SCIENTIFIC JUSTIFICATION OF THE INNOVATIVE APPROACH TO HEALTH CONTROL IN STUDENTS FROM GENERAL EDUCATIONAL INSTITUTIONS OF VARIOUS TYPES

Setko AG, Zhdanova OM ✉, Tyurin AV

Orenburg State Medical University, Orenburg, Russia

Increasing academic load, intensification of academic activity, use of not priorly certified innovative pedagogical technologies have been linked with steadily declining health in students. This is how a search for new effective methods of formation, strengthening and increasing health of students is initiated. An important task is to provide for scientific justification of the innovative approach to health control in students from general educational institutions of various types. Heavy academic activity, research of the functional condition of the central nervous, respiratory and cardiovascular systems were assessed in lyceum and school students in Grades 9–10. Students from an 'at-risk' group had their psychophysiological condition corrected; the effectiveness was assessed by comparison of psychophysiological indicators before and after the session. When intensive academic activity is involved, adolescents from a lyceum had better operational indicators of the central nervous system, and functional indicators of the respiratory system as compared with schoolchildren. Students from the both groups had reduced biological, social and psychological adaptation. Sessions of functional biocontrol resulted in the increased number of those examined with normal working capacity and satisfactory biological adaptation against the background of a decreasing number of adolescents with a high level of psychoemotional stress. Functional biocontrol is an effective correction method of psychophysiological state of those educated. This determines the necessity of its use in educational institutions of various types.

Key words: students, physical and mental health, functional biocontrol

Author contributions: Setko AG — trial concept and design, editing, Zhdanova OM, Tyurin AV — data collection and processing, Zhdanova OM — text statistical processing and writing.

Compliance with ethical standards: written informed consent forms required to undergo an examination were obtained from all the students and their parents. The research was approved by the local ethics committee of the FSBEI Orenburg State Medical University of the Ministry of Health of the Russian Federation (protocol No. 258 dated 09.10.2020).

✉ **Correspondence should be addressed:** Olesya M. Zhdanova
ul. Sovetskaya, 6, Orenburg, 460000, Russia; robokors@yandex.ru

Received: 02.08.2021 **Accepted:** 22.08.2021 **Published online:** 30.09.2021

DOI: 10.24075/rbh.2021.024

НАУЧНОЕ ОБОСНОВАНИЕ ИННОВАЦИОННОГО ПОДХОДА К УПРАВЛЕНИЮ ЗДОРОВЬЕМ ОБУЧАЮЩИХСЯ ОБЩЕОБРАЗОВАТЕЛЬНЫХ ОРГАНИЗАЦИЙ РАЗЛИЧНОГО ТИПА

А. Г. Сетко, О. М. Жданова ✉, А. В. Тюрин

Оренбургский государственный медицинский университет, Оренбург, Россия

На фоне возрастающих учебных нагрузок, интенсификации учебной деятельности, применения инновационных педагогических технологий, не апробированных ранее, уровень здоровья учащихся неуклонно снижается, что инициирует поиск новых эффективных методов формирования, укрепления и повышения состояния здоровья школьников. Важная задача научно обосновать инновационный подход к управлению здоровьем учащихся общеобразовательных организаций различного типа. У учащихся 9–10-х классов лицея и школы проведена оценка напряжённости учебной деятельности; исследование функционального состояния центральной нервной, дыхательной, сердечно-сосудистой систем. Учащимся «группы риска» проведена коррекция психофизиологического состояния, эффективность которого оценивалась путем сравнения психофизиологических показателей до и после выполнения тренинга. В условиях высокой напряженности учебного процесса у лицеистов в сравнении со школьниками увеличивались оперативные показатели центральной нервной системы и функциональные показатели дыхательной системы, при этом у учеников обеих групп установлено снижение уровня биологической и социально-психологической адаптации. После проведения тренингов функционального биоуправления увеличилось число обследуемых с нормальной работоспособностью и удовлетворительной биологической адаптацией, на фоне снижения количества подростков с высоким психоэмоциональным напряжением. Функциональное биоуправление является эффективным методом коррекции психофизиологического состояния обучающихся, что определяет необходимость его использования в общеобразовательных организациях различного типа.

Ключевые слова: учащиеся, состояние физического и психического здоровья, функциональное биоуправление

Вклад авторов: Сетко А. Г. — концепция и дизайн исследования, Жданова О. М., Тюрин А. В. — редактирование, сбор и обработка материала, Жданова О. М. — статистическая обработка и написание текста.

Соблюдение этических стандартов: предварительно от всех учащихся и их родителей были получены письменные информированные согласия на включение в обследование. Исследование одобрено локальным этическим комитетом ФГБОУ ВО ОрГМУ МЗ РФ (протокол № 258 от 09.10.2020).

✉ **Для корреспонденции:** Олеся Михайловна Жданова
ул. Советская, д. 6, г. Оренбург, 460000, Россия; robokors@yandex.ru

Поступила: 02.08.2021 **Статья принята к печати:** 22.08.2021 **Опубликована онлайн:** 30.09.2021

DOI: 10.24075/rbh.2021.024

INTRODUCTION

Physical, mental and social health of the rising generation is the top priority of state politics as it is a marker of the future of the country and its economic, political and cultural establishment [1]. In accordance with the Federal Law on Education in the Russian Federation, safety and public health organization of students is an absolute priority for those institutions that regulate educational activity. However, educational institutions do not commonly complete these tasks at present. Increasing academic load, intensified academic activity and use of innovative pedagogical technologies without hygienic expertise in educational practice diminish adaptation reserves and increase the level of acute and chronic morbidity in students [1–3]. The students' health is progressively declined. This is very typical of innovative schools where learning activity is accompanied with intense educational load requiring boosting attention span, high mobility of mental processes, increasing the 'physiological cost' of education of children and adolescents in innovative institutions [1–3]. Thus, the actual problem is to preserve and support health of schoolchildren, initiating the search for new methods of health assessment in students of modern general educational institutions.

Purpose of the study is to provide for scientific justification of the innovative approaches to health management in students of general educational institutions of various types.

MATERIALS AND METHODS

15–16-year-old students in Grades 9–10 from two educational institutions were included into the study: adolescents from a multidisciplinary lyceum for gifted students formed the first group (n=112), whereas the second group included students from a traditional school (n=110). Training process intensity was estimated using the chronometric method by way of registration of various types of activity during training sessions with subsequent determination of the level of intellectual, emotional, sensory load, monotonicity and operating regimen following the Federal recommendations [4]. The central nervous system functional condition was diagnosed with variational chronoreflexometry [5], taking into account the nervous system functional level (SFL), nervous response stability (RS), the functionality of the formed functional system (FFS) and mental capacity. The functional condition of the cardiovascular system was examined with variation pulsometry and automated ORTO-expert [6] program using time indices (median (M), mode (Mo), mode amplitude (AMo), range ($_{\Delta}$X), standard deviation (SDNN), square root of R-R interval (RMSSD) and spectral indices (high-frequency (HF), low-frequency (LF), very low-frequency (VLF)) oscillations in heart rate; integral indices such as the vegetative balance index (VBI), vegetative rhythm index (VRI), indicator of the adequacy of heart rate regulation processes (IARP), determination of biological adaptation based on regulatory system stress indices according to V. P. Kaznacheev (1981).

The functional state of the respiratory system was examined using spirography and taking into account lung capacity (LC), forced lung capacity (FLC), forced expiratory volume in 1 second (FEV_1), peak flow rate (PFR), maximum expiratory flow at 25% of vital capacity (MOC_{25}), maximum expiratory flow at 50% of vital capacity (MOC_{50}), maximum expiratory flow at 75% of vital capacity (MOC_{75}), and average expiratory flow at 25–75% of vital capacity ($COC_{25–75}$). The students' mental health was evaluated using the 'Integral Evaluation of Dysadaptation Psychogenic Forms' method developed by N. P. Setko et al. (2016).

The psychophysiological state was corrected in 130 students from the examined educational institutions using the method of functional biocontrol with diaphragmatic and relaxation breathing on a hardware and software system and automatic registration of temperature disturbances, breathing frequency, ratio of expiratory and inspiratory duration, respiratory sinus arrythmia, and level of myotonia. The psychoemotional condition was determined by coefficients of the total deviation from the autogenic norm, and vegetative coefficient based on M. Lüscher color test. The effectiveness of functional biocontrol was evaluated by comparison of mental capacity, biological adaptation data and M. Lüscher color test results two weeks before and after the diaphragmatic and relaxation breathing.

Mathematical analysis of data was done using parametric methods of medical statistics and calculating the arithmetic mean, standard deviation, and mean square error. The parametric Student's t-test was used to find statistically significant differences. Calculations for the analysis were performed using Microsoft Office and Statistica 13.0.

RESULTS AND DISCUSSION

It is established that in the lyceum for gifted children, academic activity reached 3 class and 1 degree intensity due to pronounced intensity of intellectual (3.1±0.26 points), sensory (2.8±0.11 points), emotional (3.1±0.35 points) load and operating mode (3.0±0.11 points), when the monotonicity of academic activity only (2.3±0.24 points) corresponded to the acceptable level. At secondary school, the academic process intensity was optimal (class 1.0), including the level of sensory (1.5±0.16 points), emotional (1.3±0.15 points) load and labor monotonicity (1.4±0.15 points); it did not exceed the acceptable level by intellectual load (1.6±0.22 points) and operating mode (1.8±0.08).

Increased cognitive load probably helped gifted lyceum students train the nervous processes and form operating CNS indices. This was confirmed by increased reaction stability from 1.1±0.10 units to 1.3±0.07 units ($p \leq 0.05$) and functional capabilities of the nervous system from 2.1±0.11 units to 2.4±0.08 units ($p \leq 0.05$). In students from the 1st and 2nd groups, the basic functional level of the nervous system had no significant differences and amounted to 2.4±0.02 units and 2,4±0,03 units ($p \geq 0,05$), respectively.

The established functions of the central nervous system were reflected through distribution of students by the level of mental capacity. Thus, the predominant amount of those examined from the 1st (67.6%) and 2nd groups (60.6%) had optimal mental capacity. However, 28.4% and 4.1% of the 1st group students and 25.5% and 13.4% of the 2nd group adolescents had worse and significantly reduced capacity, respectively.

The lyceum students had significantly higher indices of the functional state of the respiratory system as compared with schoolchildren (Table 1). In adolescents from the 1st group, the values of LC, FLC, PFR, FEV1, MOC_{25}, MOC_{50}, MOC_{75} and $FEF_{25–27}$ exceeded the same values in students from the 2nd group by 11.1%, 6.6%, 20%, 22.8%, 18.7%, 13.6% and 13.8%, respectively.

In students from the 1st group, the values of peak flow rate, MOC_{25}, FEV_1, FLC and LC exceeded the same values in students from the 2nd group (physiological norm) by 2.5, 2.2, 1.5, 1.3 and 1.2 times, respectively (Table 2).

Lyceum students reported the following increased parasympathetic indices as compared to schoolchildren: ΔX from 0.33±0.023 s to 0.35±0.045 s ($p \geq 0.05$), SDNN from 0.075±0.0062 s to 0.086±0.0178 s ($p \geq 0.05$), RMSSD

Table 1. Indices of the functional state of the respiratory system in students (l/c)

Indices	Groups of students	
	1st	2nd
Lung capacity	3.6±0.36	3.2±0.13*
Forced lung capacity	3.0±0.12	2.8±0.12*
Peak flow rate	4.0±0.19	3.2±0.16*
Forced expiratory volume in one second (FEV1)	2.3±0.11	2.2±0.11
Maximum expiratory flow at 25% of vital capacity (MOC_{25})	3.5±0.15	2.7±0.15*
Maximum expiratory flow at 50% of vital capacity (MOC_{50})	3.2±0.18	2.6±0.14*
Maximum expiratory flow at 75% of vital capacity (MOC_{75})	2.2±0.11	1.9±0.11*
Forced mid-expiratory flow rate (FEF 25–75%)	2.9±0.14	2.5±0.13*

*$p \leq 0.05$ when the 1st group is compared with the 2nd group

Table 2. Distribution of students considering the correspondence of the functional state of the respiratory system to the physiological norm (%)

Indices	Groups of students	Degree of correspondence of the functional state of the respiratory system to the physiological norm		
		In the Range	Reduced	Significantly reduced
Lung capacity	1st	77.2	17.7	5.1
	2nd	66.2	25.4	8.5
Forced lung capacity	1st	68.4	17.7	13.9
	2nd	52.1	29.6	18.3
Peak flow rate	1st	49.4	41.8	8.9
	2nd	19.7	57.7	22.5
Forced expiratory volume in one second (FEV1)	1st	44.3	40.5	15.2
	2nd	29.6	31.0	39.4
Maximum expiratory flow at 25% of vital capacity (MOC_{25})	1st	46.8	40.5	12.7
	2nd	21.1	49.3	29.6
Maximum expiratory flow at 50% of vital capacity (MOC_{50})	1st	68.4	29.1	2.5
	2nd	53.5	40.8	5.6
Maximum expiratory flow at 75% of vital capacity (MOC_{75})	1st	92.4	7.6	-
	2nd	87.3	11.3	1.4
Forced mid-expiratory flow rate (FEF 25–75%)	1st	93.7	5.1	1.3
	2nd	80.3	19.7	-

from 0.075±0.0081 s to 0.081±0.0148 s ($p \geq 0.05$), and HF from 2325.9±409.38 ms^2 to 2531.0±719.29 ms^2 ($p \geq 0.05$). This certified an increased activity of the parasympathetic division of the vegetative nervous system in lyceum students and predominance of sympathetic effects in students from the secondary school (Table 3). Based on the scale of V. P Kaznacheev (1981), the value of strain of regulatory systems corresponded to the strain of mechanisms of biological adaptation and amounted to 119.9±31.58 units — 148.7±33.39 units ($p \geq 0.05$) for students from the 1st, and 2nd groups.

Thus, a satisfactory level of biological adaptation was determined in 28.4% and 15.5% of lyceum and school students only, poor adaptation and its disruption in 8.8% and 19.5% of lyceum students and 7.4% and 35.1% of schoolchildren, respectively, with disruption of biological adaptation mechanisms in the majority of students from the 1st (43.6%) and 2nd groups (42.1%).

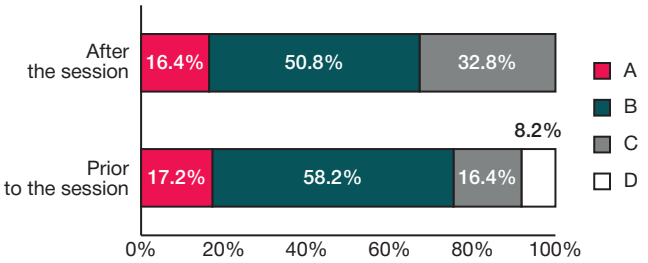
Assessment of mental adaptation has shown that 82.3% lyceum students and 75.7% schoolchildren had a normal level of mental adaptation. The average and high intensity of mental dysadaptation with high emotional stress was determined in 8.0–9.7% of lyceum students and 6.1–18.2% of school adolescents.

To decrease the level of mental stress and to increase adaptation capabilities and mental capacity in those examined, a method of functional biocontrol was used. It has been shown that in adolescents, muscular tension reduced from 4186.0±470.39 V to 2787.6±351.40 V ($p \leq 0.05$) after the first 4-minute session of diaphragmatic and relaxation breathing with a peripheral temperature increase from 27.9±0.43 C^0 to 28.9±0.62 C^0 ($p \geq 0.05$). This shows that the students' psychoemotional condition was improved. The session was followed by a decreased respiratory rate from 11.3±0.53 times per minute to 10.3±0.58 times per minute ($p \geq 0.05$),

Table 3. Heart rate variability indices in students

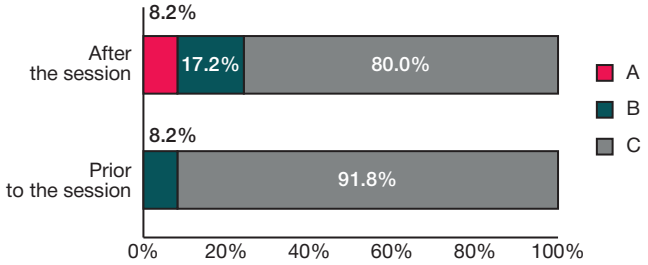
Indices	Groups of students	
	1st	2nd
Median (M, s)	0.7±0.04	0.4±0.38
Mode (Mo, s)	0.7±0.04	0.7±0.01
Mode amplitude (AMo,%)	34.3±4.50	38.2±2.17
Range ($_{\Delta}$X, s)	0.33±0.023	0.35±0.045
Standard deviation (SDNN, s)	0.75±0.0062	0.86±0.0178
Square root of R-R interval (RMSSD, s)	0.075±0.0081	0.081±0.0148
Very low-frequency oscillations in heart rate (VLF, ms^2)	3543.3±1086.12	5115.1±796.72
Low-frequency oscillations in heart rate (LF, ms^2)	3688.4±990.56	3584.0±455.47
High-frequency oscillations in heart rate (HF, ms^2)	2531.0±719.29	2325.9±409.38
Vegetative balance index (VBI, units)	159.0±25.7	192.8±28.91
Vegetative rhythm index (VRI, units)	5.3±0.44	6.1±0.56
Indicator of the adequacy of regulation processes (IARP, units)	48.1±3.33	56.3±3.89
Regulatory system stress index (SI, units)	119.9±31.58	148.7±33.39

*p≤0.05 when the 1st group is compared with the 2nd group



A ≤ 0,6 — predominance of fixation on rest and mitigation of own efforts; B = 0.6–1.11 physiological standard; C = 1.1–1.5 optimum vegetative balance to implement all human capabilities under stress; D ≥1.5 excessive stress

Fig. 1. Distribution of students depending on whether the vegetative coefficient is in the range prior to and after diaphragmatic and relaxation breathing sessions (%)



A ≤10 condition characterized by a high activity and positive attitude to task accomplishment; B = 10–14 physiological standard; C ≥14 high level of non-productive, neuropsychic intensity.

Fig. 2. Distribution of students depending on whether the overall deviation is in the autogenic range prior to and after diaphragmatic and relaxation breathing sessions (%)

reducing the respiratory sinus arrythmia from 27.1±2.65 units to 23.5±2.34 units (p≥0.05). This is how the additional body burden was decreased due to a synchronous activity of the cardiovascular and respiratory systems.

Among the students who trained on a regular basis, a number of those examined with an optimal vegetative balance increased twice; if, prior to the session, 8.2% students reported excessive stress, then the condition was not found after the session (Fig. 1).

At the same time a number of students with a high level of neuropsychic stress reduced from 91.8% to 80.0% against the background of increased specific gravity of students with a physiological standard from 8.2% to 17.2%, and an increased number of those examined with high activity and positive attitude to work (to 8.2%).

It is stated that prior to the session, only 16.7% of the students had a satisfactory level of biological adaptation, whereas all the other students (16.7% and 66.6%) had an unsatisfactory level and disturbed biological adaptation, respectively. Following the session, 25.0% of the adolescents had a satisfactory level of biological adaptation, 66.7% of those examined reported stressed adaptation mechanisms and only 8.3% had disruption of biological adaptation (Fig. 2).

After the sessions, the number of students with normal mental capacity increased from 9.1% to 18.2%, those with insignificantly reduced capacity increased from 59.1% to 72.7%, whereas the number of students with reduced capacity decreased from 31.8% to 9.1%.

CONCLUSION

When intensive academic activity is involved, adolescents from a multidisciplinary lyceum demonstrated better operational indicators of the central nervous system, and functional indicators of the respiratory system as compared with schoolchildren. Students from the both groups had functional stress with reduced biological, social and psychological adaptation. It is proved that diaphragmatic and relaxation breathing is effective; when done on a regular basis, it reduces psychoemotional stress, improves adaptation reserves and mental capacity. Thus, functional biocontrol is an effective correction method of psychophysiological state of those educated. This determines the necessity of its use at educational institutions of various types including innovative institutions for gifted children.

References

1. Kuchma VR, Fisenko AP. Medical-preventional directions of strengthening the health of children within the framework of the implementation of the action plan for the decade of the childhood till 2020. Voprosy shkol'noj i universitetskoj mediciny i zdorov'ja. 2018; (3): 4–10. Russian.
2. Setko IM, Setko NP. Sovremennye problemy sostojanija zdorov'ja shkol'nikov v uslovijah kompleksnogo vlijanija faktorov sredy obitanija. Orenburgskij medicinskij vestnik. 2018; (2): 4–14. Russian.
3. Karkashadze GA, Namazova-Baranova LS, Zaharova IN, Makarova SG, Maslova OI. Syndrome of High Academic Loads in School-Aged Children and Adolescents. Pediatricheskaja farmakologija. 2017; 14 (1): 7–23. Russian.
4. Kuchma VR, Tkachuk EA, Efimova NV, Myl'nikova IV. Federal'nye rekomendacii «Gigienicheskaja ocenka naprjazhennosti uchebnoj dejatel'nosti obuchajushhihsja». Utverzhdeny Profil'noj komissiej Minzdrava Rossii po shkol'noj medicine, gigiene detej i podrostkov 14 fevralja 2015 g. protokol № 4. Russian.
5. Moroz MP. Jekspress-diagnostika rabotosposobnosti i funkcional'nogo sostojanija cheloveka: metodicheskoe rukovodstvo. SPb.: IMATON, 2007; 25 c. Russian.
6. Igisheva LN, Galeev AR. Kompleks ORTO-expert kak komponent zdorov'esberegajushhih tehnologij v obrazovatel'nyh uchrezhdenijah: Metodicheskoe rukovodstvo. Kemerovo. 2003; 36 c. Russian.

Литература

1. Кучма В. Р., Фисенко А. П. Медико-профилактические направления укрепления здоровья детей в рамках реализации Плана мероприятий Десятилетия детства до 2020 г. Вопросы школьной и университетской медицины и здоровья. 2018; (3): 4–10.
2. Сетко И. М., Сетко Н. П. Современные проблемы состояния здоровья школьников в условиях комплексного влияния факторов среды обитания. Оренбургский медицинский вестник. 2018; (2): 4–14.
3. Каркашадзе Г. А., Намазова-Баранова Л.С., Захарова И. Н., Макарова С. Г., Маслова О. И. Синдром высоких учебных нагрузок у детей школьного и подросткового возраста. Педиатрическая фармакология. 2017; 14 (1): 7–23.
4. Кучма В. Р., Ткачук Е. А., Ефимова Н. В., Мыльникова И. В. Федеральные рекомендации «Гигиеническая оценка напряженности учебной деятельности обучающихся». Утверждены Профильной комиссией Минздрава России по школьной медицине, гигиене детей и подростков 14 февраля 2015 г. протокол № 4.
5. Мороз М. П. Экспресс-диагностика работоспособности и функционального состояния человека: методическое руководство. СПб.: ИМАТОН. 2007; 25.
6. Игишева Л. Н. Галеев А. Р. Комплекс ORTO-expert как компонент здоровьесберегающих технологий в образовательных учреждениях: Методическое руководство. Кемерово. 2003; 36.