

Distinguishing sensorimotor reactions among students with varied forms of physical education training organization in sports sambo

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Abstract:

The speed of sensorimotor response to external stimuli is a critical determinant of training effectiveness and an athlete's performance success. **Research objective:** To conduct a comparative analysis of visual-motor reaction states in students undergoing different organizational forms of sports training, with the aim of personalizing the training process in sport sambo. **Materials and methods:** The study comprised 64 male students, including 33 engaged in sport sambo as part of elective physical education and sports classes at the university, and 31 individuals part of the university's national team in this sport. Representatives of the second group had sports grades up to the first senior, as well as experience in martial arts from six months. The visual-motor reaction console "TVES" and the software "Psychophysiology" were used as equipment. The research used the "choice reaction" technique, in which the subject was asked to press the appropriate remote control button when stimuli appeared on a red or green screen. The number of stimuli presented was at least 70. The indicators of the average response time (ms), the time of correct and erroneous reactions, the standard deviation, the number of all errors, units and the Whipple accuracy coefficient, cu were analyzed. Also, at the end of the test, the number of subjects in each group who had a characteristic of the parameters as "average" was estimated. Students with the response time parameters "more than average" or "inert" and "less than average" or "mobility" were identified. **Results.** The analysis of the visual-motor reaction showed that the students who are part of the national sport sambo teams have a high response rate to the visual stimulus. The best results were also recorded among them in the average time values of correct and incorrect reactions, and the standard deviation. Students in the elective course of physical education showed the worst results in the number of errors when performing testing, as well as when comparing the accuracy coefficient. In addition, there were more subjects in this group who had an "inert" type of nervous processes. **Conclusions.** Students-athletes have a higher level of functional state of the central nervous system. The presence of sports specialization affects the lability and mobility of nervous processes and physical performance. The acquired knowledge can be used to individualize the educational and training process in martial arts.

Key Words: physical education (PE), athletes, sambo, visual-motor reaction (VMR), physical training

Introduction

In sports, the visual-motor response (VMR) is a reliable indicator of the activity of the human central nervous system. It characterizes the rate of the state of inhibition development and arousal in the cerebral cortex and an athlete's ability to differentially slow down the work performed. The study of sensorimotor characteristics is of great importance for identifying the prerequisites determining the characteristics of psychomotor development and the functional state of the athlete's body, which is important for the training process individualization (Korobeynikov et al., 2020; Janicijevic & Garcia-Ramos, 2022). It is generally believed that the speed of sensorimotor reaction is one of the most important qualities determining an athlete's actions success (Aksutin & Korobeynikov, 2014; Reid et al., 2020). The complex motor reaction of choosing a response leads to the development of an athlete's ability to predict an opponent's actions, which is especially important in martial arts (Kozina et al., 2017).

It is noted that when studying only the motor and physical capabilities of people engaged in physical culture and sports, it is possible to obtain only part of the information about the student's current functional state. Such information is not complete enough about the student's readiness for physical activity (Benjamin et al., 2017; Rahman & Islam, 2021; Romanova et al., 2023). When evaluating neurodynamic features, it becomes possible to obtain sufficiently complete information about a person's readiness for training and competitive processes. It is known that physical exercise reduces the response time to a visual-auditory stimulus (Islam et al., 2020).

The implementation of physical education programs in higher education institutions, as well as athletes' with various levels training is accompanied by the need to effectively use their individual abilities (Burris et al., 2020; Reid et al., 2021). In this case, the neurodynamic and psychological components of the learning person come to the fore. It is due to the fact that their individual characteristics determine the variety of complex coordination movements and vestibular stability during exercise (Hülsdünker & Mierau, 2021).

The assessment of sensorimotor function can be carried out using the method of visual-motor reaction (VMR), which reflects the speed of nervous processes dynamics, the state of visual-motor coordination, the activity of the central nervous system and the overall level of physical performance (Bocharin et al., 2019; Hunzinger et al., 2020). Using the simple timing of visual reaction method, it was found that among university athletes and girls who lead a sedentary lifestyle, a strong arm is faster than a weak one (Rahman et al., 2020). The scientific literature presents the results of the VMR use in monitoring groups of children with high and low physical activity (Reigal et al., 2019). Researchers have found that the response time of the visual-motor response to a stimulus is shorter in children who are characterized by great physical activity compared with children who are physically inactive. According to psychological tests, physically active children had a higher level of attention.

In the process of evaluating sensorimotor reactions, the speed and accuracy of a person's response to a visual stimulus is evaluated. In this case, two consecutive components are distinguished. The first is the latent period – from the moment of visual information perception and a nerve impulse transmission along the optic nerve to the cerebral cortex. The second period characterizes the motor response. This period is characterized by the movement performance by skeletal muscles contraction and the implementation of proprioceptive control of movement parameters (Liu et al., 2016). In this way, the total VMR speed can be estimated, which makes it possible to characterize the properties of nervous processes, the patterns of impulse conduction along the reflex arc and the degree of information processing, the type of the central nervous system activity, as well as combinations of various factors (Liu et al., 2016).

In the process of doing physical education and sports, it is necessary to quickly perceive information by the nervous system and develop the only correct motor movements at the moment (Badau et al., 2018). At the same time, the delay in perception during signal transmission is the main limiting components in achieving the greatest efficiency not only in the educational and training process and competitions, but also in the cognitive functions development. This relationship has been established in young female volleyball players (Trecroci et al., 2021). Reaction time is a key parameter in assessing the characteristics and functional state of the central nervous system, as well as the student's readiness for physical activity and the competitive process (Morsella et al., 2016; Milic et al., 2019).

Scientists H. Rahman & M. Islam (2021) present a comparative analysis of the results of the visual-motor reaction study of athletes in game sports (basketball, handball, volleyball, football and cricket) and non-athletes. It is relevant to study the sensorimotor reactions of students under the conditions of the combined influence of educational and training environmental factors during sport sambo classes. These issues need to be detailed due to their insufficient coverage in the scientific literature. The obtained research results will allow to individualize the educational and training process of students who are engaged in sport sambo in the sports section of the university and in the elective course of physical education.

Research objective: To individualize the educational and training process in sport sambo, to conduct a comparative analysis of the state of visual-motor reactions in students who have a different form of classes organization in this sport.

Material & methods

64 male students of the Volga Region Research Medical University (Russia) took part in the research. The boys were aged 19-20 (19.3 ± 1.6); they were divided into two groups. The first group (non-athletes) included 33 students who did not have special sports training, did not engage in martial arts and did not have sports grades. They began to practice sport sambo for the first year as part of elective PE and sports classes at the university. They had classes 2 times a week for 2 hours each.

The second group included 31 young men who were members of the university's national sports sambo team. Representatives of the second group had sports grades up to the first senior, as well as training experience from six months. The training sessions in this group were 3 times a week, each for 2 hours.

Testing of sensorimotor parameters in all young men was carried out outside the training process in a quiet room with a complete absence of extraneous stimuli. The assessment of visual-motor reactions was carried out using the software and hardware complex "TVES visual-motor reaction console" (Russia, model TU9442-

051-00226454-2014), as well as the software "Psychophysiology". The complex is a visual-motor analyzer, which includes a control panel with buttons for pressing when a light signal is received. The «choice reaction» technique was used in the research. In it, the subject must press the corresponding remote control button as soon as possible when stimuli appear on the red or green screen. The received data was processed in accordance with the time of pressing the button on the red signal. The light impulse was applied at random points in time to prevent a conditioned reflex development at time intervals.

Each subsequent signal was given regularly enough to be expected. The interval between pulses was 0.5-2.5 s. The number of stimuli presented was 70. As monitoring, the VMR method analyzed the indicators of the average time of all young men (M, ms), the time of correct and erroneous reactions (Mcor, Merr, ms), standard deviation (SD, ms), the number of all errors (NE, units) and the coefficient of accuracy of tasks (CA) according to the Whipple formula, cu.

$$CA = \frac{N-r}{N+p}$$

Where N - the total number of detected stimuli; r - the number of incorrectly detected stimuli; p - the number of missed stimuli.

Also, the number of young men in each group whose conclusion at the end of the test was estimated as "average", "less -" and "more than average". At the beginning of the research, all students gave written consent to participate voluntarily in it. The work carried out does not contradict the requirements of the Helsinki Declaration of 2003.

The digital material was processed using the Statistica 10.1 and MS Excel 2016 software package. The data were checked for the normality of the distribution using the Shapiro-Wilk criterion. The results obtained are presented in the form of an arithmetic mean (M) and a standard error of the mean (m). Statistically significant differences between groups of students engaged in elective martial arts classes and students who are part of the university's sport sambo team were determined using the parametric Student t-test and the nonparametric Mann-Whitney U test. The differences were considered statistically significant at $p < 0.05$.

Results

The result of testing the visual-motor reaction of students having different organizational forms of sport sambo classes is presented in Table 1.

Table 1. The values of the visual-motor reaction indicators of students engaged in sport sambo in various organizational forms of training sessions

No	Indicator	The organizational form of a sport sambo training session		Normative age indicators
		Elective PE classes (n=33)	Sports section (n=31)	
1	M, ms	353.2 [339.3; 365.8]	324.9 [313.6; 337.3] *	332-434
2	Mcor, ms	472.2 [459.6; 484.3]	357.3 [344.2; 365.7] *	332-434
3	Merr, ms	239.4 [221.9; 250.3]	298.6 [286.5; 314.1] *	332-434
4	SD, ms	345.4 [332.6; 358.1]	318.2 [307.3; 331.7] *	69-113
5	NE, units	6.2±0.7	4.3±0.6 *	-
6	CA, cu	0.08±0.6	0.14±0.3	0.04-0.18

Note. * - the significance of the difference between the indicator values for students having different organizational forms of training sessions, $p < 0.05$

A comparative analysis of the indicators values that were obtained during the research in young men of different organizational forms of training sessions with average normative values showed some differences. For students who attend elective PE classes, the response time to the stimulus is within the age average limits. The average time of incorrect reactions is set below the threshold value of the age range.

It is reflected in the values of the standard deviation, which significantly exceeds the standard level, thereby indicating a decrease in the stability of the sensorimotor reaction among this group of subjects. In addition, the values of the standard deviation and the average time of incorrect reactions additionally indicate the predominance of inert nervous processes in them. The average number of errors was recorded at 6.2±0.7 units, and the accuracy coefficient was 0.08±0.6, which indicates a decrease in the stability of attention when performing the visual-motor reaction test.

The results of sensorimotor reaction among students engaged in sport sambo in sports sections were better. The reaction time value and correct reaction in students-athletes corresponds to the norm (324.9 ms and 357.3 ms, respectively). At the same time, the time of incorrect reactions is below the minimum threshold of the average age index (298.6 ms), the level of standard deviation (318.2 ms) exceeds the age standard, which

indicates a decrease in sensorimotor reaction among students caused by intense physical loads in the sports section. The number of errors in these athletes during testing was 4.3 ± 0.6 units, and the value of the accuracy coefficient was 0.14 ± 0.3 cu, which generally indicates stabilization of attention when performing visual-motor testing.

There was a significant difference in the values of all indicators (except for the value of the CA indicator) between students with different organizational forms of training sessions. Students involved in the sports section of sport sambo have a shorter response time to the stimulus, the time of correct answers, the standard deviation and a higher value of the accuracy coefficient. The percentage difference between the values of the indicators of visual-motor reaction of students having various organizational forms of training sessions is shown in Figure 1.

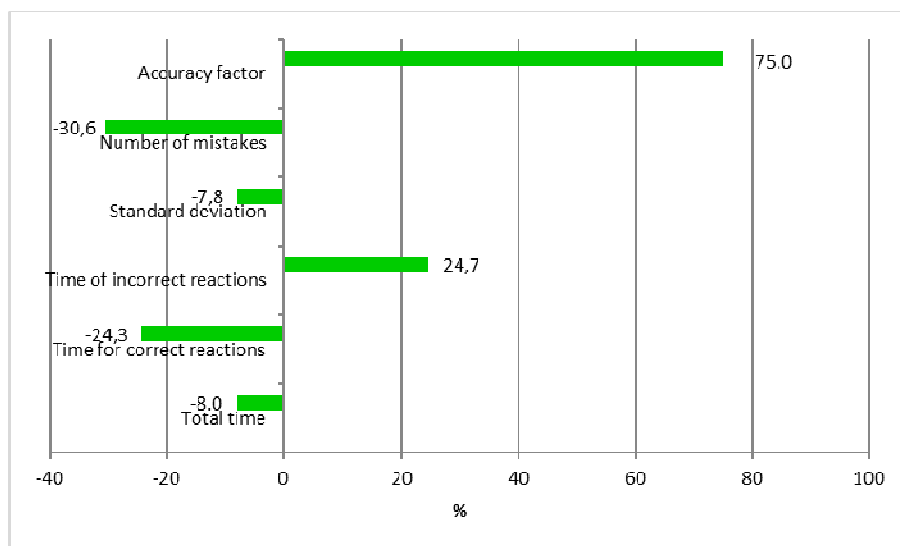


Fig. 1. The difference between the indicators values of visual-motor reaction in young men engaged in sport sambo in elective courses and at the sports section

During the comparative analysis of the data obtained among both groups of students, it was found that the total reaction time of athletes is 8.0% less than the same indicator for students engaged in elective classes, which is generally a pattern, taking into account the experience of students engaged in sports training. The time of correct reactions among the subjects without sports experience turned out to be 24.3% longer relative to students-athletes. It reflects the peculiarities of functional rearrangements in the central nervous system in athletes, indicating higher possibilities of adaptation to the conditions of testing and a higher rate of motor response.

The time of erroneous reactions, sambo athletes showed a 24.7% increase compared to the time of students with minimal training experience ($p < 0.05$). Apparently, students with a sports specialization process the received visual stimulus in more detail, which is reflected in a compensatory increase in reaction speed when they doubt the correctness of choosing the appropriate indicator on the remote control. It is reflected in a more «balanced» choice of reaction to a visual stimulus, in addition, the athletes' erroneous reactions were mostly random.

It should be noted that sensorimotor reactions in students without sports experience turned out to be less stable, taking into account the obtained values of the standard deviation, which in the subjects of this group was 7.8% higher relative to the group of athletes ($p < 0.05$).

The accuracy of the reactions in the studied groups also turned out to be heterogeneous. The students who practiced sambo in the elective course had 30.6% more errors than those involved in this sport in the sports section. In addition, the accuracy coefficient value was 75.0% higher than that of young men engaged in martial arts in elective courses. It indicates higher functional capabilities of the central nervous system in students who are engaged in the sambo sports section compared with less prepared young men and shows differences in the neurodynamic support of the body's activity with different functional mobility of nervous processes and the multidirectional occurrence of fatigue among the subjects.

It is of scientific and practical interest to determine the proportion of students, having a particular response time to a visual stimulus in the total cohort of students in the observed group, Figure 2.

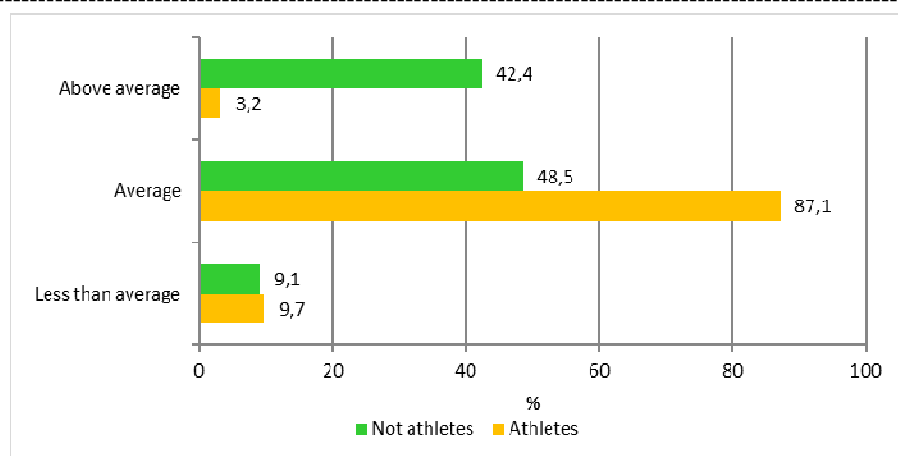


Fig. 2. The number of students with different gradation of motor response time to a visual stimulus

Among students engaged in martial arts as part of elective PE classes, 48.5% had a response time to a visual stimulus within the limits of the «average» age standard, 42.4% of young men had a graduation rate of «more than average», 9.1% – «less than average». This distribution of the number of students indicates that more than 90% of young men in this group have an «average» response time to a visual stimulus and a time grading more than average» statistical age value. At the same time, in the group of student athletes, the proportion of test takers with an «average» reaction time was 2 times higher (87.1%). The number of students-athletes with a graded response time of «more than average» or «inert» was 13 times less compared to the group of young men who attended elective PE courses. The number of students with a graded response time of «less than average» or classified as «mobile» was approximately the same in both groups. These research results indicate a higher level of the visual-motor reaction stabilization in students who study in the sports section and a higher level of the functional state of the central nervous system in them.

It was found that a higher level of the central nervous system adaptation to physical loads was recorded in students who practice martial arts in sports sections. Also, students-athletes are dominated by the processes of the nervous system balance and a higher level of the nervous processes strength.

Dicussion

A marker for assessing a person's mental and physical performance is an indicator of the functional state of the body. It is characterized by the degree of all physiological systems activation to perform a certain type of activity (Bocharin et al., 2022; Romanova et al., 2023). Information on timely monitoring and necessary correction of the functional state is of great importance in the educational and training programs implementation, in preparation for physical education and performance at competitions (Van Biesen et al., 2018). Control and correction are important for individualizing the training process (Korobeynikov et al., 2020; Janicijevic & Garcia-Ramos, 2022). At the same time, the performance of motor movements occurs with the central nervous system activation, which acts as an analyzer for processing incoming information and launching a certain program to perform a motor act (Vorobyov et al., 2019; Wang et al., 2023). Improving the mechanism of coherence in the work of the central nervous system underlies the development of complex coordination skills of movement, vestibular stability, which is an essential condition for achieving high athletic performance (Aksutin & Korobeynikov, 2014; Reid et al., 2020). When analyzing the indicators of visual-motor reaction, it was found that students who practice sport sambo on the basis of the sports section show the best indicators of total response time, average time of correct answers and their accuracy. Our data are consistent with the results obtained by other authors (Miller et al., 2019; Islam et al., 2020; Rahman and Islam, 2021). The time of the motor response is the main parameter in assessing the characteristics and functional state of the central nervous system, as well as the student's readiness for physical activity and competition (Morsella et al., 2016; Milich et al., 2019). In addition, according to our data, athletes have a more stable level of sensorimotor reaction, as evidenced by the value of the standard deviation indicator. This fact is confirmed by an analysis of the number of mistakes made when performing the test, where the students of the university's national sambo teams made the least number of them. This trend is confirmed in the value of the accuracy coefficient, which reflects a higher adaptation of the central nervous system in students who have experience in martial arts training. The time of erroneous reactions in sambo athletes was 24.7% longer compared to the time of students with minimal training experience. We believe that students who train in the sports section, process the received visual stimulus more carefully. It is reflected in a compensatory increase in the reaction speed and the athlete's ability to differentially slow down the work performed when in doubt about the correctness of choosing the appropriate indicator on the remote control. This fact affects a more «balanced» choice of reaction to a visual stimulus. The development of differentiated inhibition of the motor response lies in the formation of forecasting an opponent's actions, which is especially important in martial arts (Kozina et al., 2017).

In addition, in the study of mobility and inertia of nervous processes, a higher ratio and number of subjects with the conclusion «inert» were in the group engaged in the program within the framework of elective physical education and sports. This fact confirms the different specificity of reactions to visual stimuli under the influence of the level of athletic training. The analysis of the reaction to visual stimuli in the observed groups showed that among students engaged in martial arts as part of elective PE classes, 42.4% of the subjects had a reaction time to a visual stimulus in the gradation of the indicator "more than average". The gradation of the time indicator «less than average» was found in 9.1% of young men, and 48.5% had an «average» value. For athletes, this distribution looked as follows: the proportion of test subjects who have an "average" reaction time was 87.1%, "more than average" – 3.2%, "less than average" - 9.7%. A significantly smaller proportion of students-athletes who have a response time gradation of «more than average» compared to young men engaged in sambo on an elective course is confirmation of a positive trend in the development of the speed of response to a visual stimulus. The research results by Reigal et al. (2019) can serve as confirmation of the positive effect of physical activity on improving the response to a visual-auditory impulse. The authors showed that children having high physical activity had a shorter response time to the stimulus than physically inactive ones. The results of psychological tests were also better for children with an optimal level of physical activity.

The development of an athlete's speed of response to an external stimulus makes it possible to more effectively improve complex coordination abilities and vestibular stability during physical activity (Hülsdünker & Mierau, 2021). In turn, the coordination abilities development, to a large extent, can determine individual characteristics in sports activities and effectiveness in competitive activities. Thus, a higher level of the central nervous system adaptation to physical activity was recorded among students with experience in sports specialization in sports sambo. Students-athletes have a predominant balance of the nervous system and a higher level of the nervous processes strength compared to students attending an elective PE course. We believe that the development of the visual-motor reaction speed in athletes makes it possible to make adjustments to the individualization of the educational and training process of martial arts classes.

Conclusions

The analysis of the research results of visual-motor reaction among students engaged in sport sambo in various forms of training sessions organization showed that the young men who are part of the national teams in this sport have a high response rate to visual stimulus. Among them, the best values of the indicators of the average time of correct responses, standard deviation and accuracy coefficient were recorded in comparison with students engaged in sambo in an elective PE course.

It was found that in the group of people engaged in sambo in the elective PE course, the reaction time was "more than average" in 42.4% of the subjects, "less than average» in 9.1% of students, and in 48.5% the "average" value. In the group of athletes, the proportion of people with an "average" reaction time was 87.1%, "more than average" 3.2%, "less than average" 9.7%. Students-athletes have a higher level of their visual-motor reaction stabilization, which indicates an increase in the central nervous system adaptation and also in its functional state. Also, students-athletes are dominated by balance and a higher level of nervous processes strength, which allows them to develop their coordination abilities to a greater extent and individualize the educational and training process. We believe that the organizational form of the educational and training process during martial arts exercises affects the lability and mobility of nervous processes, the state of physical performance and athletic performance.

Conflicts of interest. The authors declare no conflict of interest.

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