

INFLUENCE OF MENTAL LOAD ON NEUROVEGETATIVE REGULATION OF HEART RHYTHM IN YOUNG CHESS PLAYERS

¹Alieva N.R., ²Muxamedjanova F.R.

^{1,2}Tashkent Pediatric Medical Institute

<https://doi.org/10.5281/zenodo.10326226>

Abstract. *Preservation and strengthening of the health of children and adolescents is one of the most essential tasks of the State in the context of the transition to new standards of education in general education schools, connected with the introduction of innovative pedagogical technologies, increasing the level of information component and intensification of mental loads (additional classes, sections, circles), computerization of the educational process [2, 3, 8]. The beginning of learning at school is one of the most stressful periods of life activity when the mechanisms of brain support for cognitive activity are formed during a sharp change of social conditions [1, 2].*

Keywords: *neurovegetative regulation, stressogenic period, neurodynamic indices, spectral rhythm, supragmentary and segmentary level.*

Data on the physical development of children studying software innovative programs are diverse: both deterioration of indicators [5] and absence of adverse changes of indicators [6], or prevalence of average values of indicators of physical development among the surveyed population of students [4] were revealed. A rather close connection between the physical development indicators, somatotype and functional state of the cardiovascular system has been established [3, 8, 9]. An important role in the adaptation of a child's organism to mental loads is played by the peculiarities of neurovegetative regulation of cardiovascular system activity, which are the indicators of adaptive processes of the organism as a whole [6, 7]. Statistical characteristics of the cardiac rhythm of children 7-9 years old are rather stable individual indicators and can serve for evaluation of corrective actions [3, 5].

Intellectual loadings in systematic chess practice contribute to the increase of cognitive needs, independence of thinking, and the overall level of development of children. The researches spent so far are devoted to studying of psychological or pedagogical aspects of influence of the raised intellectual loadings at software lessons of the program of chess general education [3, 5, 7, 8]; however results of numerous medical and pedagogical examinations of last years testify to a lousy situation with health of schoolboys, and growth of various functional disorders and chronic diseases among schoolboys is connected more often with educational process and introduction of innovative programs of training [7, 8].

Objective of the study: To study the data of comparative analysis of peculiarities of neuroinhibitory regulation of heart rhythm in a state of rest and at the sample with mental load.

Materials and methods of the study: the study is based on data from a survey of 87 children aged 6 to 11 years, engaged in professional chess, including 58 boys (66.7%) and 29 girls (33.3%), the average age of 10.1±0.2 years. Among the children of chess players, 43 had at least 2 years of experience in chess, and 44 had more than 3 years of experience. The average length of

experience in sport is 3.1 ± 0.01 years. All children chess players once a year pass medical examination. These children have made the primary group.

The comparison group consisted of 85 children from 2nd and 4th grades of Tashkent secondary schools who did not participate in sports sections. The average age of these children was 9.8 ± 0.3 years, 50.6 per cent (43 children) were boys and 49.4 per cent (42 children) were girls.

Comparative analysis was carried out among the children surveyed, including a study of neurodynamic indicators and the activity of various levels of neurovegetative regulation of the heart's rhythm at rest and at tests with mental strain. The "learning" mental load (ML) for second-graders was to solve problems on addition and subtraction, for fourth-graders on multiplication and division).

The method of cardiointervalography of R.M. Baevskiy's software with the help of hardware-software complex "Ritm" (HSC "Ritm," Republic of Uzbekistan, firm "ALEN") was used for the research [1]. The examination was conducted in the morning hours, in the position of the test subjects sitting down. Heart rate (HR), activity indices of sympathetic and parasympathetic links of ANS were registered. We calculated the fashion amplitude (A_{mon}) - a conventional indicator of activity of the sympathetic regulatory link; the difference between the maximum and minimum values of cardiointervals (M_xD_{Mn}) characterizing the maximum amplitude of regulatory influences; the RMSSD indicator showing the activity of the parasympathetic regulatory link; pNN50 - an indicator of the degree of prevalence of the parasympathetic regulatory link over the sympathetic one. The degree of activity of the autonomous and central regulatory circuits was estimated by the values of CC1 and CC0, respectively. The degree of prevalence of activity of the central regulation mechanisms over the autonomous ones reflected the stress index (voltage index of regulatory systems, SI), the degree of centralization of heart rhythm control - the index of centralization (IC). The contribution of specific regulation mechanisms (parasympathetic - HF, sympathetic - VLF and vasomotor center - LF) to the total activity level of regulatory systems (TR) was calculated from the power of their spectrum in %.

Four main levels were adopted to assess the reliability of statistical indicators: high - $p < 0.001$, average - $p < 0.010$, low (marginal) - $p < 0.050$, insignificant (unreliable) - $p > 0.050$.

Research results: when studying the peculiarities of neurovegetative regulation of heart rhythm as an integral indicator of adaptive processes, no intergroup and gender differences in the initial values of the total power of the spectrum were revealed in the 2nd-grade pupils. In boys of the main group, there was an increase in the indices of the supra-segmentary level of heart rhythm regulation in comparison with the indices of girls of the comparison group.

Conducting a sample with mental load resulted in an increase in the activity of the segmental level of heart rhythm regulation - both sympathetic and parasympathetic parts of the autonomous nervous system. At the same time, the activity of supra-segmentary rhythm regulation was also increased in girls, which was documented by the increase in HF-vibration capacity.

Pupils of the 4th grade had an insignificant predominance of the suprimental level of MS regulation in the main group, while the segmentary level - in the comparison group (Fig. 1). In comparison with the 2nd-graders' indicators, an increase in the significance of the supra-segmentary level of heart rhythm regulation in girls of the main group and the comparison group by 25% on average ($p < 0.05$) can be noted.

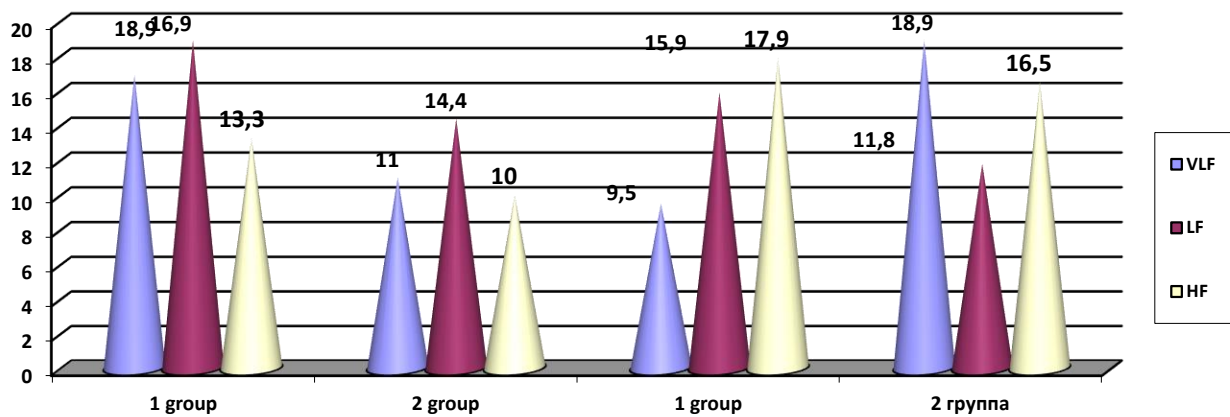


Fig. 1. Heart spectral rhythm readings as a function of age

In response to the mental load, the activity of both supra-segmentary and segmental levels of PC regulation ($p < 0.05$) increased, with a higher proportion of LF and VLF fluctuations in the structure of the total spectrum power. In female chess players, the response was the predominant growth of the influence of the sympathetic department ($p < 0.01$) and its prevalence in the structure of the total spectrum power. In the control group, the expressed sympathicotonic reaction with increase of absolute (in 2,1-2,6 times, $p < 0,05-0,01$) and relative power of low-frequency oscillations (more than in 1,8 times, $p < 0,01$; the share of VLF-vibrations is more than 43%) was revealed, that characterizes excessive activation of sympathetic-adrenal system on the influence of stress factors.

The influence of "chess" load at chess players of 2nd classes caused more pronounced activation of supra-segmentary and segmentary levels of regulation in comparison with "training" load (relative power of VLF-vibrations is more than 30%, LF-vibrations - more than 39%), at the same time the tendency to decrease the power and share of HF-vibrations was established: from $24.8 \pm 1.9\%$ to $15.3 \pm 1.3\%$ ($p < 0.01$) for boys (at "study" load - $29.2 \pm 2.20\%$, $p < 0.001$) and from $36.4 \pm 2.2\%$ to $20.0 \pm 1.4\%$ ($p < 0.01$) for girls (at "study" load - $31.3 \pm 2.2\%$, $p < 0.001$) (Figure 2).

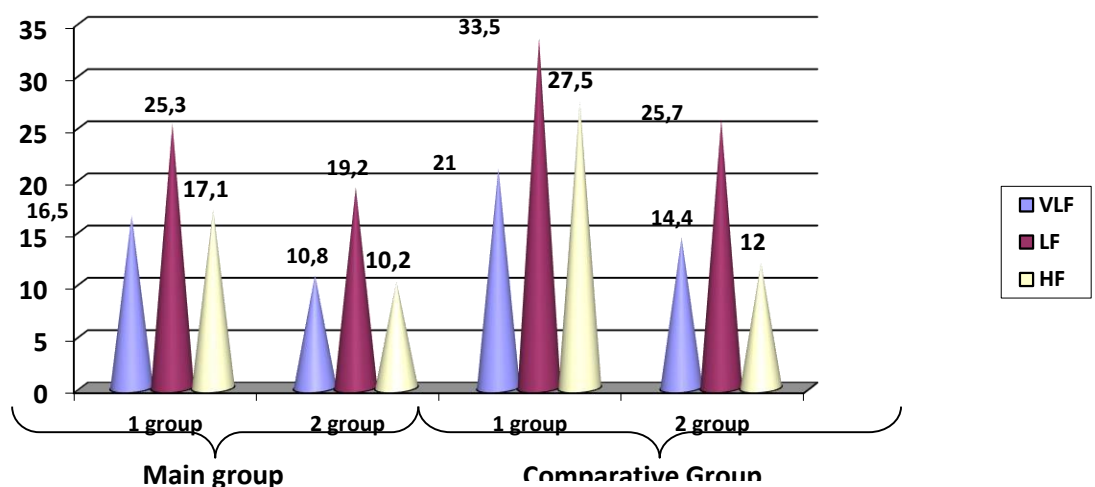


Fig. 2. The age-related spectral rhythm of the heart (mental capacity)

Adaptive reactions to the "chess" load in chess players of the 4th grade were characterized by the preferential activation of the supra-segmentary level of MS regulation with moderate sympathicotonic reaction: the share of LF-vibrations was 35% in girls and 26% in boys. The relative power of VLF-vibrations in female chess players of the 4th grade after the chess problem was $37.9 \pm 1.4\%$ ($26.8 \pm 1.2\%$ after the "learning" load, $p < 0.001$) and $42.2 \pm 1.7\%$ (against $38.6 \pm 1.7\%$, $p < 0.05$) in boys, which reflects the most significant contribution of the central supra-segmentary structures of neurovegetative regulation to the mental performance. The total LF-vibration power values were 35% lower than those of chess players of the 2nd grade ($p < 0.01$).

Thus, spectral characteristics of heart rhythm are used as markers of the degree of tension of mechanisms of adaptation of an organism to the influence of environmental factors (R.M. Baevsky et al., 2000).

When assessing the results of the Slow Wave Variability spectral analysis of children at the age of 7-8 years old, the initial HR value as well as the total spectrum power did not have reliable intergroup differences. The following gender differences were revealed: the value of HF oscillations characterizing the influence of segmental level (parasympathetic department) of vegetative regulation on SWs was the highest in the main and the comparison group of girls compared to boys. A calculation of the vagosympathetic index (LF/HF) in boys at the given age section eutonia was revealed (in the main group 1.10 ± 0.20 , in the comparison group - $1.05 \pm 0.1b$ units), in girls it was 0.82 ± 0.18 and 0.53 ± 0.24 units, respectively. According to the literature, in the specified age period there is an increase in parasympathictonia (D.A.Dmitriev et al., 2004); judging by the results presented by us, it occurs in girls at an earlier stage of development.

Conclusions:

1. In ontogenesis in children of both sexes from 8 to 11 years of age, there is an increase in the activity of supra-segmentary and segmentary level of heart rhythm regulation and inotropic function and tone of large vessels. In 11-year-old girls, as compared to boys, the activity of supra-segmentary level of regulation of Chrono- and inotropic heart function at rest is higher; the increasing significance of parasympathicotonic effects on chrono- and inotropic function at mental load in girls was revealed at earlier age (8-9 years) as compared to boys (11 years).

2. At 11 years of age, irrespective of sex and curriculum, there is greater stability in the spectral characteristics of the average dynamic pressure in response to mental load, compared with 8-year-old children.

3. Adaptation to additional intellectual load (chess general education program for 3 years) leads to differences in response to mental load: Unidirectional changes in indicators of slow-wave variability of heart rhythm and stroke volume - increase of importance of humoral-metabolic factors of regulation (increase of relative power of very low-frequency fluctuations of rhythm up to 25-37%) and activity of sympathetic department (increase of absolute power of LF fluctuations up to 30%, $p < 0,05$); in the comparison group the response was accompanied by a pronounced sympathicotonic reaction with a significant increase in absolute power of low-frequency heart rhythm oscillations (more than 2 times, $p < 0.01$), relative power of LF oscillations of average dynamic pressure (up to 57%) and insignificant shifts of spectral characteristics of the shock volume.

REFERENCES

1. Baevskiy, P.M. Heart rate variability: theoretical aspects and possibilities of clinical application (in Russian) / P.M. Baevskiy, G.G. Ivanov. Moscow: Medicine, 2000. –p. 295.

2. Bykov E.V. Ontogenetic Aspects of Arterial Pressure Regulation in Pupils of Junior Classes with Different Intellectual Loads / E.V. Bykov, E.A. Mekeshkin, O.V. Kazakova. N.G. Zinurova // Vestnik of SUSU. Education, public health services, physical culture" series. - 2010. - Vestnik. 24. - №24, (200). - pp. 24-27.
3. Wayne, A.M. Classification of vegetative disorders / A.M. Wayne // Vegetative disorders: Clinic, treatment, diagnosis. M.: MIA, 2000. -pp. 103-108.
4. Vershinin, M.A. Formation of logical thinking of chess players at different stages of sports improvement / M.A. Vershinin // Physical culture: education, training. - — 2006. - — №1 — pp. 30-34.
5. Gainanova, N.K. Estimation of the first-graders mental performance level at adaptation to the training loads / N.K. Gainanova, P.M. Belikova // Ros. physiol. Zhurnal. I.M. Sechenov. 2004. - T. 90, №8. - p. 351.
6. Zayneyev, M.M. Age-specific features of cardiorespiratory system reaction of younger schoolchildren on dynamic and isometric load in different periods of the academic year: Ph.D. thesis abstract. Kazan, 2009. – p. 28.
7. Zvezdina, I.V. Functional state of the cardiovascular system of children in the dynamics of primary school education / I.V. Zvezdina, N.S. Zhigareva, J.I.A. Agapova // Russian Pediatric Journal: scientific and practical journal. 2009. - №2. - pp. 19-23
8. Krivolapchuk I.A. Psychophysiological price of the intense information load at children and teenagers in 5-14 years (in Russian) / I.A. Krivolapchuk. 2008. - T. 34, № 4. - pp. 28-35.
9. Sato, N. Cardiovascular reaction to mental stress: relationship with the menstrual cycle and gender / N. Sato, S. Miyake // J. Pysiol. Anthropol. Appl. Hum. Science. 2004. - V. 23. - №6. - P. 215.