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# RISK-ASSOCIATED HEALTH DISORDERS OCCURING IN JUNIOR SCHOOLCHILDREN WHO ATTEND SCHOOLS WITH HIGHER STRESS AND INTENSITY OF EDUCATIONAL PROCESS

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*We performed comparative sanitary-hygienic assessment of regime, stress and intensity of educational process in different educational establishments, a comprehensive secondary school and an innovative educational establishment - lyceum. We detected that studying regime tended to be tight, classes were longer and more intense than in an ordinary school, and educational process involved considerable intellectual, sensory and emotional loads for children; such loads reached "1st category intense" level. Schoolchildren attending lyceums are also busy with additional educational programs and it significantly increases length of total educational load on them. By the end of a school year 20% of lyceum pupils suffer from sympathoadrenal system overstress and it doesn't only determine emotional tonus level in children but also leads to disorders in concentration and decision-making speed, lower reading speed and articulation, slower motor reactions. 15% of lyceum pupils have higher activity of autonomous nervous system and lower adaptation of cardiovascular system to psycho-emotional and physical loads. Lyceum pupils also run 2.5 times higher risk of chronic nervous system diseases evolvement than school children attending ordinary schools. Autonomous nervous system disorders, posture disorders and nutrition disorders are predominant nosologic pathology forms in lyceum pupils as they occur in them 1.6-2.9 times more frequent than in schoolchildren of the same age who attend an ordinary comprehensive school. We detected direct correlation between higher intellectual and emotional components of educational process, and total educational intensity as well, and frequency of autonomous system disorders and musculoskeletal system diseases in pupils.*

***Key words**: children, educational process, elementary school, regime, intensity and stress risk-associated health disorders, nosologic pathology forms.*



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Nowadays there is an apparent negative dynamics in children health parameters, and it is most obvious for schoolchildren [3, 8, 9]. Observation results reveal that by the end of school years a share of healthy children decreases by 2.0-5.0 times and amounts to not more than 3.5% of school leavers; besides, a number of children who has the 3rd and 4th health category increases substantially, up to 43% [11, 20]. As per data obtained by Age Physiology Institute of Russian Academy of Education, frequency of eyesight disorders and posture disorders grows by 5 times in children during their school education period; psychoneurological disorders frequency becomes 4.0 times higher, and cardiovascular system pathologies and digestive organs pathologies occur 3.0 times more frequently [7, 11, 19].

Educational process intensification and wide implementation of information technologies in it are among the most significant risk factors causing health deterioration for contemporary schoolchildren [1, 2, 4, 10, 13, 15]. Reforms which school education undergoes, and implementation of new specialized authors' programs, as a rule, involve greater volumes and complexity of learnt subjects, application of a wide range of innovative teaching and learning technologies in educational process, educational process intensification, and growth in total educational load. Physical activity reduces, and structure of students' educational regime deteriorates [6, 10, 12, 13, 15, 17, 18, 21]. It was detected that when interactive equipment was applied in educational process, it exerted negative impacts on students' psychoemotional health, their visual organs, and nervous system, even if all the existing regulations on its operation were strictly observed [5, 7, 14, 16]. Educational load duration is an additional risk factor. Nowadays it takes schoolchildren a long time to do their homework; 50% of them spend such a long time doing it that it exceeds hygienic standards more than twice [7]. High intensity of educational process combined with unfavorable sanitary and hygienic learning conditions and, quite often, with malnutrition, can lead to overexhaustion, hypodynamia, lower working capacity, stress-induced functional disorders in organs and systems, disharmony in physical development, and chronic pathologies evolvement, in schoolchildren [1, 2, 4, 8, 9, 10, 20, 23].

Multi-factor analysis results reveal that educational process organization holds the first rank place as per contribution into students' health in grammar schools and lyceums (up to 25%). The second and third places belong to students' psychophysiological peculiarities (up to 20%) and ecological situation existing in places where educational establishments are located. In traditional schools the leading factors determining schoolchildren health dynamics are social ones (up to 24%), the second place is taken by level of school organization and attendance (23%), and the third place belongs to ecological factors (23 %) [8].

Thus, hygienic research results give evidence that health-preserving educational technologies design for secondary schools, and first of all, for innovative organizations, requires further examinations of influence exerted by various educational loads on students' health. We also should improve regulatory base in the sphere of educational process technologies and organization.

**Our research goal was** to perform comparative examination of peculiarities which regime, educational process stress, and educational process intensity has in educational establishments of two different type (an ordinary school and a lyceum); we also assessed their influence on students' health.

**Data and methods.** Our research objects were:

– educational process regimes, as well as educational process intensity and stress parameters for children from the 1st, 2nd, 3rd, and 4th grade in a standard secondary school and an innovative educational establishment, namely lyceum;

– 190 children aged 7–11 from 1–4th grades, attending a secondary school (89 schoolchildren) and innovative educational establishment, lyceum (101 schoolchildren).

Our research subjects were:

– lessons and breaks schedule;

– educational programs, applied in educational process in a secondary school and in a lyceum;

– sociological examination questionnaires collected among parents;

– protocols of neuropsychological testing performed on pupils from 1-4th grades in the examined educational establishments;

– clinical-laboratory parameters of pupils' health;

– protocols of functional and instrumental techniques used for assessing pupils' health.

Medical and biological research was conducted in full conformity with ethical principles stated in Helsinki Declaration (1983) and the RF State Standard "Appropriate Clinical Practices" (ICH E6 GCP). The research program was approved by the ethics committee of Rospotrebnadzor Federal Scientific Center for Medical and Preventive Health Risk Management Technologies (Protocol No. 2, 2016). To perform sociological, clinical-functional, and laboratory research, we made sure that a legal representative of each examined child gave his or her voluntary written consent to take part in them. The research was accomplished within the framework of scientific research work funded by the state according to a plan of such work given to Rospotrebnadzor Federal Scientific Center for Medical and Preventive Health Risk Management Technologies.

Sanitary-hygienic research included comparative assessment of educational process regimes, educational load stress and intensity in 1-4th grade in a secondary school and in a lyceum.

To perform comparative assessment of educational processes regimes we examined classes schedules in 1-4th grade in a school and in a lyceum paying special attention to their conformity with Hygienic Requirements 2.4.2.2821-10 «Sanitary-epidemiologic requirements to conditions and organization in general education establishments».

We examined learning activity stress for pupils in full conformity with federal recommendations on providing medical assistance for learners «Hygienic assessment of learning activity stress for learners» [22]. Our examination involved assessing intellectual, emotional, and sensory loads during a lesson, their monotony, and working regime. To assess stress caused by each of the examined load types objectively, primary education teachers performed this assessment as per scoring system (from 1 to 4), where 1 score corresponded to the 1st stress category; 2 scores, the 2nd category; 3 scores, the 3rd category with 1st stress degree (3.1), and 4 scores were the 3rd category with the 2nd stress degree (3.2). The final assessment of stress caused by each of the examined load types was calculated as a mean value of all the components. This obtained mean value for all factors of a certain load type was compared with standard values fixed in the federal recommendations «Hygienic assessment of learning activity stress for learners»:

– «optimal» (1st category) – 1.0–1.5 scores;

– «allowable» (2nd category) – 1.6–2.5 scores;

– «stressful» (3rd category) – 2.6–4.0 scores:

– «stressful with 1st stress degree» (3.1 category) – 2.6–3.5 scores;

– «stressful with 2nd stress degree» (3.2 category) – 3.6–4.0 scores.

Teachers-psychologists were invited to take part in analyzing results of examining educational process stress.

To assess educational process intensity, we performed a sociological examination. Data were collected through voluntary questioning conducted among pupils' parents; a questionnaire for the research was designed by experts from the laboratory for sociological risks analysis techniques of

Federal Scientific Center for Medical and Preventive Health Risk Management Technologies. The questionnaire included medical, social-economic, and ecological sections, as well as questions devoted to assessment of educational process intensity.

Clinical and functional examination of the children was completed in two stages; the first one was at the beginning of school year (September) and the second, at the end of the third term (March). Research program included assessment of physical development, functional state of cardiovascular and respiratory systems, assessment of children's psychoemotional state and motor functions development. Besides, we examined general somatic morbidity of the children and determined their individual health groups. All research was accomplished as per standard procedures. Clinical examination included outpatient development records analysis; the children were also examined by medical specialists (pediatrician, gastroenterologist, neurologist, and physical training therapist). We carried out electrocardiographic examination on «Schiller AT-2 plus» electrocardiograph; spirography was made on «Schiller PS spirometry» spirometer (SP-260 sensor, Schiller AG, Switzerland); ultrasound scanning of thyroid gland was performed with «Vivid q» scanner (GE Vingmed Ultrasound AS, Norway) with the use of linear matrix sensor 5–15 MHz. We applied computer testing system «Vienna» (VTS, Austria) to assess children's neuropsychological state and their motor functions development.

Laboratory research was performed in certified laboratories as per standard procedures and only certified equipment was applied (AcT5diff AL automatic hematologic analyzer, the USA, France, Backman Coulter Inc; «Konelab 20» biochemical analyzer, ThermoFisher, Finland; «Infinite F50» immune-enzyme analyzer, Austria, Tecan). Our work involved assessing hematologic and biochemical parameters, immunologic state and non-specific resistance, hormonal homeostasis, neuromediators level, and genetic state. Quality control in all performed diagnostic research was provided by conducting laboratory quality control (as per order issued by the RF Public Health Ministry No. 45 dated February 07, 2000), by participation in Federal system of external quality assessment (laboratory certificate No. 10843 for biochemical research, No. 10845 for general clinic research) and in EQAS international system for laboratory research quality assessment (laboratory certificate No. 9473).

We analyzed all the data obtained in the course of sanitary-hygienic, clinical-functional, and laboratory research with the use of Statistica 6.0 statistic analysis software and with specially designed software compatible with MS-Office. Research results were mathematically processed with the use of parametric statistic techniques. Samples features were given as a mean (M) ± standard error of the mean (m). We compared two unlinked groups as per Student's t-criterion value. Any discrepancies corresponding to probability error estimate $p \leq 0,05$ were considered to be statistically significant. Statistical processing of the sociological research results was accomplished via calculating and comparing arithmetical mean values, as well as determining frequency and structural features. We checked validity of discrepancies in sociological parameters as per sex, age, and educational establishment criteria with the use of non-parametric Kruskal-Wallis criterion (for more than two samples; "age" as grouping variable), and Mann-Whitney criterion (for two samples; "sex" and "educational establishment" as grouping variables).

**Results and discussion.** Comparative hygienic assessment of educational process regimes in secondary school and in lyceum revealed that 1st and 4th grade pupils attended them in the first shift (classes started at 8.30), and 2nd and 3rd grade pupils, in the second shift (classes started at 15.00 in secondary school and at 14.15 in lyceum). Learning week lasted for 5 days for 1-3rd grades (from Monday to Friday), and 4th grade pupils had to study 6 days a week (from

Monday to Saturday). As per classes schedule, a lesson in 1st grade lasted for 40 minutes in school and for 35 minutes in lyceum; lessons in 2-4th grade in school lasted for 45 minutes, and in lyceum for 40 minutes. Breaks had the same length in both shifts in school and they were either short (10 minutes) or long (20 minutes). A long break in the first shift usually took place after 2-3rd lesson, and in the second shift, after 1-2nd lesson. Short breaks in lyceum lasted for 5-10 minutes in the first shift, and a long one was 20 minutes and took place after 4-5th lesson. During the second shift in lyceum short breaks lasted for 5 minutes, and a long one which was after 1-2nd lesson lasted for 15 minutes. A break between shift in school was 50 minutes and in lyceum only 10. So, overall time 1st grade pupils had to spend at school amounted to 3 hours 20 minutes, and it was only 2 hours 40 minutes in lyceum as lessons and breaks there were shorter. This time period amounted to 4 hours 35 minutes for 2-4th grade pupils in school, and to 3 hours 50 minutes or 4 hours, in lyceum.

According to schedule, weekly load in 1st grade of secondary school amounted to 21 hours. in 2-3rd grade, to 22 hours, and in 4th grade, to 23 hours. In lyceum weekly load for 1st grade pupils also mounted to 21 hours, but it reached 23 hours in 2nd grade already. Daily educational load in 1st grade in both educational establishment didn't exceed 4 lessons; however, one day a week there was the fifth lesson (physical training). 2-4th grade pupils usually had 4-5- lessons a day; besides, lyceum schedule for 4th grade included two physical training lessons on Saturday. We examined classes schedule for primary grades in both examined establishments; the examination revealed that the schedule was worked out allowing for school subject difficulty and peculiarities of pupils' daily and weekly mental working capacity. Educational process in 1st grade in both educational establishment didn't include any marks-based assessment of knowledge and homework, and "step-by-step" educational regime was applied during the first two terms. The most difficult subjects (mathematics, Russian, a foreign language) were taught to 1st grade pupils as the 2nd lesson, and to 2-4th grade pupils, as the 2nd-3rd lessons. There were no double lessons on the same subject in junior classes in both educational establishments. When classes schedule was drawn up in school, subjects varying in difficulty interleaved both during a day and a week; thus, basic subjects (mathematics, Russian, a foreign language, natural study, informatics) interleaved with lessons on music, art, technology, and physical training. This hygienic requirement wasn't fulfilled in lyceum. To increase children's physical activity in both educational establishments the schedules included three physical training lessons and it corresponded to maximum allowable weekly school load. Two physical training lessons out of three in school were swimming and rhythmics, while in lyceum pupils had only standard physical training lessons. Pupils' daily load calculation made as 11-score scale by I.G. Sivkov [14], revealed that Wednesday was a day with the highest load in school, and Monday and Friday were the easiest. There were two days with the highest load in lyceum, Wednesday and Thursday, and besides, Monday and Friday also had rather high points for mental load, namely 23-24.

Thus, educational process organization analysis gives evidence that general requirements stated in 2.4.2.2821-10 «Sanitary-epidemiologic requirements to conditions and organization in general education establishments» were met in secondary school. But in lyceum, subjects varying in difficulty didn't interleave, and educational load was not distributed adequately during a week, breaks were shorter, as well as a break between two shifts (Table 1).

Hygienic assessment of learning activity stress for pupils revealed that it was not optimal in either of the examined establishments. Educational process stress reached 1.8-2.2 scores in secondary school ($2.05 \pm 0.31$), and in lyceum, 1.7–2.5 scores

(2.10 ± 0.52), which was not statistically different (p = 0.86) and corresponded to allowable load level (1.6–2.5 scores) (Table 2).

At the same time, intellectual loads in junior school grades don't exceed allowable level (2.3-2.5 scores), but most pupils of 1-4th grades in lyceum (3.03-3.5) have "stressful with 1st stress degree" intellectual loads (2.6-3.5). Sensory loads level (1.5-1.9) for school pupils corresponds to optimal and allowable levels, but they reach 2.8 scores for 4th grade lyceum pupils and are "stressful with 1st stress degree". However, if emotional loads in 1-3rd lyceum grade correspond to optimal and allowable levels (1.5-2.3 scores) and are "stressful with 1st stress degree" only for 4th grade pupils (2.8 scores), then 1st grade school pupils (3.0) and 4th grade school pupils (2.8) undergo stressful emotional loads (1st stress degree) which are optimal only in 3rd grade (1.5 scores). If we generalize the obtained results, we should point out that specific components of educational process in both examined establishments are mostly optimal/allowable for 1-3rd grades, and only intellectual loads for lyceum students reach "stressful with 1st stress degree" level (2.5-3.5 scores). Most substantial discrepancies are observed in 4th grades; all basic components of overall stress in lyceum belong to "stressful with 1st stress degree" (intellectual loads have 3.0 scores; sensory loads, 2.8 scores; emotional loads, 2.8), but in school only emotional loads reach such a level (2.8), while others have scoring varying from 1.6 to 2.5.

Table 1

Educational process organization conformity with 2.4.2.2821-10 «Sanitary-epidemiologic requirements to conditions and organization in general education establishments» in junior classes of secondary school and lyceum

| Criterion | conforms (+) /doesn't conform (–) | |
|---|---|---|
| | secondary school | lyceum |
| Educational process organization in 1st grade | + | + |
| Beginning of classes | + | + |
| Shifts | + | – |
| Lessons duration | + | + |
| Breaks duration | + | – |
| Daily load | + | + |
| Weekly load | + | + |
| Having «difficult» subjects as 2–3rd lessons | + | + |
| Subjects varying in difficulty interleave | + | – |
| Double lessons | + | + |
| Three lessons of physical training | + | + |
| Distribution of educational load during a week | + | – |

Table 2

Results of educational process stress in junior grades of different educational establishments (scores)

| Parameter | 1st grade | | 2nd grade | | 3rd grade | | 4th grade | |
|---|---|---|---|---|---|---|---|---|
| | school | lyceum | school | lyceum | school | lyceum | school | lyceum |
| Intellectual loads | 2,5 | 3,0 | 2,8 | 2,5 | 2,3 | 3,5 | 2,5 | 3,0 |
| Sensory loads | 1,6 | 1,5 | 1,9 | 1,9 | 1,5 | 1,8 | 1,6 | 2,8 |
| Emotional loads | 3,0 | 1,5 | 1,5 | 2,3 | 1,8 | 1,5 | 2,8 | 2,8 |
| Loads monotony | 2,0 | 1,5 | 2,0 | 2,0 | 2,3 | 2,3 | 2,0 | 2,3 |
| Working regime | 2,0 | 1,0 | 1,7 | 2,0 | 1,3 | 1,3 | 2,0 | 1,6 |
| Overall educational process stress | 2,2 | 1,7 | 2,0 | 2,1 | 1,8 | 2,1 | 2,2 | 2,5 |

As we examined education intensity as per results of parents' questioning, we detected that all school pupils from 1-4th grades attended classes 5 days a week while only 75% lyceum pupils in the same grades had 5-day-schedule, 18.2% attended lyceum 6 days a week, and another 6.8% had mixed schedule, 5-6- days a week (contingency coefficient 0.3, p = 0.0001, average correlation). Questioning results enabled detecting that only 66.7% of school pupil had 5 lessons a day or more, while in lyceum all pupils had such quantity of lessons a day (contingency coefficient 0.5; p = 0.0001; strong correlation).

Only 25.7% parents of schoolchildren mentioned creative home tasks while 41.6% parents of lyceum pupils told their children had to do such tasks (contingency coefficient 0.2; p = 0.045; weak correlation).

We detected in our research that regardless of educational establishment type 32.9% pupils attending classes in the first shift spent more than two hours a day to do their homework. There were two time more such pupils in the second shift (58.4%) (p = 0.001). In general, 3.8% school pupils and 16.9% lyceum pupils spent less than one hour on their homework (p = 0.003); 47.4 and 38.2 % correspondingly (p = 0.19), from one to two hours; 42.3 and 37.1 % (p = 0.46), from two to three hours; 6.4 and 7.9 % pupils from compared groups (p = 0.68), more than three hours. We didn't detect any statistically authentic discrepancies between "educational establishment type" and "average time spent on doing homework" variables (p≥0.05). The obtained results revealed that each second pupil from junior grades (48.8 % in secondary school and 44.9 % in lyceum; p = 0.003) spent more time on doing his or her homework than it was recommended by 2.4.2.2821-10 «Sanitary-epidemiologic requirements to conditions and organization in general education establishments».

The research results revealed that 85.3% of junior grades pupils in school and 91.1% in lyceum (p = 0.20) attended additional educational establishments; and each third of them attended more than one (26.8 % school pupils and 34.9 % lyceum pupils; p = 0.22). However, schoolchildren attended sports sections less frequently than lyceum pupils (50.0 % against 74.1 %; p = 0.001). Overall, 68.8% school pupils and 82.8% lyceum pupils had regular physical training and did sports (p = 0.02). 32.8% school pupils and 49.3% lyceum pupils from them did it every day/4-5- times a week (p = 0.02); 61.8 and 41.1 % correspondingly (p = 0.004), 2-3- times a week; 5.5 and 9.6 % (p = 0.28), once week. Most primary school pupils, regardless of their educational establishment, spent from 3 to 5 hours a week on doing sports (42.6 % school pupils and 43.1 % lyceum pupils; p = 0.94); a bit more than one third, 6–8 hours a week (35.2 and 33.3 % correspondingly; p = 0.78); about 12 % children spent on doing sports only 1-2- hours a week; about 10 %, 9 and more hours a week.

So, the results we obtained due to sanitary-hygienic assessment of educational process prove that education in innovative establishments (lyceum) involves tighter regime of classes for children; period of their daily learning activity lasts longer than in secondary school during a week; lyceum pupils undergo significant intellectual, sensory, and emotional loads, and educational process during a lesson is rather intense; homework often involves creative tasks. Practically all pupils attending innovative educational establishments have additional classes every day (they go to sport sections, art schools, or visit tutors). Besides, one third of them deal with two different subject spheres during their additional classes, and it leads to substantial increase in total volume of learning activity loads.

We didn't perform any statistically significant discrepancies in 1st grade pupils from two different educational establishment after comparative analysis of somatometric examination results. Their weight-height parameters, chest and head circumference, and carpal dynamometry data were quite similar and didn't have any deviations from physiological age standard (p = 0.45–0.98), and children also had similar values of body

Table 3

Comparative characteristic of physical development parameters in 1st grade pupils attending different educational establishments

| Parameter | Boys | | | Girls | | |
|---|---|---|---|---|---|---|
| | Lyceum | School | Validity of discrepancies | Lyceum | School | Validity of discrepancies |
| Height, cm | 130,33 ± 6,08 | 130,21 ± 5,96 | 0,98 | 125,80 ± 4,52 | 124,75 ± 4,95 | 0,76 |
| Body weight, cm | 26,97 ± 3,99 | 28,18 ± 6,62 | 0,76 | 22,69 ± 1,82 | 23,74 ± 5,03 | 0,70 |
| Chest circumference, cm | 60,33 ± 4,05 | 60,64 ± 7,64 | 0,94 | 56,30 ± 3,06 | 56,50 ± 5,53 | 0,91 |
| Chest excursion, cm | 8,25 ± 1,91 | 7,36 ± 1,39 | 0,45 | 7,30 ± 2,26 | 7,00 ± 0,93 | 0,81 |
| Head circumference, cm | 52,00 ± 1,35 | 53,64 ± 1,98 | 0,18 | 50,60 ± 2,32 | 52,25 ± 1,39 | 0,19 |
| Right carpal dynamometry, kg | 9,00 ± 2,26 | 9,29 ± 3,89 | 0,90 | 6,40 ± 2,01 | 6,75 ± 1,67 | 0,79 |
| Left carpal dynamometry, kg | 7,50 ± 1,68 | 7,79 ± 3,04 | 0,87 | 5,80 ± 1,87 | 5,63 ± 2,58 | 0,92 |
| Body weight index (st.units) | 15,82 ± 1,66 | 16,49 ± 2,66 | 0,67 | 14,33 ± 0,66 | 15,18 ± 2,09 | 0,44 |
| Pignet index (st.units) | 43,03 ± 5,94 | 41,40 ± 10,96 | 0,79 | 46,81 ± 3,62 | 44,51 ± 8,41 | 0,62 |

Table 4

Comparative characteristic of physical development parameters in 4th grade pupils attending different educational establishments

| Parameter | Boys | | | Girls | | |
|---|---|---|---|---|---|---|
| | Lyceum | School | Validity of discrepancies | Lyceum | School | Validity of discrepancies |
| Height, cm | 144,67 ± 8,21 | 142,93 ± 5,00 | 0,72 | 145,71 ± 8,88 | 147,75 ± 6,99 | 0,72 |
| Body weight, cm | 38,85 ± 3,78 | 35,69 ± 8,43 | 0,50 | 35,29 ± 7,51 | 37,13 ± 8,52 | 0,75 |
| Chest circumference, cm | 66,44 ± 9,04 | 66,21 ± 6,36 | 0,93 | 65,36 ± 5,99 | 66,0 ± 7,38 | 0,89 |
| Chest excursion, cm | 8,05 ± 2,34 | 8,13 ± 2,67 | 0,96 | 7,60 ± 2,38 | 8,31 ± 1,89 | 0,64 |
| Head circumference, cm | 52,39 ± 1,65 | 53,36 ± 1,50 | 0,39 | 53,36 ± 1,95 | 53,88 ± 1,36 | 0,87 |
| Right carpal dynamometry, kg | 13,06 ± 2,44 | 12,93 ± 2,06 | 0,94 | 11,43 ± 2,28 | 9,88 ± 2,31 | 0,34 |
| Left carpal dynamometry, kg | 11,39 ± 2,23 | 12,50 ± 1,95 | 0,46 | 10,57 ± 2,28 | 9,56 ± 1,90 | 0,50 |
| Body weight index (st.units) | 17,97 ± 4,13 | 17,32 ± 3,14 | 0,82 | 16,43 ± 2,04 | 16,83 ± 2,49 | 0,91 |
| Pignet index (st.units) | 37,30 ± 8,35 | 38,29 ± 15,25 | 0,91 | 42,06 ± 3,64 | 44,63 ± 10,86 | 0,66 |

Table 5

Dynamics in physical development parameters for pupils over 4 learning years in different educational establishments

| Parameter | Boys | | | Girls | | |
|---|---|---|---|---|---|---|
| | Lyceum | School | Validity of discrepancies | Lyceum | School | Validity of discrepancies |
| Height, cm | 14,34 ± 2,15 | 12,72 ± 1,96 | 0,27 | 19,91 ± 2,71 | 23,0 ± 2,97 | 0,13 |
| Body weight, cm | 11,88 ± 2,89 | 7,51 ± 2,53 | **0,03** | 12,6 ± 4,67 | 13,39 ± 4,78 | 0,81 |
| Chest circumference, cm | 6,11 ± 0,55 | 5,57 ± 0,11 | 0,06 | 9,06 ± 2,53 | 9,50 ± 2,46 | 0,82 |
| Chest excursion, cm | 0 | 0,77 ± 0,03 | 0,06 | 0,30 ± 0,02 | 0,31 ± 0,14 | 0,93 |
| Head circumference, cm | 0,39 ± 0,15 | 0,28 ± 0,14 | 0,29 | 2,72 ± 0,14 | 1,63 ± 0,38 | **0,001** |
| Right carpal dynamometry, kg | 4,06 ± 2,35 | 3,64 ± 2,98 | 0,83 | 5,03 ± 2,39 | 3,13 ± 1,99 | 0,22 |
| Left carpal dynamometry, kg | 3,89 ± 1,96 | 4,71 ± 2,5 | 0,61 | 4,77 ± 2,08 | 3,93 ± 2,24 | 0,58 |
| Body weight index (st.units) | 2,15 ± 0,9 | 0,83 ± 0,9 | **0,05** | 2,10 ± 0,35 | 1,65 ± 0,29 | **0,05** |

weight index and Pignet index, as well as chest excursion (p = 0.18–0.92) (Table 3). Results of physical development examination for 4th grade pupils were also quite similar in both comparison groups (p = 0.39–0.94) (Table 4). At the same time, comparative analysis of 4-year dynamics in somatometric parameters allowed to detect authentically higher body weight index values in girls, as well as higher growth rate in body weight index in all lyceum pupils (p = 0.05) (Table 5).

So, in spite of tighter classes regime, as well as intense and stressful learning activity, physical development of children attending innovative educational establishments is quite similar to parameters which children of their age attending traditional secondary schools have.

However, growth rates for body weight and body weight index in pupils attending innovative educational establishment are higher. The detected peculiarity can be related to, notably, social and economic conditions of child-rearing. Questionnaire data analysis revealed that a family of each third lyceum pupil had more than 30,000 rubles income per each family member, and 37.7% had 15,000 rubles income per each family member, while in ordinary school not more than 12.7-14.9% of families correspondingly had such incomes (p = 0.0001–0.003). Besides, as we examined pupils nutrition regimes we detected that 44.6% of lyceum pupils and only 30.7% of school pupils ate regularly (4-5- times a day) (p = 0.04), 51.8% of lyceum pupils and 64% of school pupils had 3 meals a day (p = 0.08), 3.6 and 5.3% of children correspondingly had 1-2-meals a day (p = 0.56). We also detected that 71.6% of lyceum pupils had 1-2 additional mid-afternoon snacks (only 52.2 % of school pupils; p = 0.005), and 28.3 % «had 3-5 snacks» (47.8 % of school children, p = 0.005).

Results of assessing cardiovascular system functional state revealed that at the beginning of school year almost half of the examined 1st grade students in both educational establishments had deviations from physiological standards in specific electrocardiogram parameters (43.1 % of

lyceum pupils and 43.6 % of school pupils; p = 0.96). Heart rhythm disorder as per respiratory sinus arrhythmia was the most frequent (23.5 % of lyceum pupils and 35.9 % of school pupils; p = 0.20), which was typical of children from this age group. A number of children with normal electrocardiogram went down to 52% in 4th grades in lyceum by the end of school year, but this number in school increased to 61.3% (p = 0.68), and heart rhythm disorders were detected 48.0% more frequently in lyceum pupils (p = 0.69), and 38.7% less frequently in school pupils (p = 0.68). We should highlight that sinus bradycardia which was the evidence of vegetative nervous system being more active and of children being poorly adapted increased from 7.8 to 14.6% among junior grades lyceum pupils (p = 0.16) and was authentically higher than the same parameter in school pupils (1.2 %; p = 0.01) (Table 6). The detected opposite trends in dynamics of cardiovascular system functional state in the examined children prove that apparently children attending an ordinary school become gradually adapted to growing educational loads.

As we examined respiratory system functional state we detected that each tenth 1st grade pupil, regardless of his or her educational establishment, had disorders in lungs ventilatory capacity, mostly as per restrictive type, which disappeared in most children by the end of primary school (p = 0.06–0.69).

As per data obtained via ultrasound scanning of thyroid gland not more than 32.5-36.1% of the examined pupils from both educational establishments had physiological structure of the organ (p = 0.60); lyceum pupils had changes in thyroid gland tissue structure 1.6 times more frequently than school pupils (47.5 against 30.6 %, p = 0.02) (Table 7). Cystic-enlarged follicles occurrence was the most frequent reason for changes in the organ structure. We should note that this pathological morphology was 2.1 times more frequent in lyceum pupils than in school pupils (40.0 against 19.4 %, p = 0.002). According to contemporary scientific research, cystic-follicle transformation of thyroid gland evolves not only due to iodine deficiency, exposure to chemicals, traumas, etc., but also due to chronic stress and psychophysical overstrain [24].

Table 6

Dynamics in electrocardiogram parameters in junior grades pupils attending different educational establishments over 4 school years (%)

| Electrocardiogram data | 1st grade | | | 4th grade | | |
|---|---|---|---|---|---|---|
| | Lyceum | School | Validity of dis-crepan-cies | Lyceum | School | Validi-ty of discrep crep-ancies |
| Standard | 56,9 | 56,4 | 0,96 | 52,0 | 61,3 | 0,41 |
| Electrocardiogram deviations from standard: | 43,1 | 43,6 | 0,96 | 48,0 | 38,7 | 0,41 |
| Sinus tachycardia (moderate and apparent) | 2 | 2,6 | 0,50 | 5,4 | 7,5 | 0,32 |
| Sinus bradycardia (moderate and apparent) | 7,8 | 0 | 0,10 | 14,6 | 1,2 | **0,01** |
| Sinus arrhythmia (moderate and apparent) | 23,5 | 35,9 | 0,20 | 28,0 | 30,0 | 0,85 |
| Supraventricular extrasystole | 9,8 | 5,1 | 0,23 | 0 | 0 | – |

Table 7

Results of thyroid gland ultrasound scanning performed on junior grades pupils attending different educational establishments, %

| Data of thyroid gland ultrasound scanning | Lyceum | School | Validity of discrepancy |
|---|---|---|---|
| Ultrasound standard | 32,5 | 36,1 | 0,60 |
| Ultrasound pathology signs | 67,5 | 63,9 | 0,60 |
| Standard volume of thyroid gland | 65,0 | 55,5 | 0,18 |
| Changes in thyroid gland volumes | 35,0 | 44,4 | 0,19 |
| Increased thyroid gland volume | 5,0 | 5,5 | 0,76 |
| Decreased thyroid gland volume | 30,0 | 38,9 | 0,20 |
| Standard thyroid gland structure | 52,5 | 69,4 | **0,02** |
| Changed thyroid gland structure | 47,5 | 30,6 | **0,02** |
| Diffuse structural changes | 0,0 | 2,78 | 0,08 |
| Microfocal neoplasms occurrence | 15,0 | 11,1 | 0,43 |
| Cystic-enlarged follicles occurrence | 40,0 | 19,4 | **0,002** |
| Ultrasound signs f congenital hypothyroidism | 0,0 | 2,78 | 0,08 |

Neuropsychological testing results showed that by the end of school year average response time and movement speed at visual-acoustic stimuli tended to reduce in school pupils ($p = 0.13–0.50$), while they increased in lyceum pupils, and prolongation in time of motor response to a stimulus reached statistic significance ($p = 0.0001$) (Tables 8 and 9).

Overall, motor response time and motor response dissipation were authentically higher in lyceum pupils ($595.261 \pm 17.228$ and $93.011 \pm 5.255$ msec correspondingly) than in school pupils ($526.854 \pm 25.234$ and $86.366 \pm 7.078$ msec; $p = 0.001–0.05$). We should note that reading speed and articulation speed authentically decreased by the end of school year in lyceum pupils under exposure to interfering information (literal and colored) ($p = 0.03–0.05$). There were no substantial changes in these parameters in school children during school year ($p = 0.23–0.98$), and response time median for reading even decreased ($p = 0.03$) (Table 10).

All the obtained data prove that by the end of school year pupils attending innovative educational establishment had authentically lower attention function and associative-integrative processes of their intellectual activity became apparently slower than in pupils attending ordinary school.

Comparative analysis of stress hormones content in blood revealed that at the beginning of school year levels of dopamine ($36.83 \pm 8.85$ picogram/cm3 in lyceum pupils and $34.83 \pm 2.06$ picogram/cm3 in school pupils), noradrenalin ($126.76 \pm 15.30$ and $138.46 \pm\pm 10.90$ picogram/cm3 correspondingly) and adrenalin ($42.80 \pm 12,23$ and $54.10 \pm 16.52$ picogram/cm3 correspondingly) in pupils from both educational establishments corresponded to physiological standard and didn't have any significant discrepancies ($p = 0.0.34–0.79$).

Table 8

Neuropsychological testing results for junior grade pupils attending secondary school

| Test features | Beginning of school year | End of school year | Validity of discrepancy |
|---|---|---|---|
| *RT-test* | | | |
| Average response time (msec) | 599,736 ± 27,742 | 526,854 ± 25,234 | 0,13 |
| Average motor time (msec) | 239,138 ± 16,567 | 227,854 ± 21,880 | 0,50 |
| Response time dissipation (msec) | 106,057 ± 9,151 | 86,366 ± 7,078 | 0,11 |
| Motor time dissipation (msec) | 42,276 ± 6,109 | 35,512 ± 4,876 | 0,42 |
| Responded correctly (st.units) | 15,826 ± 0,094 | 15,927 ± 0,083 | 0,27 |
| Didn't respond (st.units) | 0,184 ± 0,120 | 0,073 ± 0,083 | 0,44 |
| Didn't fully respond (st.units) | 0,023 ± 0,032 | 0,000 ± 0,000 | 0,32 |
| Responded incorrectly (st.units) | 0,561 ± 0,409 | 0,293 ± 0,592 | 0,96 |
| *STROOP- test* | | | |
| Interference susceptibility when reading (sec) | 0,348 ± 0,052 | 0,368 ± 0,064 | 0,98 |
| Interference susceptibility when articulating (sec) | 0,259 ± 0,047 | 0,247 ± 0,049 | 0,23 |
| Detailed results – baseline for reading response time median (sec) | 1,002 ± 0,039 | 0,914 ± 0,060 | **0,03** |
| Detailed results – baseline for articulation response time median (sec) | 0,936 ± 0,031 | 0,890 ± 0,054 | 0,50 |
| Incorrect reading results 1 (st.units) | 4,287 ± 0,820 | 2,125 ± 0,714 | **0,04** |
| Incorrect articulation results 1 (st.units) | 4,034 ± 1,188 | 1,850 ± 0,658 | 0,07 |
| Detailed results-interference conditions for response time median, reading (sec) | 1,350 ± 0,068 | 1,282 ± 0,113 | 0,10 |
| Detailed results-interference conditions for response time median, articulation (sec) | 1,195 ± 0,060 | 1,137 ± 0,088 | 0,25 |
| Incorrect reading results 2 (st.units) | 9,046 ± 2,523 | 7,225 ± 2,833 | 0,93 |
| Incorrect articulation results 2 (st.units) | 5,080 ± 1,653 | 3,625 ± 1,147 | 0,46 |

Table 9

Neuropsychological testing results for junior grade pupils attending secondary school

| Test features | Beginning of school year | End of school year | Validity of discrepancy |
|---|---|---|---|
| *RT-test* | | | |
| Average response time (msec) | 546,731 ± 16,870 | 595,261 ± 17,228 | **0,0001** |
| Average motor time (msec) | 227,164 ± 16,046 | 240,250 ± 13,460 | 0,22 |
| Response time dissipation (msec) | 94,463 ± 5,773 | 93,011 ± 5,255 | 0,71 |
| Motor time dissipation (msec) | 37,463 ± 4,033 | 37,625 ± 3,066 | 0,95 |
| Responded correctly (st.units) | 15,833 ± 0,110 | 15,943 ± 0,049 | 0,07 |
| Didn't respond (st.units) | 0,194 ± 0,149 | 0,057 ± 0,049 | 0,08 |
| Didn't fully respond (st.units) | 0,030 ± 0,042 | 0,000 ± 0,000 | 0,16 |
| Responded incorrectly (st.units) | 0,629 ± 0,527 | 0,125 ± 0,077 | 0,06 |
| *STROOP- test* | | | |
| Interference susceptibility when reading (sec) | 0,357 ± 0,056 | 0,437 ± 0,049 | **0,03** |
| Interference susceptibility when articulating (sec) | 0,251 ± 0,042 | 0,303 ± 0,041 | **0,05** |
| Detailed results – baseline for reading response time median (sec) | 0,979 ± 0,040 | 0,954 ± 0,029 | 0,33 |
| Detailed results – baseline for articulation response time median (sec) | 0,908 ± 0,029 | 0,921 ± 0,026 | 0,51 |

Continuation of table 9

| | | | |
|---|---|---|---|
| Incorrect reading results 1 (st.units) | 4,433 ± 0,958 | 2,080 ± 0,491 | **0,0001** |
| Incorrect articulation results 1 (st.units) | 3,791 ± 1,080 | 2,227 ± 0,523 | **0,01** |
| Detailed results-interference conditions for response time median, reading (sec) | 1,336 ± 0,077 | 1,406 ± 0,071 | 0,18 |
| Detailed results-interference conditions for response time median, articulation (sec) | 1,159 ± 0,058 | 1,224 ± 0,059 | 0,12 |
| Incorrect reading results 2 (st.units) | 7,910 ± 1,663 | 5,420 ± 0,863 | **0,009** |
| Incorrect articulation results 2 (st.units) | 4,463 ± 1,169 | 2,864 ± 1,016 | **0,04** |

Table 10

Neuropsychological testing results for junior grade pupils attending different educational establishments at the end of school year

| | School | Lyceum | Validity of discrepancy |
|---|---|---|---|
| *RT- test* | | | |
| Average response time (msec) | 526,854 ± 25,234 | 595,261 ± 17,228 | **0,001** |
| Average motor time (msec) | 227,854 ± 21,880 | 240,250 ± 13,460 | 0,33 |
| Response time dissipation (msec) | 86,366 ± 7,078 | 93,011 ± 5,255 | **0,048** |
| Motor time dissipation (msec) | 35,512 ± 4,876 | 37,625 ± 3,066 | 0,16 |
| Responded correctly (st.units) | 15,927 ± 0,083 | 15,943 ± 0,049 | 0,99 |
| Didn't respond (st.units) | 0,073 ± 0,083 | 0,057 ± 0,049 | 0,73 |
| Didn't fully respond (st.units) | 0,000 ± 0,000 | 0,000 ± 0,000 | 1,0 |
| Responded incorrectly (st.units) | 0,293 ± 0,592 | 0,125 ± 0,077 | 0,57 |
| *STROOP- test* | | | |
| Interference susceptibility when reading (sec) | 0,368 ± 0,064 | 0,437 ± 0,049 | **0,05** |
| Interference susceptibility when articulating (sec) | 0,247 ± 0,049 | 0,303 ± 0,041 | **0,05** |
| Detailed results – baseline for reading response time median (sec) | 0,914 ± 0,060 | 0,954 ± 0,029 | 0,23 |
| Detailed results – baseline for articulation response time median (sec) | 0,890 ± 0,054 | 0,921 ± 0,026 | 0,29 |
| Incorrect reading results 1 (st.units) | 2,125 ± 0,714 | 2,080 ± 0,491 | 0,92 |
| Incorrect articulation results 1 (st.units) | 1,850 ± 0,658 | 2,227 ± 0,523 | 0,37 |
| Detailed results-interference conditions for response time median, reading (sec) | 1,282 ± 0,113 | 1,406 ± 0,071 | **0,05** |
| Detailed results-interference conditions for response time median, articulation (sec) | 1,137 ± 0,088 | 1,224 ± 0,059 | 0,1 |
| Incorrect reading results 2 (st.units) | 7,225 ± 2,833 | 5,420 ± 0,863 | 0,22 |
| Incorrect articulation results 2 (st.units) | 3,625 ± 1,147 | 2,864 ± 1,016 | 0,31 |

By the end of school year noradrenalin content in lyceum pupils increased to 232.37 ± 95.69 picogram/cm3 (p = 0.001) (in school pupils, to 229.11 ± 49.00 picogram/cm3; p = 0.001), and adrenalin content (28.25 ± 12.36 against 20.37 ±± 6.53 picogram/cm3 in school pupils; p = 0.48) tended to decrease (p = 0.001–0.07). We should note that dopamine content was authentically lower in lyceum pupils than in school pupils (13.03 ± 8.12 against 26.21 ± 5.75 picogram/cm3, p = 0.01). Hydrocortisone content in lyceum pupils was authentically higher than in school pupils of the same age (408,.37 ± 44.54 against 296.29 ± 51.07 nmol/cm3; p = 0.03), and its level was higher than physiological standard in only 18,0 % of lyceum pupils (only 7,9 % among school pupils; p = 0.03). Simultaneously, serotonin content in lyceum pupils was authentically lower than the same parameter in school pupils (192.69 ± 16.27 against 256.17 ± ± 17.77 ng/cm3, p = 0.02). Thyrothrophin and crude T4 content didn't have any significant

discrepancies in both groups (2.03 ± 0.31 μME/cm3 and 106.38 ± 5.75 nmol/dm3 correspondingly against 2.33 ± 0.23 μME/cm3 and 105.63 ± 4.41 nmol/dm3, p = 0.68–0.87).

We detected in our research that by the end of school year content of cGMP initiating anabolic processes and muscle relaxation reactions was authentically higher in lyceum pupils (4.42 ± 0.94 pmol/cm3), than in school children (3.32 ± 0.51 pmol/cm3; p = 0.04), and its level was higher than physiological standard in 27.3 % of lyceum pupils and reached 7.12 ± 1.91 pmol/cm3 (p = 0.02). There were not more than 6,2 % of children with such levels among school pupils, p = 0.02, and cGMP level in them didn't exceed 5.95 ± 0.64 pmol/cm3 (p = 0.04). Besides, lowered apolpoprotein A1 content and increased "apolipoprotein B100/ apolipoprotein A as per A1" coefficient were detected 1.7 times more frequently among lyceum pupils (24.2% of children); (a number of school pupils with the same levels didn't exceed 14.0-13.8% correspondingly; OR = 1.8; p = 0.03). A number of lyceum pupils with elevated crude cholesterol level (6.06 ± 0.04 mmol/dm3) was 1.6 times higher (12.1 against 7.5 %; OR = 1.4; p = 0.04).

Genetic examination results revealed that 7% of lyceum pupils and 16% of school pupils (p = 0.04) had variant homozygote of glutamate receptor gene (AMPA gene). Its occurrence exerts negative impacts on associative-integrative processes of intellectual activity, speed and volume of memorized information, which ultimately leads to lower efficiency of children teachability. Rarer AMPA gene homozygote occurrence in lyceum pupils is most likely related to stricter requirements set forth for preliminary choice of pupils who can attend innovative educational establishments.

So, laboratory examination results prove that most junior grades pupils, regardless of their educational establishment, adapt to educational processes conditions. However, this process development involves sympathoadrenal system overstrain in pupils attending innovative educational establishments. Lower dopamine and serotonin levels detected in lyceum pupils by the end of school year not only determine lower emotional state of children but also cause slower decision-taking speed, especially under exposure to interfering information. Low dopamine level combined with elevated cGMP content (27.2% of lyceum pupils) has negative influence on pupils' reading speed, articulation speed and motor response time. Low apolipoprotein A1 levels and increase in "apolipoprotein B100/apolipoprotein A as per A1" coefficient detected in each forth lyceum pupil combined with elevated cGMP content are predictors of probable lipoprotein metabolism disorders and cardiovascular pathology evolvement in older age groups.

Analysis of the results obtained in the course of clinical-functional and laboratory examination performed on children attending different educational establishments revealed that a number of absolutely healthy children in both educational establishments didn't exceed 4.0–4.5 % (Table 11).

Table 11

Frequency of basic nosologies detection (ICD-10) in junior grade children attending different educational establishments (%)

| Nosology category | Lyceum | School | Validity of discrepancies between groups |
|---|---|---|---|
| Digestive organs diseases (K00-K99) | 44,5 | 56,1 | 0,11 |
| Nervous system diseases (G00-G99) | 57,3 | 40,4 | **0,02** |
| Respiratory organs diseases (J00-J99) | 14,9 | 20,2 | 0,34 |
| Musculoskeletal system diseases (M00-M99) | 59,3 | 43,7 | **0,03** |
| Endocrine system diseases (E00-E99) | 47,4 | 31,4 | **0,03** |
| Skin and subcutaneous tissue diseases (L00-L99) | 7,9 | 9,0 | 0,79 |
| Healthy | 4,0 | 4,5 | 0,86 |

Table 12

Chronic somatic pathology structure in junior grade pupils attending different educational establishments (%)

| Nosologic form | Lyceum | School | Validity of discrepancies |
|---|---|---|---|
| *Digestive system diseases* | | | |
| Biliary dysfunction syndrome (K83.8) | 24,7 | 33,7 | 0,17 |
| Functional dyspepsia (K30) | 17,8 | 20,2 | 0,67 |
| Caries (K02.9) | 2,97 | 4,49 | 0,96 |
| Chronic gastroduodenitis | 1,98 | 2,2 | 0,98 |
| *Respiratory organs diseases* | | | |
| Bronchial asthma (J45.0) | 0,99 | 2,2 | 0,98 |
| Recurrent bronchitis, tracheitis (J39.8, J44.8) | 0,99 | 0,0 | 0,97 |
| Allergic rhinitis (J30.0, J30.1, J30.3) | 5,94 | 7,86 | 0,59 |
| Chronic tonsillitis (J35.0) | 0.99 | 0 | 0,98 |
| Adenoid hypertrophy (J35.2, J35.3) | 5,94 | 10,1 | 0,31 |
| *Nervous system diseases* | | | |
| Vegetative nervous system disorders (G90.8) | 25,7 | 8,98 | 0,03 |
| Asthenoneurotic syndrome (G93.8) | 31,6 | 31,4 | 0,99 |
| *Musculoskeletal system diseases* | | | |
| Posture disorders (M43.8, M43.9) | 51,4 | 32,5 | 0,01 |
| Platypodia (M21.4, M21.0) | 7,92 | 11,2 | 0,45 |
| *Endocrine system diseases* | | | |
| Excessive height (E34.4) | 9,9 | 8,98 | 0,82 |
| Insufficient height (E34.3) | 1,98 | 0 | 0,98 |
| Malnutrition (E44.1, E46, E67.8) | 30,6 | 16,8 | 0,03 |
| Obesity (E66.0) | 4,95 | 5,61 | 0,76 |
| *Skin diseases* | | | |
| Atopic dermatitis (L20.8, L27.9) | 7,9 | 9,0 | 0,81 |

Table 13

Dynamics of children distribution as per health groups over primary school learning period in different educational establishments, %

| Health group | Lyceum | | | School | | | p3 | p4 |
|---|---|---|---|---|---|---|---|---|
| | 1st grade | 4th grade | p1 | 1st grade | 4th grade | p1 | | |
| I | 4,5 | 0,0 | **0,03** | 0,0 | 3,6 | 0,07 | **0,02** | **0,05** |
| II | 86,5 | 92,0 | 0,19 | 100,0 | 85,7 | **0,001** | **0,001** | 0,15 |
| III | 9,0 | 8,0 | **0,04** | 0,0 | 10,7 | **0,001** | **0,001** | 0,51 |

Note:
*p1* is validity of discrepancy between 1st and 4th lyceum grades;
*p2* is validity of discrepancy between 1st and 4th school grades;
*p3* is validity of discrepancy between 1st grades of different educational establishments;
*p4* is validity of discrepancy between 4th grades of different educational establishments.

Analysis of chronic somatic pathology structure in children of this age group proves that most widely spread nosologies among pupils from both educational establishments are digestive organs diseases (K00-K99), nervous system diseases (G00-G99), musculoskeletal system diseases (M00-M99), and endocrine system diseases (E00-E99).

Our research results revealed that levels of nervous system morbidity among lyceum pupils (57.3 against 40.4 % in school pupils), musculoskeletal system morbidity (59.3 against 43.7 % correspondingly) and endocrine system morbidity (47.4 against 31.4 %) were authentically 1.4–1.5 times higher than among school pupils (p = 0.02–0.03) (Table 12).

Comparative analysis enabled detecting that certain nosologies belonging to various nosologic groups were authentically more frequently detected in junior grade pupils attending lyceum than in school children, i.e. vegetative nervous system disorders among nervous system diseases (G90.8) (2.7 against 8.98 % in schoolpupils, p = 0.03; OR = 2.5; DI = 1.4–3.2; p = 0.02); posture disorders among musculoskeletal system diseases (M43.8, M43.9) (51.4 against 32.5 % correspondingly, p = 0.01; OR = 1.6; DI = 1.2–1.9; p = 0.03), and malnutrition among endocrine system diseases (E44.1, E46, E67.8) (30.6 against 16.8 % correspondingly, p = 0.03; OR = 1.8; DI = 1.5–2.2; p = 0.02) (Table 12).We detected direct correlation between greater intellectual and sensory components of educational process and frequency of vegetative nervous system disorders in pupils (G90.8) (F = 114.31–286.77; R2 = 0.34–0.41; p = 0.02–0.03), as well as between increased intellectual load and general learning activity stress and frequency of musculoskeletal system diseases (F = 73.29–193.83; R2 = 0.29–0.37; p = 0.02).

We examined dynamics of children distribution as per health groups over primary school learning period in different educational establishments; the examination revealed that all 1st grade pupils had the 2nd health group when they started school while only 86.5% of those entering lyceum had the same health group (p = 0.001); however, 4.5 % belonged to the 1st health group (p = 0.02), but 9,0 % had only the 3rd one (p = 0.001). By the end of the 4th school year 3.6 % of school pupils had the 1st health group (0 % among lyceum pupils, p = 0.05), 85.7 % belonged to the 2nd group (92.0 % among lyceum pupils, p = 0.15), however, each tenth child (10.7 %) belonged to the 3rd group (8.0 % among lyceum pupils, p = 0.51) (Table 13).

**Conclusions:** 1. Innovative educational establishments tend to have tighter organizational regime, longer duration and greater intensity of classes, and educational process involves considerable intellectual, sensory, and emotional loads. Pupils attending innovative educational establishments also have greater loads as they attend additional education establishments so overall educational loads grow significantly.

2. Most pupils attending innovative educational establishments are adapted to educational process conditions, however, by the end of school year 20% lyceum pupils have signs of sympathoadrenal system overstrain. It doesn't only determine children's emotional state but also causes attention function disorders and slower decision-taking, slower reading and articulation speed, longer motor responses time.

3. 15% 4th grade pupils attending innovative educational establishment tend to have elevated vegetative nervous system activity and their cardiovascular system is poorly adapted to psychoemotional and physical loads.

4. 25 % junior grades pupils whose educational process is stressful and intense tend to have low apolipoprotein A1 levels and increased "apolipoprotein B100/apolipoprotein A as per A1" coefficient; when it is combined with high cGMP content, we can treat it as a predictor of lipoprotein metabolism disorders and cardiovascular pathology evolvement in older age groups.

5. Lyceum pupils run 2.5 times higher risk for chronic nervous system diseases, musculoskeletal system diseases and endocrine system diseases, than pupils attending ordinary schools. Vegetative nervous system diseases, posture disorder and malnutrition are prevailing nosologic forms as they are 1.6-2.9 times more frequently detected in lyceum pupils than in school pupils.

6. We detected direct correlation between greater intellectual and sensory components of educational process, as well as overall educational process stress, and frequency of vegetative nervous system disorders and musculoskeletal system diseases occurrence in pupils.

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