

Impact of study load on psychophysiological status of high school students

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Abstract. The study comprised 43 students of the 10th grade of a comprehensive school with socio-economic bias and lyceum with physical and mathematical bias. Lung capacity was measured using a dry-air spirometer. According to the results of spirometry, the functional state of the respiratory system in the majority (76.67 %) of the tested schoolchildren and lyceum students turned out to be below average, which indicates a lag in their physical development. The endurance ratio was calculated in order to characterize the functionality of the cardiovascular system. For the majority of students (97.68 %) it corresponded to the average level, and for the minimum number of students (2.32 %) it was low. The functional state of the body was also assessed by determining the stress level indicator. In 81.82 % of schoolchildren, the stress level at rest had a value corresponding to its increase, and only in 18.18 % of schoolchildren, the stress level indicator was within the normal level. Thus, most tenth graders experienced high levels of stress. In addition, the psycho-emotional state of students was studied by other methods using standard tests: determining the level of personal and reactive (situational) anxiety, assessment of personal well-being, activity and mood. The results of self-assessment of lyceum students and schoolchildren corresponded to good and favorable conditions. Among tenth graders, 8.7 % of lyceum students were characterized by an unfavorable condition. 30.4 % of lyceum students and 55.0 % of schoolchildren with high personal anxiety were identified.

1 Introduction

One of the problems inherent to educational activity is the schoolchildren's adaptation to the educational process, which is accompanied by a significant decrease in students' health [1, 2]. It is well known that students' adaptation to mental stress occurs under conditions of psycho-emotional tension and stress, as well as reduced ontogenetic development of the functional reserves of the cardiorespiratory system [3, 4].

In recent years, the health of the younger generation has been of increasing concern. The modern school puts forward a number of acute problems associated with the growing deterioration in students' health. According to medical examinations in 2005, the number of children and adolescents lagging behind in physical development made up 3.5 %. Respiratory diseases were in the first place in the structure of morbidity in children aged 0 to 14 years. The results of preventive examinations of children and adolescent schoolchildren under the age of 17 inclusively showed an increase in the number of children with a decrease in visual acuity [4, 5]. The proportion of children and adolescent schoolchildren with visual impairments in 2013 amounted to 7.07 % (in 2012 – 7.2 %; in 2011 – 7.39 %; in 2010 – 7.34 %).

Under these conditions, one of the main tasks is to bring the educational process in line with the psychophysiological capabilities of students. To solve it, it is necessary to know the peculiarities of schoolchildren's adaptation to study loads.

The educational process is inevitably accompanied by a certain intellectual and psychological load of students. The implementation of most educational programs is accompanied by educational process intensification, an increase in the total study load and a decrease in physical activity. Modern educational process creates constant stress overload in schoolchildren, which can lead to a breakdown in the mechanisms of self-regulation of physiological functions and contribute to the development of chronic diseases. According to teachers, the use of educational programs, many of which are designed for the so-called "advanced" level of education, in mass schools does not correspond to the educational and cognitive capabilities of most students. The schedule of lessons in schools is often drawn up irrationally, without regarding the dynamics of students' working capacity [5].

Amidst overload, diligent children have problems with physical health, and those who are not able to cope with such a volume of tasks due to natural abilities – with moral health. The situation of coercion created by

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teachers and parents not only hinders the development of the child's creative abilities but also blocks the activity and independence in solving educational problems. It forms low self-esteem, self-distrust, turns study into hard and overwhelming work. High anxiety indicates poor adaptation, the presence of emotional and behavioral signs of chronic stress, which often lead to somatic disorders and nervous breakdowns. Thus, half of high school students suffer from hyperexcitability, i.e. are in a stressful situation. This is apparently due to control works, responsibility for the final grades, lack of time to prepare assignments [6].

The problem of overload not only leads to a lag in the physical development of the child, but also can disrupt the psychological and mental status. Long-term and systematic exposure to adverse factors in the school environment contributes to disorders and even diseases of the neuropsychic sphere. Excessive study load has not only a direct, but also an indirect negative impact on students' health, impeding the realization of their age-related biological needs for physical activity, exposure to air, and sleep. In addition, the number of children engaged in additional education and motor activities has decreased. It is known that the most important means in reducing negative impacts on a young organism is the development of motor qualities: strength, flexibility, dexterity, speed, endurance. Good physical fitness is the basis of the student's performance in all types of educational activities. Whereas nowadays computer games and watching television often become the main activities used to spend free time even at the stage of primary education. The lack of activities adequate to the age, diverse and very necessary motor activity for the child's body does not provide a good rest and stimulation of mental performance, reduces their resistance to fatigue. Under these conditions, it is necessary to raise interest and motivation for physical improvement and practicing various sports. Let us present the results of hygienic studies to illustrate the urgency of this issue. Thus, 72.2 % of parents spoke in favor of reducing the study load, 46.3 % expressed complained about the results of pupils selection into classes, 38.4 % of respondents noted insufficient attention to creating conditions for the motor activity of adolescents in schools, 27.6 % were concerned about the insufficient level of professionalism of some teachers. The proclaimed requirement of providing three lessons of physical education per week at school is practically impossible due to the lack of proper conditions and physical education teachers. There is no doubt that the optimization of children's motor activity is one of the most effective ways to reduce the tiring impact of the study load but not the only. The rational distribution of the study load during the school day and week is an important factor in the prevention of schoolchildren's fatigue [6, 7].

The purpose of this research was to study the psycho-emotional and adaptive states of the organism of senior students of a secondary school and lyceum in the process of educational activities. In this regard, the following tasks were formulated: to compare the personal anxiety of lyceum students and schoolchildren; determine the

coefficient of endurance for these two groups of high school students; identify the number of students having a high level of stress; correlate the data obtained with the level of physical development and academic performance.

2 Materials and Methods

The study engaged tenth graders of "Secondary School No. 62" in Cheboksary (socio-economic bias) and "Lyceum No. 3" in Cheboksary (physical and mathematical bias). 43 schoolchildren of both sexes aged 16–17 were examined during breaktime after algebra. The studies were conducted twice: in the first and second half of the 2020th–2021st academic year.

The functional body state was assessed based on the existing concept of the cardiovascular system as an indicator of the adaptive functions of the body [8]. An automatic tonometer OMRON M2 Basic Automatic Blood Pressure Monitor (Japan) determined the pulse, systolic and diastolic pressure (SYS and DIA). Each parameter was recorded 3 times for each test person.

In order to characterize the fitness of the cardiovascular system, the endurance ratio (ER) was calculated using the Quaas formula: heart rate (HR) divided by pulse pressure (ER = HR/pulse pressure). An increase in ER indicated weakening of cardiovascular system capabilities, and a decrease indicates an increase in them.

The stress index was determined by the formula:

$$S = f \times PAP \times M^{1/3} \times C,$$

where S is stress level, conditional units; f is heart rate, min^{-1} ; PAP is pulse arterial pressure, mm Hg; M is body weight, kg; C is the regulating coefficient

S values equal to less than 1.12 conventional units correspond to a normal level of stress in a state of physical rest, and S values greater than 1.12 conventional units reflect an increase in stress levels.

The lung capacity was measured using a dry-air spirometer. Lung capacity is the volume of air exhaled from the lungs after a maximum inspiration. It consists of tidal volume, inspiratory reserve volume, and expiratory reserve volume. It depends on many parameters: gender, age, body size, physical fitness. The best physical fitness correlates with a greater value of lung capacity. For girls, this parameter is on average 2.5–4 liters, for boys – 3.5–5 liters. In accordance with the methodology accepted in our study, lung capacity was measured 3 times in each person.

The level of anxiety is one of the important and fairly stable personal qualities. Anxiety is understood as a stable state often manifested in the form of increased emotional tension accompanied by fears, worry, apprehensions that interfere with normal activity and communication [9–11]. In this work, the psycho-emotional state of students and the level of personal and reactive (situational) anxiety were determined by generally recognized methods using the Spielberger-Khanin questionnaire; personal well-being, activity and mood was assessed as well [11].

The obtained data was statistically processed in the MS® Excel® 2021™ spreadsheet environment using the Statistica® 13.3 package (StatSoft Inc., USA). Validation of differences results was calculated by Student's t-test.

3 Results and Discussion

The mean group results for well-being, activity and mood were as follows. Lyceum students had 5.04 ± 0.12 points and schoolchildren – 5.2 ± 0.19 points, which corresponded to good and favorable conditions. Among them, 2 lyceum students (8.7 %) had an unfavorable condition. At the same time, the average group indicator of endurance ratio was 1.84 ± 0.11 for lyceum students and 1.66 ± 0.22 for schoolchildren, which corresponded to average, normal values. Specifically, this parameter was within the normal range in 97.68 % of the examined. Among the examined, there was only one student (2.32 %) with endurance ratio corresponding to the low functional capabilities of the cardiovascular system. The average (moderate) optimal level of “useful anxiety” of the majority of schoolchildren and lyceum students in the second half of the year should be considered as an active reaction, as a result of which the body turns on protective adaptive mechanisms and mobilizes its resources. This is consistent with the endurance ratio, which characterizes the optimal adaptive stress of the cardiovascular system.

However, the average stress level of schoolchildren at rest was 1.44 ± 0.13 , reflecting its increase (in the norm, less than 1.12 cu). At the same time, only 2 schoolchildren (18.18 %) had values corresponding to the normal level of stress. In the vast majority of the examined (81.82 %), the level of stress at rest was increased. Thus, most schoolchildren experienced a high level of stress against the background of a normal endurance ration. This is due to the adequate tension of the adaptive capabilities of the young organism. However, the very fact of their being under conditions of chronic stress is alarming.

There are a large number of modern physiological works demonstrating the relationship between the emotional sphere, individual properties of the psyche and the functional state of the body [12-15]. One of these indicators is the level of anxiety. This is due to the fact that anxiety is characteristic of social phobias and occurs in situations related to evaluation activities, for example, during classes and exams [16].

In the present study, the average group indicators of the personal anxiety level were 41.61 ± 1.68 points for lyceum students (average level), and 49.05 ± 1.61 points for schoolchildren, which corresponded to a high level of anxiety.

Table 1. Personal anxiety of tenth graders.

Anxiety level	Number of persons, <i>n</i>	
	School (20 in total)	Lyceum (23 in total)
Low	–	2 (8.7 %)
Average	9 (45 %)	14 (60.8 %)

High	11 (55 %)	7 (30.43 %)
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During the analysis (Table 1) of the anxiety level, only 2 lyceum students (8.7 %) with low personal anxiety were identified. Moderate, average personal anxiety characterized 14 lyceum students (60.87 %, 4 girls and 10 boys) and 9 schoolchildren (45 %, 7 girls and 2 boys). 30.43 % (3 girls and 4 boys) of lyceum students and 55 % (8 and 3, respectively) of schoolchildren had high personal anxiety.

Table 2. Reactive anxiety of tenth graders.

Anxiety level	Number of persons, <i>n</i>			
	School		Lyceum	
	The 1 st half of the year (21 in total)	The 2 nd half of the year (24 in total)	The 1 st half of the year (23 in total)	The 2 nd half of the year (27 in total)
Low	15 (71.43 %)	7 (29.17 %)	18 (78.26 %)	5 (18.52 %)
Average	6 (28.57 %)	12 (50 %)	4 (17.39 %)	19 (70.37 %)
High	–	5 (20.83 %)	1 (4.35 %)	3 (11.11 %)

The average group indicators of the reactive (situational) anxiety level were determined. For lyceum students, this indicator was 21.22 ± 2.19 points in the first half of the year, which corresponded to a low level. However, already in the second half of the year, the reactive (situational) anxiety increased to an average level and amounted to 37.19 ± 1.85 . For schoolchildren in the first half of the year, this indicator corresponded to a low level of 24.67 ± 1.94 . In the second half of the year it increased to 37.62 ± 2.29 (average level). In particular, in the first half of the year (Table 2), a low level of reactive (situational) anxiety was detected in 18 (78.26 %) lyceum students and in 15 (71.43 %) schoolchildren; average anxiety – in 4 (17.39 %) lyceum students and in 6 (28.57 %) schoolchildren; high – in 1 (4.35 %) lyceum student. The second half of the year marked a decrease in the number of lyceum students (3rd, 18.52 %) and schoolchildren (7 people, 29.17 %) with a low level of reactive (situational) anxiety. The number of lyceum students (19 people, 70.37 %) and schoolchildren (12 surveyed, 50 %) with an average reactive (situational) anxiety increased. The number of students with a high level of anxiety also significantly increased (3 lyceum students (29.63 %) and 5 schoolchildren (20.83 %)). In the first half of the year, such a state was not observed among schoolchildren.

High anxiety in the second half of the year indicated poor adaptation, the presence of emotional and behavioral signs of chronic stress, which often lead to somatic disorders and nervous breakdowns [17]. Thus, half of high school students were in a state of increased excitability, i.e. in a stressful situation. As shown by our previous studies, this was due to control work, responsibility for final grades, lack of time to prepare assignments [18].

The average group indicator of lung capacity was 3100.0 ± 180.64 ml (average level) in lyceum students and 2772.73 ± 148.38 ml in schoolchildren, which corresponded to a level below the average. Of these, only 7 (23.33 %) of the subjects (5 lyceum students and 2 schoolchildren) had lung capacity indicators corresponding to the average level, and in the majority (76.67 %) of tenth graders they were below the average. Low levels of lung capacity in schoolchildren characterized poor physical fitness of the body.

Table 3. Number of children (%) with different performance levels.

	Performance level, %			
	«2»	«3»	«4»	«5»
Comprehensive school No. 62 I academic quarter	0	35	50	15
Comprehensive school No. 62 II academic quarter	0	50	50	0
Lyceum No. 3 I academic quarter	8	48	44	0
Lyceum No. 3 II academic quarter	11	52	33	4

Comparative analysis of progress dynamics (Table 3) showed that the students of comprehensive school No. 62 and Lyceum No. 3 had the problem of decreasing motivation to study. This can be explained by the complication of educational programs of tenth graders, as well as an increase in the study load.

Pupils of the 11th grades of secondary schools were not included in the studies presented in this article. It is reasonable that in the last year of study, on the eve of final exams, the level of stress anxiety, excessive stress on the adaptive systems of the body of young people will be even higher.

4 Conclusion

A high level of personal anxiety occurred in 30.43 % of lyceum students and 55 % of schoolchildren.

The coefficient of endurance for the majority of schoolchildren and lyceum students corresponded to the norm.

The majority (81.82 %) of schoolchildren experienced a high stress level. Only 2 schoolchildren (18.18 %) had values corresponding to the normal level of stress.

Most schoolchildren and lyceum students were characterized by low physical fitness in terms of lung capacity. There is a need to increase the indicators of physical development by systematic physical education and optimize the daily routine of students.

Analysis of the average grades for the second academic quarter indicated a decrease in the performance levels of schoolchildren and lyceum students.

The results of the study can be used in the development of evidence-based tools and measures aimed to optimize the activity of the physiological systems of high school students and correct functional

disorders that occur during various phases of adaptation to new conditions.

Research on the effects of study loads on the state of the cardiovascular system allows teachers to optimize the dosing of such loads for specific students.

The results obtained are of direct practical importance for teachers. The availability of research methods, their high informational significance and physiological validity allow to systematically monitor the functional state of the children's body.

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