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NEURODYNAMIC FEATURES OF THE 3RD-4TH GRADE PUPILS WITHIN LEARNING DYNAMICS

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Annotation. The basic neurodynamic indicators of the 3rd-4th grade pupils in the course of two academic years have been analyzed. An increase in the time parameters of the visual-motor reaction and the number of errors during the performance of the tests "simple visual-motor reaction" and "hindrance immunity" were revealed. By the end of the 4th grade, the contingent with a predominance of inhibition of nervous processes increases, mostly in girls. Such specificity of the functioning of the central nervous system reflects a significant decrease in the functional capabilities of the organism against the background of an increase in the effect of fatigue accumulation at the final stage of primary education.

Introduction. Identifying specificity of the nervous system's function within the process of ontogenesis is an important condition of maintaining normal physical and mental development of a child. Pedagogical effectiveness of education is determined by how adequate the educational environment is and how it corresponds with age-related psychophysiological features of pupils. Features of the physiological systems' function at various stages of age development attract the researchers' attention for a long time [1-6]. Despite a big number of gathered physiological material, data on developmental physiology cannot find an appropriate application in the teaching process. During the educational period in school, the organism of children and adolescents has its own specificity of adaptation, when, against the background of age-related processes, there is a need to adapt simultaneously to educational programs that are high in volume and intensity. An importance of solving contradiction between biological and social development programs defines a need to search for such model of academic activity that could consider both age-based and adaptive capabilities of the child's organism.

According to the concept of P.K. Anokhin, in the structure of functional systems that contribute to processes of the stable level of activity in case of minimizing physiological penalty, the nervous central system takes the leading

role, and the organism's adaptation is dependent on interaction between managing and executive regulation curves [7]. Such properties as psychomotor performance, mobility of nervous processes, anxiety etc. play a significantly big role in forming adaptive response to the influencing factor, including educational loads. Functional neurodynamic components that implement sensorimotor activity are intensively developing during childhood [5]. Another thing to consider is that educational period in primary school is a period of the highest sensitivity to environmental factors, including unfavorable ones.

In this case, an issue of evaluating conditions of educational environment and its influence on the organism of primary school pupils is relevant, since the child's organism is not protected enough due to insufficient development of functional systems and incomplete development of growth processes, formation and adaptation, when the balance in functional reserves has not formed yet, and educational activity makes additional requirements to psychophysiological resources of the organism, especially in conditions of innovational education programs [8]. The central nervous system is the one that can maintain compensation responses, i.e. activate an expense of functional reserves by means of linked executive systems in case of shortage in functional reserves of one of the systems [9-10].

Studies, related to psychophysiological assessment of the effect of modern forms of educational organization to current functional state of the nervous system of primary school pupils, are fragmentary in nature and represent a current relative issue.

Methods and organization. The longitudinal study involved 19 primal school pupils who studied in the general education school, according to the "School of Russia" program. The experiment took place during their education in 3rd and 4th grades.

Examination of features of the pupils' neurodynamic state was carried out with the "NS-PsychoTest" computer set (made by NeuroSoft, Ivanovo). We studied indicators of simple visual-motor reaction (SVMR), tapping test and hindrance stability. These methods are classic and allow characterizing a quality of agility, lability, mobility and strength of nervous processes. In addition, we identified indicators of the reaction to a moving object that lies at the basis of agility, which show lability and mobility of nervous processes, degree of their balance [11].

The data was statistically processed with the STATISTICS 6.0 software package. Evaluation of differences' significance was carried out with the Student's test.

Results and discussion. Strength of nervous processes that define functional resources of a pupil is the one of active components of the educational process and has an effect on academic success. Properties of the nervous system can be a limiting factor in effective implementation of educational activity. One of integral neurodynamic indicators, which determines strength of nervous processes and is the basic indicator of the central nervous system's functional state, is the maximum frequency of movement or tapping [4].

Results of the tapping test revealed that 25% of 3rd grade pupils had a strong type of the nervous system, against the background of which their organism is able to endure more intense and longer loads without reducing functional reserves of the central nervous system. 46% of pupils had the nervous system of average strength. This type is characterized by a stability of indicators, a moderate performance of nerve cells, maximum tempo is held on the approximately same level in the course of the whole process. 11% of pupils had a weak type of the nervous system. Maximum tempo of work is registered in first 5 seconds. Then, beginning at the next 5-second section, tempo is reduced and remains at a reduced level up until the end of the work. It means that these pupils have a quickly developing phase of fatigue, leading to reduction of functional reserves of the central nervous system and the organism's performance.

Gender analysis of psychomotor indicators, obtained in the tapping test, found that dynamics of the psychomotor performance among 3rd grade boys and girls did not have significant differences. However, among 4th grade children, we registered higher psychomotor performance in boys compared to girls during the whole period ($p<0,05$). The performance level in girls was lower than in the 3rd grade ($p<0,05$) (fig. 1, 2).

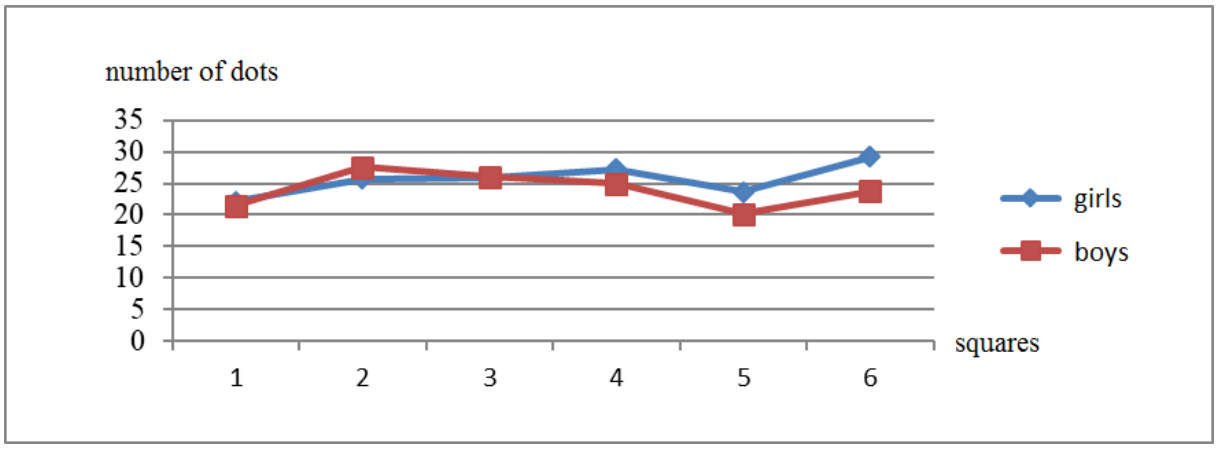

Fig. 1. Performance curve of 3rd grade pupils, according to the tapping test

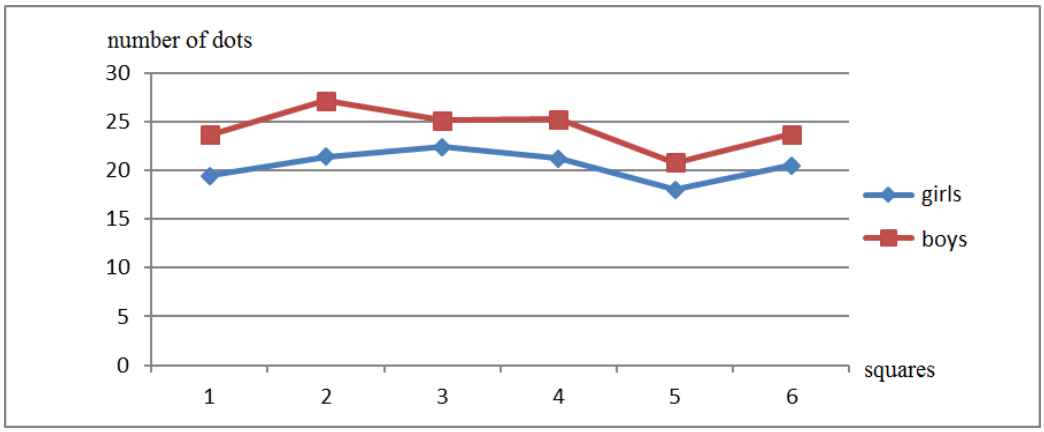

Fig. 1. Performance curve of 4th grade pupils, according to the tapping test

It means that accumulative effect of developed fatigue that occurred at the end of educational process took the leading role in revealed changes. It is more pronounced in girls, because they are more dutiful towards learning and have a higher level of motivation to achieve success.

The comparative assessment of the latent period of the SVRM that shows agility and a level of sensor correction demonstrated that among all examined pupils it corresponded to age-related normal values. At the end of the academic year, the SVMR in the 4th grade slightly increased, but it did not exceed standard values. There were no statistically significant differences in the SVMR between boys and girls. Meanwhile, a number of errors (skips and untimely taps) in conditions of the SVMR test increased from the beginning to the end of the year equally both in boys and girls (table). As a rule, worsening of time and precision parameters of activity is connected to a reduced performance [11].

Table

Neurodynamic indicators of 3rd and 4th grade pupils

	boys	girls	boys		girls	
Period	3 grade autumn		4 grade autumn	4 grade spring	4 grade autumn	4 grade spring
Simple visual-motor reaction						
Reaction time, ms	289,3±8,2	3112,0±7,3	270,4±10,1	276,6±9,4	292,5±10,2	293,3±9,0
Number of errors	2,0±0,1	2,2±0,2	2,2±0,1	3,0±0,1	2,4±0,2	2,9±0,2
Precision coefficient	0,09±0,04	0,09±0,03	0,09±0,01	0,9 ±0,01*	0,09±0,02	0,94±0,02*
Hindrance stability						
Reaction time, ms	335,4±10,3	343,0±18,6	316,8±29,7	425,3±31,1*	348,2±27,2	445,5±36,0*
Number of errors	2,7±0,4	3,7±0,5	3,1±0,3	4,4±0,4	2,3±0,3	3,3±0,4
Precision coefficient	0,09±0,05	0,10±0,03	0,12±0,01	0,9±0,02*	0,08±0,01	0,9±0,01*

Note: * – significance of differences ($p<0,05$) between pupils in different periods of examination (autumn-spring)

According to studies, carried out by O.B. Gilevaya [12], reaction time can be considered as a psychophysiological predictor of academic success. This fact corresponds with the data from other researchers who show that increase in reaction time is a risk factor of pupils' maladaptation [2].

It is important to note that among pupils, who are successful in learning, there can be children with high values of the CVMR time. It means that these pupils are exposed to overloading and belong to the risk group of developing maladaptation against the background of increased physiological penalty of adaptation in case of fatigue and overfatigue.

Value of the precision coefficient when performing the task, both in boys and girls, is reducing from the beginning till the end of the fourth academic year (from 0,09±0,01 to 0,93±0,01, $p<0,01$), which also reflects the developing fatigue.

The "hindrance stability" test is an option of the visual-motor reaction in conditions of dynamic interferences. Increased reaction time, number of errors, significant reduction of the precision coefficient by the spring of the 4th grade demonstrates the worsened adaptive state (table).

According to the ontogenesis theory, the reaction time reduces with age, since the regulation system improves during the process, including the system that defines features of perception and analysis of given stimuli. It is known, that at the age of 10 years, another stage of structural and functional transformation in the brain concludes. The child's organism, as a result, obtains new functional capabilities. According to several studies [5], the period from 10 to 11 years is characterized by a rapid decrease of the reaction time's mean value. The fact that we revealed worsening of the central nervous system's functional state in examined pupils means that revealed changes are caused not by natural processes of growth and development during ontogenesis, but by an accumulative effect of academic classes, which lead to developing fatigue, when the physiological penalty for adaptation grows. In this case, the organism pays the high prize through spending energy of various reserves, including protective ones, by means of mobilizing physiological systems of regulatory, adaptive, homeostatic and behavioral levels. Against the background of stress in regulatory-adaptive and homeostatic adaptation mechanisms, reduction of functional reserves occurs, accompanied typically by an appearance of hemodynamic, energy and structural disturbances in executive systems. It leads to change of the current functional state of the nervous system and development of the maladaptation phase [8, 11].

The same conclusion can be made when analyzing results of the reaction on a moving object. For example, at the beginning of the academic year, both boys and girls had a predominant number of anticipate reactions (40,0% and 53,5%). By

the end of the 4th grade, we registered a rapid increase in a number of delays from 23,4% to 43,5% in boys and from 20,0% to 45,7% in girls.

The reaction on a moving object is a substantially precise indicator of the central nervous system's functional state, which shows a degree of its fatigue. Discovered dynamics of increasing number in delayed reactions show changes in the balance of nervous processes in primary school children in the course of academic activity, volume and intensity of which do not correspond with age-related and adaptive capabilities of examined pupils.

Conclusion. Therefore, discovered dynamics of basic neurodynamic indicators in 3rd and 4th grade pupils demonstrates worsened functional state of the central nervous system by the end of the fourth academic year. In this case, there is an increase in the reaction time and the number of errors, as well as a growing number of children with the unstable nervous processes, with the predominance of inhibition in particular, mainly in girls. High intensification of academic processes, psychoemotional and learning overloads, innovative educational technologies make additional requirements to psychophysical resources of children, leading to developing the hidden compensable fatigue. In case, if it is not possible to compensate, it leads to overfatigue [1]. The most negative consequences, related to stress in school (reciting, tests, public assessment) form already at the end of the initial stage of systematic education in school. As a result, children have a reduced level of health, lose motivation to learn and learn educational programs less effectively. It means that there is a need to change the strategy, taking into account the current functional state of the central nervous system and a degree of fatigue development.

The obtained data show, that education in modern schools is an extremely stressful period in a life of children, which is shown through unfavorable dynamics of psychophysiological indicators. It should be emphasized that significant changes, which deal with the structure of the primary education, its forms, control and other aspects, are currently taking place [6, 13]. One of these changes is introduction of the system of monitoring quality of education in a form of tests into the educational system. However, additional testing loads make more requirements to psychophysiological resources of children, leads to increased anxiety, disturbance in the balance of nervous processes, which creates prerequisites for worse well-being, reduced stress resistance and declining academic success. A connection between values of psychophysiological indicators of pupils and effectiveness of the educational activity, i.e. academic success, was demonstrated in a number of works [12].

Meanwhile, in case of the individual analysis of the academic success and neurodynamic indicators, we can see a paradox in a number of cases, where we

noticed worse psychophysiological indicators in children who are academically successful. It means that the organism pays a high physiological penalty for such successful result of the activity. Taking this fact into account, there is a need to consider individual psychophysiological indicators of pupils in the educational practice. It will allow achieving the main goal, i.e. to increase effectiveness of education and preserve high level of health by means of correct arrangement of effective work of each pupil.

References

1. Berezhkov L.F. Dynamics of the health state of children during training at school / L.F. Berezhkov, N.M. Bondarenko // Successes Of Physiological Sciences. – 2012. – № 1. – P. 39-47.
2. Bystrushkin S.Kh. Features of organizing attention and emotion perception in children in the normal condition and in case of intellectual development disorders / S.Kh. Bystrushkin, R.I. Ajzman, L.I. Aftanas // Bulletin of the Siberian Department of the RAMS. – 2008. – № 3. – P. 96-100.
3. Varich L.A. Features of psychophysiological adaptation of pupils of primary school age / L.A. Varich, Yu.V. Sorokina // Bulletin of the Kemerovo State University. – 2017. – № 2. – P. 117-122.
4. Dumbaj N.V. Indicators of the speed of sensorimotor reactions and tapping test in primary school students in different years of schooling / N.V. Dumbaj, I.Y. Shamygina // Health Science. – 2004. – № 3. – P. 42-48.
5. Tikhonova O.N. Formation of psychomotor qualities in children and adolescents aged 7-16 years / O.N. Tikhonova // Bulletin of the Institute of Child Development. – 2008. – № 1. – P. 121-124.
6. Shakhanova A.V. Education and health: physiological aspects / A.V. Shakhanova, T.V. Glazun // Majkop: ASU. – 2008. – 195 p.
7. Anokhin P.K. System mechanisms of higher nervous activity / P.K. Anokhin // M.: Science. – 1979. – 453 p.
8. Medvedev V.I. Interaction of physiological and psychological mechanisms in the process of adaptation / V.I. Medvedev // Human Physiology. – 1998. – Vol. 24. – № 4. – P.7
9. Agadzhanyan N.A. Adaptation and ethnic physiology: life expectancy and human health / N.A. Aghadzanyan // M.: PFUR's Publishing House. – 2009. – P. 24-26.
10. Ozheva R.S. The role of adaptation mechanisms in the preservation of public health / R.S. Ozheva // Modern Science-Driven Technologies. – 2010. – № 9. – P. 128-129.

11. Shakhanova A.V. Psychophysiological basics of physical performance of university students in conditions of sports activity / A.V. Shakhanova, T.G. Petrova // Majkop: ASU's Publishing House. – 2015. – 124 p.

12. Gileva O.B. Reaction time as a psychophysiological predictor of academic success of schoolchildren / O.B. Gileva // Journal of Biomedical Research. – 2013. – № 3. – P. 14-23.

13. Shakhanova A.V. Innovative educational technologies, motor activity, adaptation / A.V. Shakhanova, M.N. Silant'ev // Majkop: «Quality». – 2007. – 151 p.

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