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## **Physiological assessment of adaptive reactions of organism among gifted schoolchildren**

The article gives a physiological assessment of adaptive reactions of organism among gifted schoolchildren. An increase in growth was observed both among boys and girls. Simultaneously with the increase, the body weight of adolescents also increases. Muscle strength intensively increases in adolescence. The schoolchildren had significant differences in the level of functional state of the central nervous system. Differences in the level of functional tension of the central nervous system and mental performance are noted among gifted schoolchildren, depending on age and sex. Education of the schoolboys changed organisms' functional condition and nervous — emotional activity, appreciable exhaustion of the pupils, progressive decrease of serviceability, cordial — vessel system and central nervous system, energy provisional system in the intensification educational process conditions. The badly ecological situation has a negative effect for physiological parameters and «quality» of health of the living children's population, that in a consequence will be reflected in his serviceability and illness.

*Keywords:* adolescent, age, reaction, organism, process, central nervous system, cardiovascular system, Ruffier index, muscle strength, working capacity, adaptation.

Adolescence is a natural stage in the development of organism, but at the same time, it sharply differs from all other stages of a person's lifewith its uniqueness and pace. During this period, rapid restructuring takes place in the activity of all the physiological systems of the body. From the physiological point of view, the adolescent period is characterized by an increase in the intensity of growth, increased metabolism, increased oxygen consumption, a sharp increase in the activity of the endocrine glands, active assimilatory processes, pronounced endocrine shifts, processes of morphological and functional differentiation of the brain and internal organs. A person never grows as intensely as during adolescence, except for the first two years of his life [1, 2].

In functional terms, the body is extremely unstable and prone to diseases and frustrations. The cardiovascular system undergoes significant changes. The stimulating effect on heart growth is exerted by endocrine glands whose activity is sharply activated [3].

Respiratory organs intensively develop during adolescence. The vital capacity of the lungs significantly increases [4]. Breathing becomes less frequent and deeper. The chest and respiratory muscles develop intensively; along with this the rate of their development is most intense during puberty. The type of breathing is finally formed in adolescence.

Thus, the body of adolescents on a number of parameters is approaching the level of adults, but the peculiarity of this age, consisting in the relative weakness of the cerebral cortex, the imperfections of the nervous and humoral regulation, the mobility and instability of the regulation of the autonomic nervous system, disharmony in the rate of growth of the heart, blood vessels and the body determines the increased sensitivity of their organism to various influences [4].

The introduction of innovative methods into the process should promote the development of children, training their body and adapting it to mental and physical stress [4, 5]. The improvement of education must follow the path that fosters the formation of child's personality, capable of effective adaptation in changing conditions.

### *Materials and methods of research*

The research was carried out on the basis of the school for gifted children «Daryn» affiliated with the Karaganda State University named after Ye.A. Buketov. The object of the study is pupils of grades 8–11. All schoolchildren were also divided into age periods: 14–15 years (pubertal) and 16–17 years (post-pubertal).

Anthropometric studies included: measuring the main indicators of the physical development of schoolchildren: length, body weight, chest circumference, their centile evaluation were determined; the study of individual psychological traits of personality according to the method of G.D. Eysenck, definition of personal anxiety; pulse rate measurement before and after the dosed load, calculation of the Ruffier index, sys-

toloc (SBP) and diastolic (DBP) blood pressure; mathematical analysis of the heart rhythm according to R.M. Baevskiy. Physiological studies included: measurement of the indices of functional state of the central nervous system (simple and complex AMR, VMR, Anfimov table), subjective assessment of state of health, activity and mood (SAM). To characterize the degree of tension of individual links of the system of neuro-humoral regulation in the whole organism, the method of mathematical analysis of the heart rhythm (SR) for RM Baevsky was used. Analysis of vegetovascular reaction is a method to assess the state of regulation mechanisms of physiological functions in the human and animal organism, in particular, the overall activity of regulatory mechanisms, neurohumoral regulation of the heart, the relationship between sympathetic and parasympathetic parts of the autonomic nervous system.

### Research results

As the results of the comparative analysis showed, the schoolchildren had significant differences in the level of functional state of central nervous system in the studied age periods.

Pronounced sexual and age features were noted from the point of view of sensorimotor reactions (Fig. 1). Thus, the boys in the first age period (14–15 years) showed higher values of VMR and AMR in comparison with the second age period (16–17 years). In the first age period VMR and AMR among boys were averaged  $254.8 \pm 12.5$  and  $231.0 \pm 10.6$  msec, and in the second period there was a significant decrease of  $227.0 \pm 4.4$  and  $210.3 \pm 3.9$  msec, respectively ( $p < 0.05$ ). Significant differences among girls were noted only in the time of AMR (in the first age group of AMR —  $248.9 \pm 7.7$  msec, in the second —  $229.9 \pm 6.6$  msec,  $p < 0.05$ ), significant difference in VMR was noted.

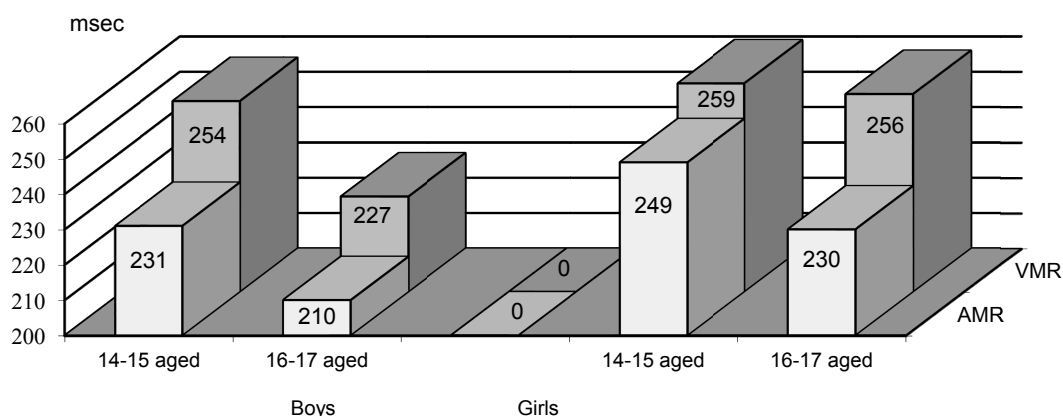


Figure 1. Level of sensorimotor reactions of schoolchildren depending on age periods

If we take into account the fact that the reaction time depends on many external and internal causes and reflects the course of many processes in the central nervous system, the observed changes in the magnitude of the reaction time correspond to the overall effect of interaction of the main processes in the central nervous system, namely, the inhibitory processes were dominated over excitation among the schoolchildren of the first age group. The direction of the general equilibrium shift between these processes, as well as the ability to focus attention to a certain extent, depends on the workload and the degree of fatigue. Consequently, the mental load in the first age group is higher than in the second, and these processes were more pronounced among boys than among the girls.

Evaluation of the effectiveness of attention process with the help of correcting tables of Anfimov showed the presence of significant differences in mental performance among girls (Fig. 2).

Its lower values were noted in the first age period — the number of scanned and found figures (in the first group,  $374.7 \pm 10.4$  and  $36.9 \pm 1.06$  figures, respectively, in the second group —  $429.4 \pm 16.5$  and  $42.0 \pm 1.69$  figures, ( $p < 0.05$ , Fig. 2.). An additional confirmation is the attention index, in the first age group this indicator had also reliably low values ( $23.4 \pm 0.65$  units) in comparison with the second ( $26.8 \pm 0.73$  units, Table 1,  $p < 0.05$ ).

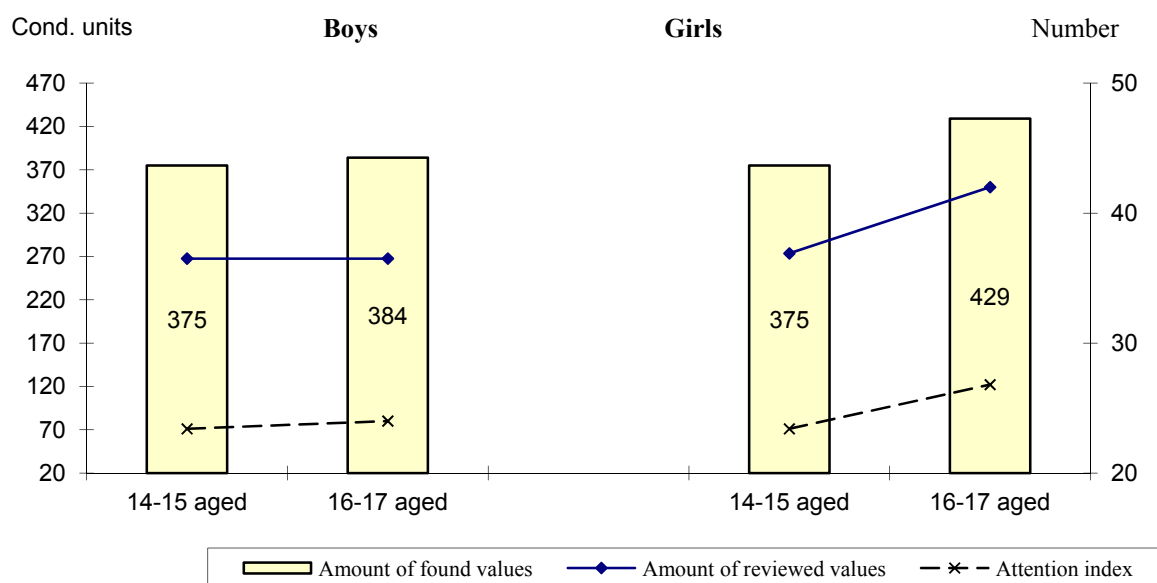


Figure 2. The level of indicators of mental performance among schoolchildren, depending on age

Table 1

**The level of functional status of the central nervous system among gifted schoolchildren in different age periods**

Indices	Boys		Girls	
	14–15 aged n=145	16–17 aged n=144	14–15 aged n=143	16–17 aged n=141
Amount of reviewed values	374.8 ± 28.2	384.5 ± 12.4	374.7 ± 10.4	429.4 ± 16.5*
Amount of found values	36.5 ± 2.59	36.5 ± 1.12	36.9 ± 1.06	42.0 ± 1.69*
Amount of mistakes	2.60 ± 0.91	2.84 ± 0.49	1.45 ± 0.30	1.91 ± 0.32
Index of attention	23.4 ± 1.76	24.0 ± 0.78	23.4 ± 0.65	26.8 ± 0.73*

Note. \* — Differences are significant ( $p < 0.05$ ).

Thus, the obtained results indicate that the gifted students have differences in the level of functional tension of the central nervous system and mental capacity for work, depending on age and sex. Moreover, boys in the 14–15 age group had a higher level of functional tension of the central nervous system, while girls of the same age period had low values of mental capacity for work.

The level of state of health, activity and mood among gifted schoolchildren did not have significant differences depending on age (Table 2).

Table 2

**Level of reactive anxiety and SAM indicators among gifted schoolchildren in different age periods**

Indices	Boys		Girls	
	14–15 aged n=145	16–17 aged n=144	14–15 aged n=143	16–17 aged n=141
State of health	5.22 ± 0.36	5.46 ± 0.14	5.20 ± 0.18	5.32 ± 0.14
Activity	4.75 ± 0.30	4.91 ± 0.15	4.40 ± 0.22	4.75 ± 0.16
Mood	5.72 ± 0.21	5.74 ± 0.12	5.55 ± 0.17	5.64 ± 0.15

Low mental performance was accompanied by the high values of reactive anxiety level —  $39.8 \pm 2.32$  units among girls of the first age group, while in the second age group —  $34.8 \pm 1.73$  units ( $p < 0.05$ , Fig. 3). There were no significant differences in the level of reactive anxiety among the boys.

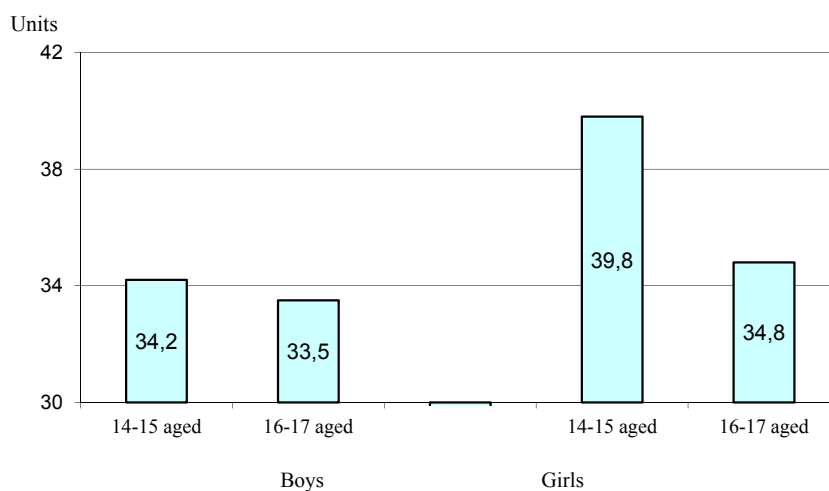


Figure 3. Level of reactive anxiety among gifted schoolchildren in different age periods

On the part of indicators that characterize the level of functional state of the cardiovascular system, there are no significant differences depending on age, except for the pulse rate among girls (Table 3). For example, in the first age group, the heart rate averaged  $84.6 \pm 1.74$  beats per minute, while in the second,  $80.2 \pm 1.66$  beats/min ( $p < 0.05$ ).

Table 3

**The level of functional state of the cardiovascular system among gifted schoolchildren in different age periods**

Indices	Boys		Girls	
	14–15 aged n=145	16–17 aged n=144	14–15 aged n=143	16–17 aged n=141
SBP	$109.6 \pm 2.2$	$111.9 \pm 1.5$	$105.7 \pm 1.8$	$109.1 \pm 2.1$
DBP	$71.2 \pm 2.05$	$72.4 \pm 1.15$	$67.3 \pm 1.52$	$68.1 \pm 1.35$
Pulse rate	$82.5 \pm 4.09$	$79.2 \pm 1.70$	$84.6 \pm 1.74$	$80.2 \pm 1.66^*$
Ruffier index	$6.75 \pm 0.61$	$6.59 \pm 0.26$	$8.63 \pm 0.39$	$7.52 \pm 0.35^*$

Note. \* — Differences are significant ( $p < 0.05$ ).

An evaluation of the intensity of labor according to the pulse rate among schoolgirls of the first age group showed that it corresponded to the level of «satisfactory», while among schoolgirls of the second age group the tension corresponded to the level of «good». Among boys, the intensity of labor according to the pulse rate, according to the quantitative gradation, corresponded to the levels as among the girls, although the quantitative values of the state of emergency did not have such pronounced differences.

This is also confirmed by the results of assessment of the functional capabilities of organism among schoolchildren, depending on the age boundaries. As can be seen from Figure 4, the response to the measured physical load among girls of the first age group is higher than in the second group. The values of the pulse rate here were higher at all stages of the sample. So, if the initial pulse rate among girls of the first age group is averaged  $84.6 \pm 1.74$  beats per minute, in the second group —  $80.2 \pm 1.66$  beats/min ( $p < 0.05$ ), after the emergency load in the first group it increased to  $137.7 \pm 2.4$  bpm, while in the second group it increased to  $129.3 \pm 2.6$  bpm ( $p < 0.05$ ).

Comparison of the average values of the Ruffier index for boys of both age groups, the range of its variability are in the range of satisfactory performance (with the criteria for satisfactory performance of 6–8 standard units, the Ruffier index was in the range of  $6.59 \pm 6.75$  units) [6]. The level of working capacity among the girls of the first age group was inadequate (i.e., more than 8 standard units), among girls of the second age group — satisfactory (Table 3).

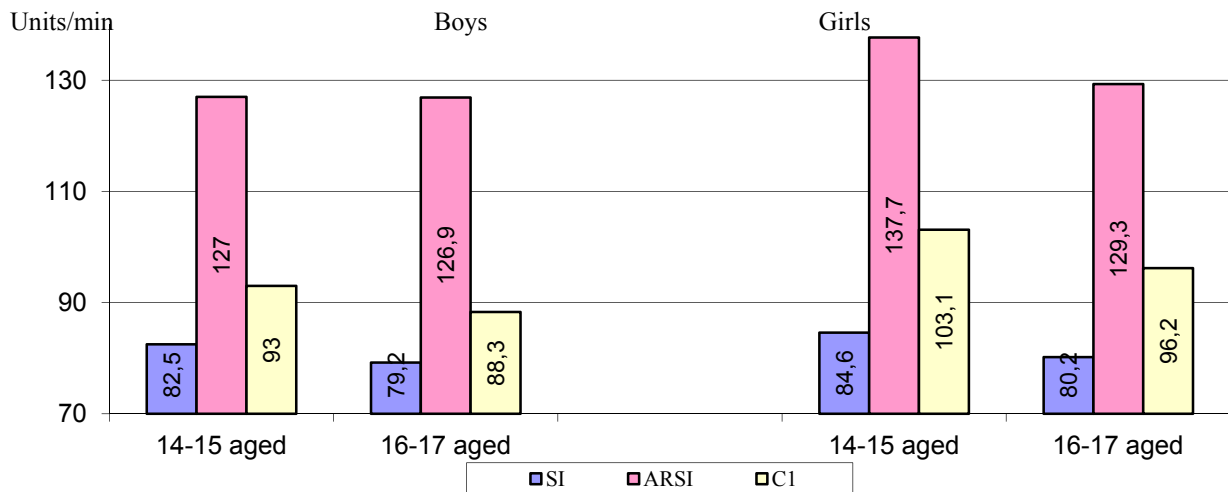


Figure 4. Dynamics of the pulse rate during the exercise test

As the analysis of the regulatory mechanisms of cardiac activity on the basis of mathematical parameters of heart rhythm showed, girls of the first age group have higher reaction intensity, and as a result, the «physiological value» of the work is higher (Table 4). The boys did not have significant differences. The higher tension of regulating systems of organism is shown by higher values of A Moreflecting the mobilizing effect of centralization of cardiac rhythm control, the conditional index of the activity of sympathetic link of regulation. The average AMO among girls of the first age group was  $49.6 \pm 3.40$  %, while in the second group it was  $41.7 \pm 2.81$  % ( $p < 0.05$ , Table 4).

Table 4

#### Level of heart rate variability among gifted schoolchildren in different age periods

Indices	Boys		Girls	
	14–15 aged n=145	16–17 aged n=144	14–15 aged n=143	16–17 aged n=141
$M_{R-R}$	$764.8 \pm 21.3$	$776.2 \pm 15.8$	$739.3 \pm 15.2$	$780.5 \pm 17.7^*$
CV	$7.23 \pm 0.91$	$7.05 \pm 0.35$	$7.61 \pm 0.67$	$7.11 \pm 0.47$
Mo	$772.6 \pm 27.4$	$782.2 \pm 19.4$	$733.7 \pm 24.7$	$779.1 \pm 21.1$
Amo	$43.8 \pm 6.33$	$40.1 \pm 2.02$	$49.6 \pm 3.40$	$41.7 \pm 2.81^*$
$\Delta X$	$286.2 \pm 50.4$	$302.5 \pm 14.6$	$252.6 \pm 27.0$	$290.5 \pm 21.1$
TP — $S_0$	$3.82 \pm 1.19$	$4.16 \pm 0.46$	$4.20 \pm 0.76$	$3.63 \pm 0.46$
HF (HFav) — $\Delta B$	$6.15 \pm 2.51$	$5.41 \pm 0.71$	$7.12 \pm 1.86$	$5.37 \pm 0.80$
LF (LFav) — MB1	$11.3 \pm 3.64$	$12.8 \pm 1.53$	$12.4 \pm 2.28$	$11.0 \pm 1.48$
VLF (VLFav) MB2	$18.3 \pm 4.31$	$17.9 \pm 2.09$	$16.2 \pm 1.66$	$12.3 \pm 1.73^*$
LF/HF	$1.06 \pm 0.19$	$1.37 \pm 0.21$	$1.05 \pm 0.20$	$0.96 \pm 0.13$

Note. \* — The differences are significant ( $p < 0.05$ ).

Thus, there is a predominance of the sympathetic part of the autonomic nervous system over the parasympathetic department.

A high degree of tension of regulatory systems is indicated by high values of the stress index, which characterizes the degree of predominance of activity of the central regulatory mechanisms over autonomous ones. An average value of stress index among girls was  $167.2 \pm 24.3$  units for the first age group,  $104.1 \pm 10.6$  units for the second age group ( $p < 0.05$ ).

Analysis of the dynamics of the stress index (Fig. 5) among girls of the first age group showed a sympathetic type of regulation ( $SI > 150$  units). Girls of the second age group and boys of both age groups have normotonic type ( $SI 60-150$  units).

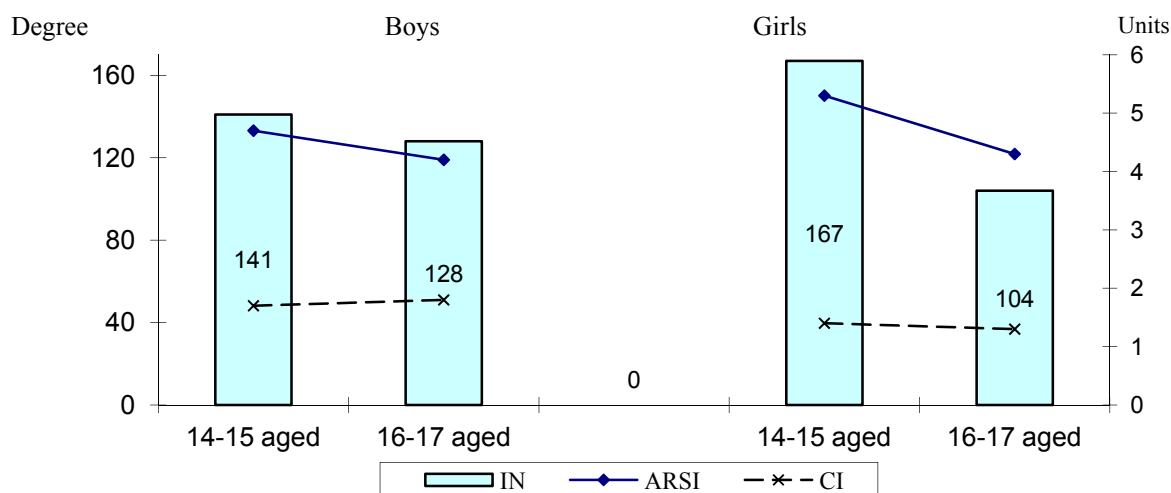


Figure 5. Level of stress and centralization index, index of activity of regulatory system among gifted schoolchildren in different age periods

Thus, the index of activity of the regulatory system, obtained by calculation, made it possible to differentiate different degrees of stress in the school's regulatory systems, depending on the age range, with the exception of 14–15 year old girls with the pronounced level of functional tension of the regulatory systems; this indicator corresponded to the level of the expressed stress in other groups.

#### References

- 1 Хрипкова А.Г. Возрастная физиология и школьная гигиена / А.Г. Хрипкова, М.В. Антропова, Д.А. Фарбер. — М.: Знание, 1990. — 319 с.
- 2 Даян А.В. Реакция сердечной деятельности старшеклассников школ с дифференцированным обучением на экзаменационный стресс / А.В. Даян, А.О. Оганесян, Е.С. Геворкян // Физиология человека. — 2003. — Т. 29, № 2. — С. 49–55.
- 3 Михеева Е.В. Гигиеническая оценка факторов формирования здоровья школьников в современных условиях: на примере Новосибирской области: дис. ... канд. мед. наук / Е.В. Михеева. — Омск, 2011. — 20 с.
- 4 Школьникова М.А. Современная структура сердечно-сосудистых заболеваний у детей, лечение и профилактика / М.А. Школьникова, И.В. Леонтьева // Вестн. Российской перинатологии и педиатрии. — 1997. — № 6. — С. 14–20.
- 5 Антонова Л.Т. О проблеме оценки состояния здоровья детей и подростков в гигиенических исследованиях / Л.Т. Антонова, Г.Н. Сердюковская // Здоровье. — 1996. — № 6. — С. 22–28.
- 6 Барнашова В.Д. Адаптация школьников к учебной нагрузке в первый год обучения / В.Д. Барнашова // Первый уральский форум «Наука, культура, образование на пороге тысячелетия»: Тез. докл. — Челябинск, 1997. — С. 22–24.

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### Дарынды оқушылар ағзасының бейімделу реакциясына физиологиялық баға беру

Мақалада дарынды оқушылар ағзасының бейімделу реакциясына физиологиялық баға берілді. Қыздар мен ұлдардың бойы мен салмағының ұлғаюы анықталды. Балалардың өтпелі кезеңінде бұлшық ет күшінің жоғары көрсеткіші зерттелді. Оқушыларда орталық жүйке жүйесінің (ОЖЖ) функционалдық жағдайының деңгейінде дәлелденген айырмашылықтар тіркелді. Дарынды оқушыларда ОЖЖ және ойлау қабілетінің функционалдық ширығу көрсеткіштерінің айырмашылықтары жасына және жынысына байланысты болды. Оқу үрдісінің күрделенуіне байланысты оқыту барысында оқушылар ағзасының эрекеттік күйінің өзгерістері, жүйке эмоционалдық белсенділігінің қажуы, жұмыс қабілеттілігінің жылдам төмендеуі, ОЖЖ және жүрек-тамыр жүйесінің жағымсыз өзгерістері пайда болады. Қолайсыз экологиялық жағдайлар осы аудандарда тұратын балалардың физиологиялық көрсеткіштеріне және денсаулық «сапасына», келешекте олардың әр түрлі ауруларға шалдығуына және жұмыс қабілеттілігіне әсер етеді.

*Кілт сөздер:* жеткеншек, жас, реакция, ағза, орталық жүйке жүйесі, қан-тамыр жүйесі, Руфье индексі, бұлшық ет күші, жұмысқа қабілеттілік, бейімделу.

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## Физиологическая оценка приспособительных реакций организма одаренных школьников

В статье дана физиологическая оценка приспособительных реакций организма одаренных школьников. Выявлено увеличение роста как у мальчиков, так и у девочек. Одновременно с ростом увеличивается и масса тела подростков. Интенсивно растет мышечная сила. У школьников отмечались достоверные различия в уровне функционального состояния центральной нервной системы. У одаренных школьников отмечены различия в уровне функционального напряжения ЦНС и умственной работоспособности в зависимости от возраста и пола. Обучение школьников в условиях интенсифицированного учебного процесса вызывает изменения функционального состояния организма и нервно-эмоциональной активности, заметное утомление учащихся, прогрессивное снижение работоспособности, неблагоприятные изменения в сердечно-сосудистой системе, системе энергообеспечения. Неблагоприятные экологические факторы негативно влияют на физиологические показатели и состояние здоровья, на заболеваемость и работоспособность детей, проживающих в этих районах.

*Ключевые слова:* подросток, возраст, реакция, организм, процесс, центральная нервная система, сердечно-сосудистая система, индекс Руфье, мышечная сила, работоспособность, адаптация.

### References

- 1 Khripkova, A.G., Antropova, M.V., & Farber, D.A. (1990). *Vozrastnaia fiziologhiia i shkolnaia hiihena [Age physiology and school hygiene]*. Moscow: Znanie [in Russian].
- 2 Dayan, A.V., Oganessian, A.O., & Gevorkyan, E.S. (2003). Reaktsiia serdechnoi deiatelnosti starsheklassnikov shkol s differentsirovannym obucheniem na ekzamenatsionnyi stress [The reaction of cardiac activity of high school students with differentiated education to examination stress]. *Fiziologhiia cheloveka — Physiology of man*, 29, 2, 49–55 [in Russian].
- 3 Mikheeva, E.V. (2011). Hiihienicheskaia otsenka faktorov formirovaniia zdorovia shkolnikov v sovremennykh usloviakh: na primere Novosibirskoi oblasti [Hygienic assessment of the factors shaping the health of schoolchildren in modern conditions: the example of the Novosibirsk region]. *Candidate's thesis*. Omsk [in Russian].
- 4 Shkolnikova, M.A., & Leontiyeva, I.V. (1997). Sovremennaia struktura serdechno-sosudistykh zabolovaniu u detei, lechenie i profilaktika [Modern structure of cardiovascular diseases among children, treatment and prevention]. *Vestnik Rossiiskoi perinatologii i pediatrii — Bulletin of Russian perinatology and pediatrics*, 6, 14–20 [in Russian].
- 5 Antonova, L.T., & Serdyukovskaya, G.N. (1996). O probleme otsenki sostoiianiia zdorovia detei i podrostkov v hiihienicheskikh issledovaniakh [About the problem of an estimation of a state of health among children and teenagers in hygienic researches]. *Zdorovie — Health*, 6, 22–28 [in Russian].
- 6 Barnashova, V.D. (1997) Adaptatsiia shkolnikov k uchebnoi nagruzke v pervyi god obucheniia [Adaptation of schoolchildren to the academic load in the first year of training]. Abstracts of Papers of «Science, culture, education on the threshold of the Millennium»: *Pervyi uralskii forum — the First Ural forum* (pp. 22–24). Chelyabinsk [in Russian].