

# Psychophysiological Fundamentals of Designing a Health-Saving Educational Path for Teenagers with Different Levels of Physical Activity

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**Abstract:** The purpose of the study is to establish the effect of different levels of physical activity on the psychophysiological characteristics of teenagers, serving as the basis for the design of a health-saving educational development path. In the course of the study, 175 teenagers (12-14 years old), including 63 girls and 112 boys (34 boys playing hockey), were examined. For all subjects, we evaluated the indicators capturing a simple and complex visual-motor reaction using the BioMouse-Research hardware-software complex. The obtained results characterize the optimal level of cerebral homeostasis, reflected in the average sensorimotor response of all examination groups falling within the age norm range. The authors argue that the developed motor skills of teenagers involved in sports contribute to a greater cerebral speed of processing elementary sensory information, as well as high activity and mobility of the nervous processes of the central nervous system in comparison to peers not involved in sports.

## 1. Introduction

The problem of maintaining the health of students in the modern educational space is widely discussed in the scientific literature [1; 2; 3; 4; 5; 6; 7]. Particular attention is paid to the organization of physical activity and the interdependence of the nature and dosage of physical activity and the level of students' health.

Features of the functioning of the body in a diverse load are characterized by an indicator of dynamic health [8; 9]. Psychophysiological indicators are objective markers of the state of mental performance and cognitive processes and can be used as criteria for assessing the level of health [8].

## 2. Materials and methods

The study involved 12-14 years-old students of various educational organizations in Chelyabinsk (n=175). In total, 63 girls and 112 boys were examined. All students had the first and second health groups. The general sample is differentiated into groups: the first group includes boys playing hockey (n=34). The second group is composed of those students who additionally attend various sports sections (n=68). The third group includes students in the main educational program (three physical education lessons per week) (n=73).

An assessment of the functional parameters of the nervous system was carried out by the express method of variational chronoreflexometry of the *BioMouse-Research hardware-software complex* (LLC "NeuroLab", Moscow). Tests of simple visual-motor reaction (SVMR) and complex visual-motor reaction (CVMR) allow us to evaluate the mobility of nervous processes and the characteristics of human sensorimotor reactions in response to light stimuli of the same or different intensity, which determine the functional state of the central nervous system.

Mathematical and statistical analysis of the results of the studied groups was carried out using the *Microsoft Excel* and *Statistica* software. Fischer F-test of univariate analysis of variance was used to compare average values. The homogeneity of the variances of the indicator in two groups was evaluated according to the Liven test. In the case of different variances of the studied trait, the comparison of means was performed using the Mann-Whitney U-test.

### 3. Results

We analyzed the psychophysiological indicators of teenagers with different levels of physical activity (Table 1).

TABLE 1. COMPARATIVE PSYCHOPHYSIOLOGICAL INDICATORS OF TEENAGERS OF RESEARCH GROUPS (M±m)

Indicator	First group (n=34)	Second group (n=73)	Third group (n=68)
SVMR, ms	202.4±13.52*	228.5±13.74●	243.3±14.23▼
CVMR, ms	323.6±14.31	330.5±23.21●	446.4±24.12▼
Frequency of Incorrect Answers, %	11.9±1.72*	15.6±2.11	19.1±4.31▼

Note: \* reliability of intergroup differences of the first and second groups of the survey; ● reliability of intergroup differences of the second and third groups of the survey; ▼ reliability of intergroup differences of the first and third groups of the survey, (p<0,05).

Based on the obtained results, the authors argue that the average SVMR in the first group of patients is significantly lower (p <0.05) than in the second and third groups (by 12.9% (26.1 ms) and 20% (40.9 ms) respectively). In terms of complex visual-motor reactions, significant differences are also noted between the values of the first and third, second, and third groups. The group CVMR indicator of the third group is, on average, 120 ms higher than the average indicators of teenagers involved in sports (122.8 ms higher than in the first group and 115 ms higher than in the second). In terms of the frequency of incorrect answers, the average indicator in the second group in absolute terms was significantly higher (by 3.7%) than in the first. The most significant differences are between the first group and the third group (7.2% in absolute terms and 60.5% in relative terms).

TABLE 2. COMPARATIVE PSYCHOPHYSIOLOGICAL INDICATORS OF TEENAGERS OF THE SECOND AND THIRD GROUPS

Indicator, unit of measure	Пол	Teenagers involved in sports (2 group)		Students in a general education program (3 group)	
		M±m (n=73)	CV	M±m (n=68)	CV
SVMR, ms	M	220.11 ± 7.84	14.1	237.19 ± 11.15	26.9
	F	236.96 ± 11.13*	13.2	249.12 ± 14.24*	27.1
CVMR, ms	M	320.09 ± 13.07	16.94	450.11 ± 19.17	21.3
	F	341.11 ± 15.91*	24.2	442.98 ± 16.12	18.7

Note: \* significance of differences in indicators in gender (p<0,05).

Table 2 shows the results of the survey by gender (second group and third group). The results indicate that the girls have higher indicators of a simple visual-motor reaction than boys both in the second group (teenagers involved in sports) and in the third group (students in the general education program). Thus, among children involved in sports, in terms of simple visual-motor reaction, the difference between boys and girls in absolute terms is 16.85 ms, that is, the rate for girls is 7.65% higher than for boys. In the group of teenagers enrolled in the general education program, the SVMR rate for girls is 11.93 ms higher than for boys, which is 5.03% in percentage terms. The significance of gender differences is confirmed by F-test (p<0,05).

We can note the differences between the groups in terms of a simple visual-motor reaction for both boys and girls. The average SVMR rate for boys enrolled in a general education program is 17.08 ms (7.8%) higher

than for boys involved in sports. A similar picture is observed when comparing girls of the third and the second groups. Still, the differences are less significant. For girls of the third group, the SVMR indicator is 12.16 ms (5.1%) higher than for girls of the second group. In terms of the complex visual-motor reaction in the second group, differences are observed that are similar to differences in the SVMR indicator. That is, the absolute average value of the indicator is 21.02 ms (6.6%) higher for girls. For boys enrolled in the general education program, the average value of the CVMR indicator is 130.02 ms higher than for boys involved in sports, which in relative terms is 40.6%. Similar differences were noted in this indicator for girls of the second and third groups: the average value of the CVMR index in the third group was 101.87 ms (29.9%) higher than in the second. The significance of differences is confirmed by F-test ( $p < 0,05$ ).

The obtained results reflect the relatively perfect mechanisms of neuronal processing of sensory information of teenagers playing hockey and teenagers involved in sports compared to peers of a general level of physical fitness, who have longer cognitive processing and lower rates of differentiation inhibition of cerebral processes.

#### **4. Discussion**

Based on literature data [5; 8; 10], we can conclude that from psychophysiological indicators, visual-motor reactions are sensitive to disturbing environmental influences, and, therefore, objectively reflect the structural and functional changes in the coordination and regulation of the body and act as objective criteria for an individual's health. Moreover, pre-adolescence and adolescence are a sensitive period in the development of personality's speed qualities. Speed indicators of simple visual-motor reactivity of a person are determined by the structural and functional features of the motor-tactile and visual analyzers, the psychophysiological state of the body, and the characteristics of the properties of the nervous processes of the subject. The latent period of the visual-motor reaction of an individual characterizes the speed and quality of response of the individual. The complex sensorimotor reaction of choice reflects not only the speed indicators of neuronal processing of visual-motor information from the corresponding analyzers. It is an objective criterion for the functional mobility of cerebral processes, that is, the ease of changing the excitation to inhibition and vice versa in the central nervous system. The CVMR indicators also allow us to characterize the severity of differentiating cerebral inhibition.

The obtained results characterize the optimal level of cerebral homeostasis, which is reflected in the average indicators of SVMR and CVMR of all examination groups falling within the age norm range. The level of the general functional state in most examined teenagers reflects the stability of the functioning of the neuronal activity of the central nervous system, which is reflected in the values of the coefficient of variation.

The analysis of the characteristics of the sensorimotor reaction of adolescent students revealed a significant improvement in the psychomotor organization and neurophysiological component of cognitive activity depending on the motor mode. An identified feature of the sport's improvement of sensorimotor responsiveness for teenagers involved in a professionally difficult coordination sport (hockey) is also important. Developed motor skills of teenagers involved in sports contribute to a greater cerebral speed of processing elementary sensory information, high CNS activity of teenagers in comparison with peers.

At the same time, the complex sensorimotor reactions of athletes had a similar severity, reliably effective compared to teenagers not involved in sports, which indicates a positive effect of playing sports in operating a variety of environmental signals and improving differentiated inhibition, economies of the cognitive component of the activity. It should also be noted that the stability of cerebral homeostasis is reflected in the least variability of the average values of sensorimotor reactions and greater reliability of activity (fewer erroneous reactions) of teenagers of the first and second groups in comparison with peers of the third group. On the whole, our results are consistent with the general trend in the determinism of neurodynamic resistance to environmental factors in sports [8]. At the same time, V. V. Markelov [11] assigns an important prognostic value to the leading property of human higher nervous activity- mobility in the implementation of sports reliability of different types of sports activities of the game character and martial arts.

Gender peculiarities in the implementation of the sensorimotor activity of teenagers are consistent with the research of V.R. Kuchma [10] and reflect the general evolutionary mechanism. At the same time, it is difficult to have a less pronounced differentiation by gender in motor response. In our opinion, this indicates a similar manifestation of cognitive processes of analytical processing of sensory information in the cerebral cortex in

response to sensory stimulation. Regardless of gender, teenagers not involved in sports slow down complex sensorimotor reactions due to an imperfect mechanism of differentiating inhibition of cerebral processes (more errors), the generalization of motor reflexes (relatively long duration of the average values of CVMR).

Educational activity in modern conditions includes complex social and environmental components that determine the need for students to adapt to it. This activity, as V. R. Kuchma notes [10], should be supervised by educators. The use of a variety of teaching methods and tools, in our opinion, should be based on taking into account individually typological features of the personality of students. The combination of the two above criteria should be included in the implementation of a differentiated approach in education by building an individual learning path [8; 12; 13].

Neurodynamic determinants that determine the effectiveness of cognitive and sensorimotor activity of teenagers involved in sports, reflect more advanced mechanisms of adaptation to environmental conditions. In this regard, it is advisable to build a health-saving learning path that eliminates the maladaptation processes of adolescent students, which leads to difficulties in complex and unusual situations. Therefore, we strengthen the mandatory inclusion in the lifestyle of moderate exercise in addition to the mandatory physical education program.

## 5. Conclusion

In this paper, the authors determine the positive impact of sports, in addition to the mandatory program of physical education in the framework of the education of teenagers, expressed in a decrease in the speed of sensorimotor response and increased reliability in adolescent athletes.

The relative stability of cerebral processes with high functional mobility characterizes the formed functional system of the optimal conditioned-reflex activity of teenagers involved in sports.

Indicators of the speed of the sensorimotor reaction can serve not only as a marker of the psychophysiological state but also as criteria for the adaptive capabilities of students. These facts necessitate their use in building a health-saving education.

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