eye. The average sensorimotor reaction time, determined by the difference between  $\bar{x}$  and SD during the stimulus impact on the left eye and the response of the left hand, is shorter than during the impact on the right eye and the response of the right hand.

The results of Table 2 showed that the latent periods of complex sensorimotor reaction between the two hemispheres are identical in their values. The obtained data indicate the same arithmetic mean value when analyzing the two hemispheres. However, the min and max values and Q1, Q2 indicate a more stable complex visuomotor reaction of the left hemisphere of the studied athletes.

The test results RMO, namely the analysis of the average values of the number of accurate hits, the number of delayed reactions, the number of anticipatory reactions, and the number of missed reactions indicate that the studied athletes exhibit an imbalance of nervous processes with a predominance of inhibition

**Table 2. Indicators of SVMRL and LCVMR**

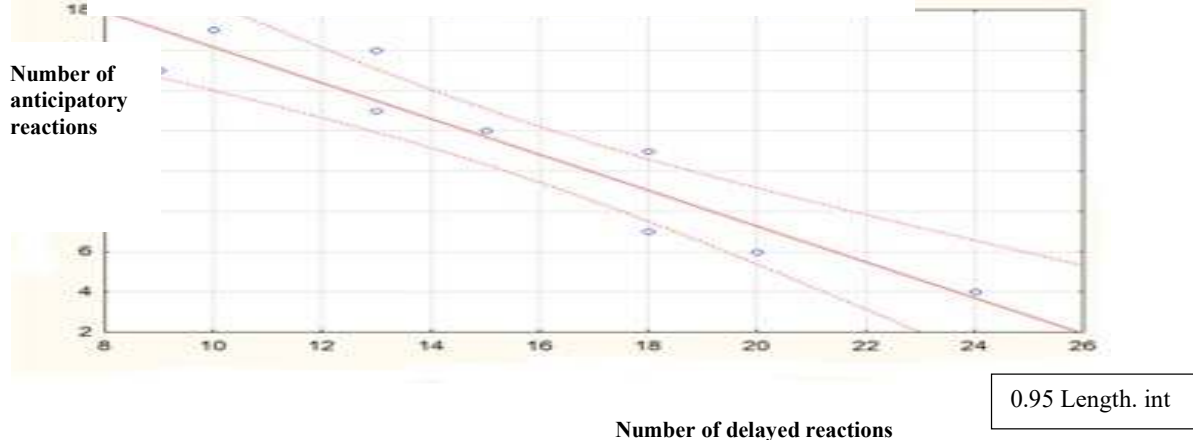
Indicators	Simple visual-motor reaction (SVMRL)				Complex visual-motor reaction (LCVMR)			
	left eye, left hand		right eye, right hand		left eye, left hand		right eye, right hand	
	Errors, qty	Reaction time, ms	Errors, quantity	Reaction time, ms	Errors, qty	Reaction time, ms	Errors, qty	Reaction time, ms
$\bar{x}$	0,44	452	0	403,2	8,2	721,4	5,8	721,5
$\mu$	0	444	0	388,7	9,0	701,4	5,0	741,1
Min	0	317	0	307,7	1,0	635,4	0,0	509,7
Max	4,0	751	0	483,5	8,0	808,2	14,0	848,1
Q1	0	363	0	335,9	5,0	665,4	2,0	647,8
Q2	0	477	0	473,2	11,0	775,2	8,0	792,6
SD	1,333	129	0	69,4	5,0	65,2	4,9	105,6
SE	0,444	42,87	0	23,2	1,7	21,7	1,6	35,2

. Also, a high inverse correlation ( $r = -0.94$ ) was found between two indicators - the number of delayed reactions and the number of anticipatory reactions, where an increase in one value is accompanied by a decrease in the other (Figure 2)

**Scatter plot: number of delayed reactions and number of anticipatory reactions.**

**Number of anticipatory reactions = 25.051 - .8890 \* Number of delayed reactions**

**Correlation:  $r = -0.9361$**



**Figure 2.** Scatter plots between two indicators during RMO methodology testing

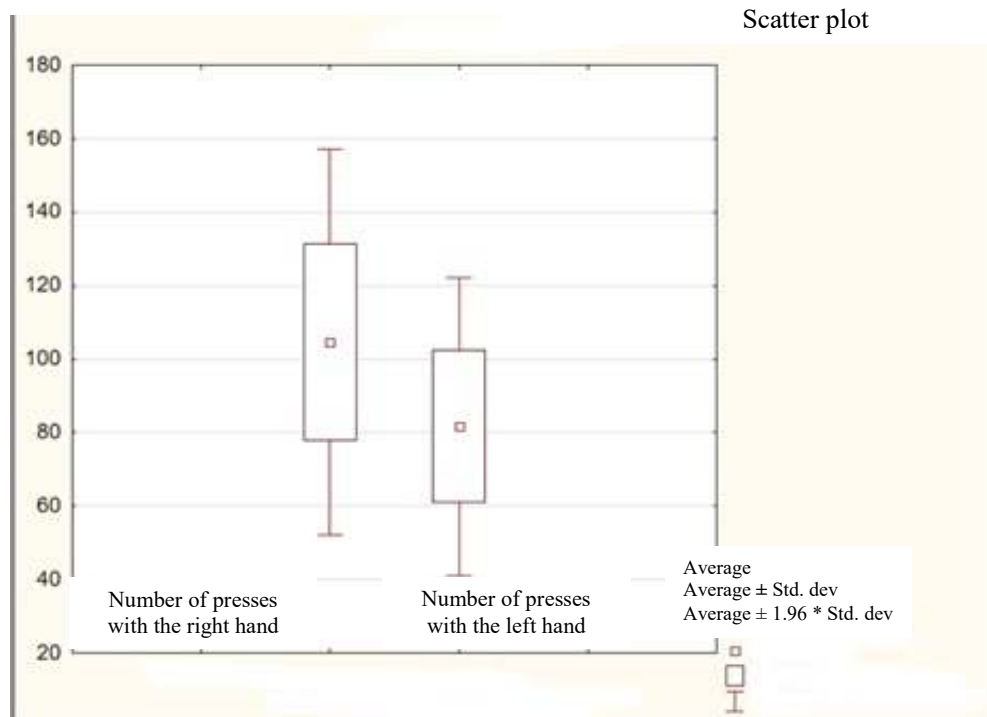
Table 3 presents the data of the test results of the 'tapping test' methodology. According to the 'tapping test' assessment, the number of presses with the right hand ( $104.7 \pm 26.8$ ) significantly exceeds the number of presses with the left hand ( $81.7 \pm 20.7$ ).

**Table 3. Test results according to the tapping test methodology**

Indicators	Number of presses with the right hand	Number of presses with the left hand
$(\bar{x})$ , n=9	104,66	81,66
Winsorized mean 5.0000%	104,66	81,66
Grubbs' Criterion	2,037	1,80
R	0,14	0,40
$\mu$	107,00	74,00
sum	942,00	735,00
Min	50,00	61,00
Max	140,00	119,00
S	26,83	20,70
SE	8,94	6,90

The advantage is almost 22%. The obtained Winsorized mean indicates that the sample size is maintained, and the Grubbs' test did not detect any outliers in the data set.

The minimum number of presses with the right hand is 50 times, and with the left hand is 61. At the same time, the maximum number of presses with the right hand is 140, and with the left hand is 119. This indicates a fairly large range within the group, as confirmed by Fig. 3. The range within the group for pressing with the right hand was 90, and with the left hand was 58 presses.



**Figure 3.** Scatter plots within the group during testing using the 'tapping test' method

The analysis of the histogram of the number of presses with the right hand (Figure 4) and the left hand (Figure 5) regarding the distribution of feature values and the expected normal curve using the Shapiro-Wilk W-test indicates that the distribution of presses with the right hand does not differ from normal at  $W=0.94$ , unlike the number of presses with the left hand at  $W=0.89$ .

Summary: number of presses with the right hand

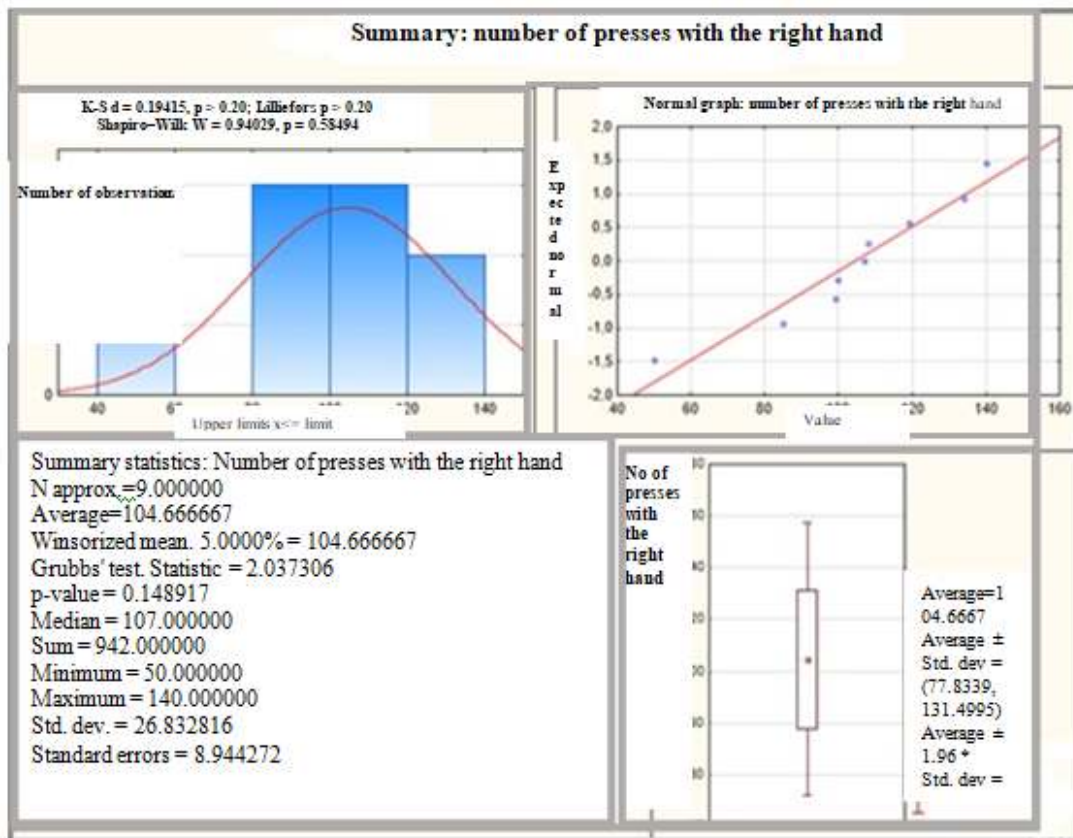
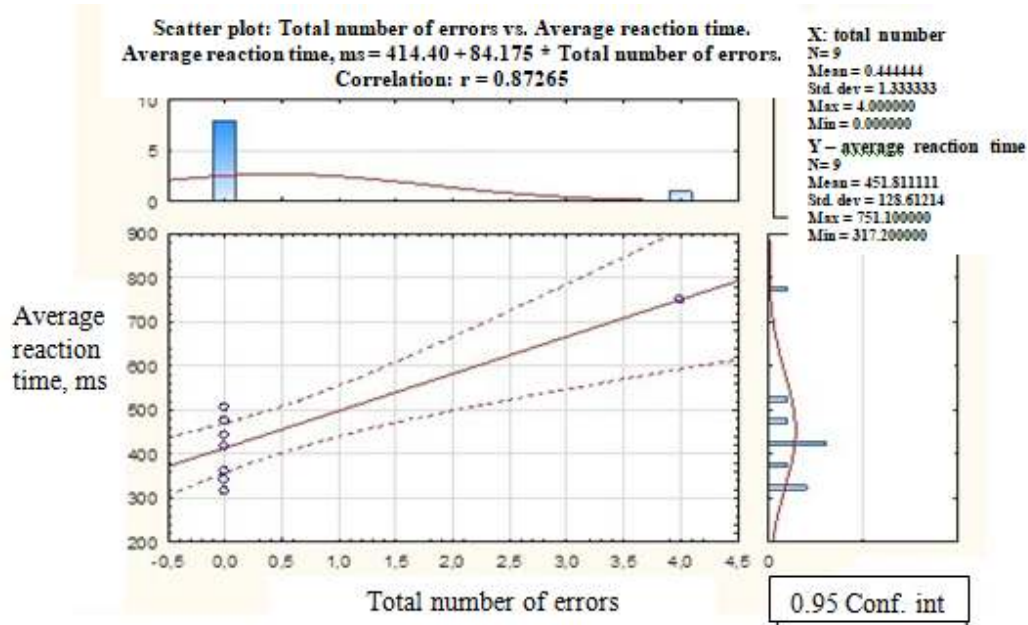


Figure 4. Histogram of the number of taps with the right hand 'tapping test'

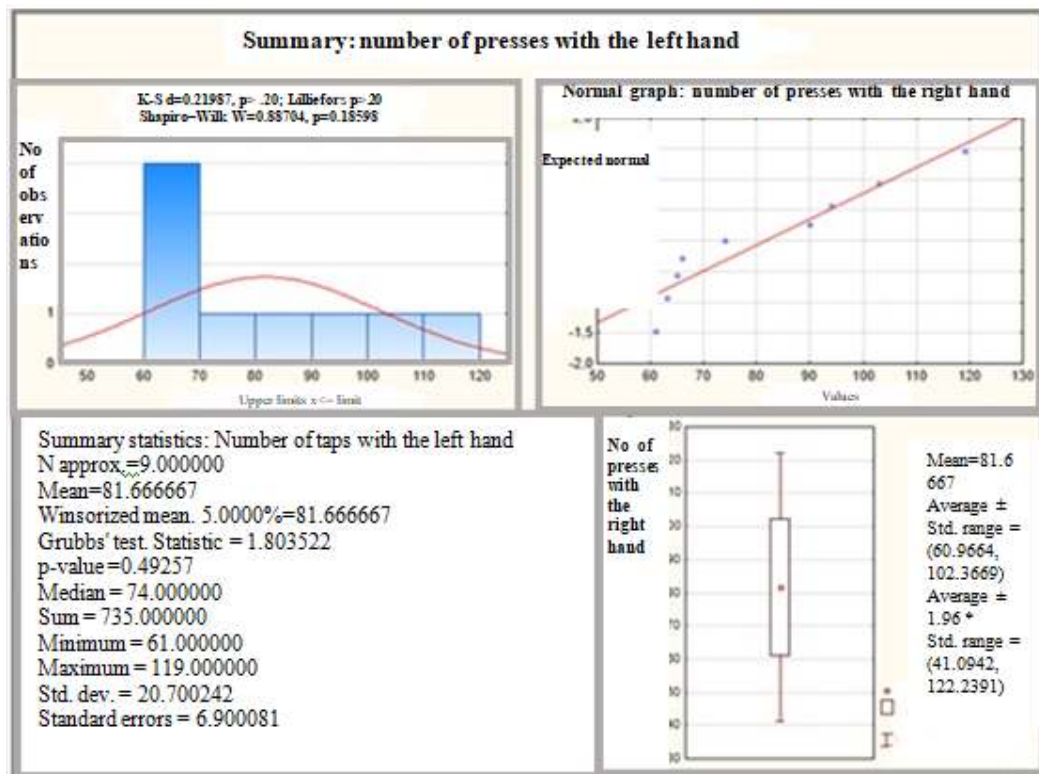


Figure 5. Histogram of the number of presses with the left hand 'tapping test'

## Discussion.

The assessment of psychophysiological characteristics of athletes is an important study that allows determining the presence of a balance of the main nervous processes. This concerns the processes of excitation and inhibition, the detection of the accuracy of sensorimotor response, its evaluation, and the ratios of excitatory and inhibitory processes in the cerebral cortex. This also applies to the functional capabilities of the motor analyzer and the strength of the excitation process and the mobility of the main nervous processes. The results of studies on the psychophysiological characteristics of athletes engaged in water skiing have not previously been the subject of detailed scientific research.

Based on the results of SVMRL testing, high mobility of nervous processes in both hemispheres of the brain was established. The study emphasized the (Badau et al., 2024) data of the unchanged level of symmetry of motor actions with maturation.

A high correlation was found between the total number of errors and the average reaction time ( $r=0.87$ ). A moderate correlation was found between the indicators of average reaction time and the overall level of functional state ( $r=0.64$ ), and a weak correlation was found between the total number of errors and the overall level of functional state ( $r=0.25$ ). These results confirm the research by Korobeynikov et al. (2018) that athletes with an increased level of functional mobility of nervous processes have a higher speed of processing external information. They also have a better ability to master motor skills against the background of quick, spontaneous, but unconsidered decisions during the execution of a motor task.

A high inverse correlation relationship was found between the indicators of error-free performance level and average reaction time ( $r=-0.87$ ), reaction stability and overall functional state level ( $r=-0.86$ ). No correlations were found between the indicators obtained as a result of testing the right hemisphere.

The results of the SVMRL test allowed us to state the predominant activity of the left hand and left eye, as evidenced by the shorter sensorimotor reaction time (the difference is 4%) compared to the time of influence on the right eye and the response reaction of the right hand.

When comparing the obtained indicators from the SVMRL and LCVMR tests of both hemispheres, the same value of the latent periods of reactions was observed. However, the LCVMR indicators of the left hemisphere are more stable, as evidenced by the minimum and maximum values of Q1 and Q2.

The indicators of the average values of the number of accurate hits, delayed reactions, anticipatory reactions, and missed reactions indicate the advantage of the imbalance of the nervous processes of athletes with

a predominance of inhibition processes. This somewhat does not coincide with the conclusions of the research by Badau et al., (2024) regarding the confirmation of the tendency towards the balance of nervous processes when engaging in complex coordination sports. It also differs from the research by Repko et al. (2018), whose data confirm the fact that athletes engaged in complex coordination sports have better latent periods of SVMRL and LCVMR than representatives of other sports. These data indicate high values of indicators that reflect different aspects of mental processes. However, this fact can be explained by the athletes we studied having a lower level of qualification due to a short training history. However, at the same time, according to the authors (Smirnovska et al., 2022), the psychophysiological characteristics of athletes are among the most informative criteria of giftedness at the initial stages of long-term preparation, and they are also well amenable to correction during the training process.

Fedorchuk et al. (2022) indicates that the indicators of reaction to a moving object of athletes can be predictive of the level of stress, the level of efficiency of mental self-regulation and adaptability.

The results of the assessment of psychophysiological characteristics using the tapping test method indicate an average level of nervous system strength. The research data, when analyzing the histogram of the number of presses with the right and left hand, indicate a normal distribution of results with the right hand, unlike the number of presses with the left hand.

It should be noted that, according to experts, a high level of variability in psychophysiological parameters is not an artifact, but only reflects the general properties of the body's current adaptation search to changes in external or internal environmental conditions. At the same time, experts confirm the fact that during the testing of psychophysiological indicators, compensatory interconnections are present, as a result of which the deterioration of some psychophysiological functions is compensated by the improvement or stabilization of others (Repko et al., 2018).

### Conclusions.

The study of psychophysiological characteristics of athletes in water skiing using the software and hardware complex «Bos-test» allowed for the establishment of high mobility of nervous processes in both hemispheres of the brain. A high level of nervous processes and a high level of interdependence between the average reaction time and the total number of errors were also confirmed. An average level of correlation between the functional state level and the indicators of average reaction time has been established; predominant activity of the left hand and left eye compared to the right has been noted. The indicators of the latent period of reaction of the left hemisphere are more stable compared to the right. During the study, the advantage of the nervous processes of athletes with a predominance of inhibition was revealed, and the performance indicator of the nervous system was determined as an indicator of average strength.

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### Conflict of interest.

The authors declare that there is no conflict of interest.

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