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Adaptation of children to Learning in Schools with Different Educational Models: The State of Autonomic Homeostasis and Personal-Characterological Adaptive Resources

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Abstract.

Psychological and behavioral factors participate in the pathogenesis of most chronic non-communicable diseases (cardiovascular, respiratory, etc.). The aim of the study is to study the adaptation characteristics of children (parameters of vegetative homeostasis, personality characteristics, and adaptive behavior style) under conditions of moderate chronic stress. Materials and methods. The study included 177 children aged 10 to 12 (11.3±0.2 years), with first and second health groups, who graduated from primary school and are enrolled in the private "IQRO" school or the secondary level of general education schools. The main group consisted of 119 students from the "IQRO" school (55 girls). The comparison group consisted of 58 students (31 girls) from one of the general education schools. All patients underwent standard electrocardiography (ECG). The baseline autonomic tone was determined using the A.M. Vein questionnaire modified by N.A. Belokon. Vegetative tests were performed based on the analysis of heart rhythm and blood pressure. A.M. Prihozhan's adapted Phillips test and L.A. Yasukova's modified 12-factor Kettell personality questionnaire were used. Statistical Analysis. Data processing was performed using the Statistica 10 software package. The critical level of statistical significance for testing null hypotheses was set at $p = 0.05$. To compare the distributions of quantitative variables across groups, in addition to the classical analysis of variance (ANOVA), nonparametric methods were applied, including the Kruskal–Wallis analysis of variance with Wilcoxon rank scores and the Van der Waerden test. Results. The analysis demonstrated that parameters of autonomic homeostasis are closely associated with personality traits and adaptive behavior styles. Baseline sympathicotonia was associated with high levels of general anxiety ($p = 0.000$) and reduced volitional self-control ($p = 0.000$). Children with excessive sympathetic reactivity were characterized by increased emotionality ($p = 0.000$), pronounced psychological tension ($p = 0.04$), decreased independence ($p = 0.001$), reduced communicative activity ($p = 0.01$), and lower volitional self-control ($p = 0.03$), as well as a tendency to adopt non-constructive behavioral coping strategies ($p = 0.001$). Conclusions. The criteria for optimal adaptation of children aged 10–12 years to new learning conditions include a balanced autonomic regulation system, good tolerance to academic workload, and successful academic performance. Deviations in health status, a sympathetic predominance in autonomic nervous system responses, reduced tolerance to loads, and insufficient learning effectiveness indicate a strained course of the adaptation process and require psychological, pedagogical, and medical-preventive interventions.

Key words: adaptation, learning, children, autonomic nervous system.

Relevance of the problem: The features of the psycho-emotional sphere are interconnected with individual characteristics of vegetative homeostasis and represent components of a unified psycho-physiological system that modulates the body's adaptive responses. Dysfunction at the level of each component of this system leads to inadequate response to stressful influences, adaptation disorders, and can contribute to the development of diseases [2]. Epidemiological studies have shown the role of psycho-emotional factors in the development of chronic somatic pathology [3, 4]. A number of interdisciplinary directions study the relationships between somatic and mental processes [5, 6]. Psychological and behavioral factors are involved in the pathogenesis of most chronic non-communicable diseases (cardiovascular, respiratory diseases, etc.), which are currently the primary cause of disability and mortality among the working-age population worldwide [4]. A significant portion of these diseases are characterized by a long preclinical period and begin to form as early as childhood: initially as a deficiency of adaptation mechanisms, then as their exhaustion and disruption. Identifying children in need of in-depth examination and starting

preventive measures in a timely manner will contribute to a reduction in morbidity not only among children but also among adults [7].

The pubertal period is characterized by intensive growth rates, complex morphofunctional restructuring, heterochronic maturation of body organs and systems, and is one of the most vulnerable to the onset of somatic pathology. In the modern world, its course is complicated by the impact of a number of stressful factors, among which the most common are the continuous expansion of educational space and the intensification of the educational process. Enrolling in a cadet education institution, like starting an education in the middle level of a general education school, can be considered a model of a stressful situation where the dynamics and success of a child's adaptation are largely determined by their individual psychophysiological characteristics. The use of autonomic and personality response parameters as criteria for assessing adaptation to prolonged exposure to stressors allows for the identification of maladaptation markers and expands the possibilities for the prenatal diagnosis of chronic non-infectious pathology in childhood.

The aim of the study is to study the adaptation characteristics of children (parameters of vegetative homeostasis, personality characteristics, and adaptive behavior style) under conditions of moderate chronic stress.

Characteristics of children and research methods

Research design: a non-randomized prospective comparative study with simultaneous inclusion of children.

Eligibility Criteria.

Inclusion criteria: children of both sexes with health groups I and II whose parents/guardians provided voluntary informed consent for participation in the study.

Exclusion criteria: presence of complaints at the time of the study, use of medications affecting the cardiovascular system, and the presence of acute infectious diseases at the time of the study or within one month prior to enrollment.

Study Duration and Setting.Conformity criteria.

Inclusion criteria: children of both sexes with first and second health groups, whose parents/guardians have given voluntary informed consent to participate in the study.

Exclusion criteria: presence of complaints at the time of the study, need for medications affecting the cardiovascular system, presence of acute infectious diseases at the time of the study and during the month preceding the study. Duration and conditions of the study. The study was conducted from September 2023 to December 2025 at city general education schools No. 13, 24 in Andijan and at the "IQRO" private school.

Research participants. The study included 177 children aged 10 to 12 (11.3±0.2 years), with first and second health groups, who graduated from primary school and are enrolled in the private "IQRO" school or the secondary level of general education schools. The main group consisted of 119 students from the "IQRO" school (55 girls). The comparison group consisted of 58 students (31 girls) from one of the general education schools. By the third stage of the examination, due to the transfer of 13 children (4 girls and 9 boys), the number of examined individuals in the main group decreased to 106 people.

Research methods. The examination of children was conducted in three stages, corresponding to the first and second half of the first year of study and the first half of the third year of study. At each stage of the study, all patients underwent standard electrocardiography (ECG) in 12 branches at a recording speed of 50 mm/s, with amplification up to 20 mV (Cardiovit AT-101, Schiller, Switzerland). The analysis of the results was carried out based on a standard protocol using standards [8]. Initial vegetative tone was determined using the A.M. Vein questionnaire modified by N.A. Belokon [9]. Vegetative tests were performed based on the analysis of heart rhythm and blood pressure: a deep controlled breathing test [10], an active orthostatic test [11], and an active clinoortostatic test [9]. The following were studied: autonomic support for cardiovascular activity, sympathetic and parasympathetic reactivity; personality characteristics were studied using the Phillips test adapted by A.M. Prihozhan and the 12-factor Kettell personality questionnaire modified by L.A. Yasukova. The study of the repertoire of preferred adaptive behavior styles (coping) was conducted using the methodology of I.M. Nikolskaya and R.M. Granovskaya. In the first and second stages of the study, 24-hour ECG (CM ECG) was recorded in 12 standard branches and blood pressure was recorded using the Cardiotechnics-04-AD-3 (M) SAMD. The volume of additional educational workload was calculated in hours per week. Time dedicated to physical education and sports training, general developmental educational programs, and the total number of non-formal education hours were taken into account. Academic performance was evaluated as an average score based on the results of the selected academic period.

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Statistical Analysis. Data processing was performed using the Statistica 10 software package. The critical level of statistical significance for testing null hypotheses was set at p = 0.05. To compare the distributions of quantitative variables across groups, in addition to the classical analysis of variance (ANOVA), nonparametric methods were applied, including the Kruskal–Wallis analysis of variance with Wilcoxon rank scores and the Van der Waerden test. The relationships between pairs of discrete qualitative variables were assessed using the analysis of contingency tables.

Results:

Educational loads and performance. Basic education in private schools and traditional secondary schools differed qualitatively and quantitatively. Its implementation occurred within the framework of the requirements of the Federal State Educational Standard for basic general education. Additional instruction (linguistic, musical, natural-scientific, artistic-aesthetic, sports) was carried out based on the individual preferences of the students. Its volume ranged from 0 to 20 hours per week. When comparing the total sample between the first and second stages of the study, it was established that the total extracurricular workload did not differ significantly and amounted to 6.5±4.5 and 6.2±4.5 hours per week, respectively. In the third stage, its volume decreased compared to the first two stages (p=0.001 and p=0.008) and became equal to 4.9±4.5 hours per week. Comparison in groups (Table. 1) showed that the total volume of extracurricular activities did not differ in the first two stages of the survey.

Table 1. Additional Education and Academic Performance.

stage	group	Additional educational workload, hours per week			успеваемость
		educational	sports	summary	
First	Primary	2,8±2,3	3,8±3,6	6,6±4,5	4,3±0,4
	Compare	1,9±2,1*	4,3±4,0	6,2±4,6	4,2±0,4*
Second	Primary	2,4±2,2	4,0±3,5	6,4±4,5	4,3±0,4
	Compare	1,6±2,2*	4,1±4,1	5,7±4,4	4,1±0,5*
Third	Primary	1,2±1,5**	4,5±3,7**	5,1±4,2**	4,2±0,3
	Compare	1,0±1,7**	3,5±4,6**	4,5±4,9**	4,0±0,4*

Note: Difference significance level p<0.05: one star between groups; two stars between stages. The Van der Varden criterion was used.

By the third stage, a decrease in it was observed in both groups (p=0.009 and p=0.000), while the load level in schoolchildren became lower (p=0.01). The number of additional sports hours was comparable among cadets and schoolchildren during the first year of study. In the third academic year, the volume of sports activities showed significant differences (p=0.02): in "IQRO" school students, it increased (p=0.01), while in schoolchildren, it decreased (p=0.003). A significant decrease in general developmental hours from the first stage to the third was observed in both private (p=0,000) and secondary schools (p=0.01). Private school students devoted more time to alternative learning in the first (p=0.01) and second (p=0.04) stages; no differences were observed in the third stage. The children's academic performance did not undergo significant changes throughout the entire observation period. In the first, second, and third semesters, the average score was higher for private education students (p=0.01; p=0.003 and p=0.004). In the first half of the academic year, against the backdrop of adaptation, children in both groups primarily exhibited: initial sympathicotonia, excessive reactivity of the sympatho-adrenal part of the autonomic nervous system, and a normal response to parasympathetic stimulation. Differences between the groups were noted only in the parameters of vegetative support for cardiovascular activity: in the main group, children with excessive reaction predominated, while in the comparison group, there were significantly more children with insufficient vegetative support (p=0.001). In the middle of the first year of study, the number of children with initial eutonia and normal reactivity of the sympathetic and parasympathetic parts of the autonomic nervous system increased.

In students of private schools and students of traditional education, these changes occurred evenly. Significantly (p=0,000), the number of children with normal vegetative provision increased; normalization was observed only in cadets, while the statistical differences found between the groups at the beginning disappeared. In the third year of study, most subjects in both groups recorded normal parameters of autonomic homeostasis: euthonia in 95 (57.9%), normal reactivity of the sympathetic and parasympathetic parts of

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the autonomic nervous system in 115 (70.1%) and 125 (76.2%), respectively, and adequate autonomic support in 99 (60.4%) individuals (Fig. 1). When comparing groups, the number of children with normal parasympathetic reactivity was significantly higher (p=0.02) among schoolchildren (Table. 2).

Table 2. Indicators of autonomic homeostasis at study stages, abs (%).

Parameters	First stage		Second stage		Third stage	
IVT:						
eithonia	35(29,4)	14(24,1)	47(39,5)	21(36,2)	62(58,5)	33(56,9)
sympathicotonia	57(47,9)	34(58,6)	47(39,5)	29(50,0)	24(22,6)	19(32,8)
vagotony	22(18,5)	10(17,2)	18(15,1)	8(13,8)	11(10,4)	5(8,6)
dystonia	5(4,2)	0	7(5,9)	0	9(8,5)	1(1,7)
SR:						
Normal	49(41,2)	24(41,4)	55(46,2)	27(46,5)	70(66,0)	45(77,6)
hypersympathetic	53(44,5)	26(44,8)	45(37,8)	23(39,7)	18(17,0)	7(12,0)
asympathetic	17(14,3)	8(13,8)	19(16,0)	8(13,8)	18(17,0)	6(10,4)
PSR:						
normal	53(44,5)	32(55,2)	56(47,0)	38(65,5)	74(69,8)	51(88,0)*
reduced	49(41,2)	19(32,8)	49(41,2)	15(25,9)	28(26,4)	5(8,6)
paradoxical	17(14,3)	7(12,0)	14(11,8)	5(8,6)	4(3,8)	2(3,4)
VOD:						
normal	38(31,9)	20(34,5)	51(42,9)*	20(34,5)	67(63,2)	32(55,2)
excess	53(44,5)	12(20,7)	53(44,5)	13(22,4)	18(17,0)	14(24,1)
insufficient	28(23,5)	26(44,8)*	15(12,6)	25(43,1)	21(19,8)	12(20,7)

Note. **p<0.05. Here and in the table. 5:: IVT - initial vegetative tone; SR – sympathetic reactivity; PSR – parasympathetic reactivity, VOD – autonomic support of activity.

Assessment of psychological adaptation resources, including personal characteristics and adaptive behavior variants, established that the groups are homogeneous across all studied traits (Table. 3).

Table 3. Personality characteristics and adaptive behavior styles of the children surveyed, abs (%).

Options	Main group	Comparison group
General activity - decrease	39 (32,7)	26 (44,8)
Communication activity - decrease	52 (43,7)	23 (39,7)
Voluntary self-control - decrease	48 (40,3)	26 (44,8)
Independence - decrease	52 (43,7)	23 (39,6)
Self-criticism - decrease	47 (39,5)	20 (34,5)
Performance - decrease	46 (38,7)	24 (41,4)
General anxiety - increased	60 (50,4)	30 (51,7)
Emotionality - Increase	36 (30,3)	25 (43,1)
Non-constructive styles of adaptive behavior	55 (46,2)	25 (43,1)
School anxiety - Increase	19 (16,0)	8 (13,8)

Analysis showed that parameters of vegetative homeostasis are closely linked to personality characteristics and adaptive behavior styles. Initial sympathicotonia was associated with high general anxiety (p=0,000) and decreased volitional self-control (p=0,000). Children with excessive sympathetic reactivity were characterized by increased emotionality (p=0,000), pronounced mental tension (p=0.04), decreased independence (p=0.001), communication activity (p=0.01), volitional self-control (p=0.03), as well as the choice of non-constructive behavioral strategies for overcoming stress (p=0.001). The following were associated with a decrease in parasympathetic reactivity (Fig. 2): low volitional self-control (p=0.002), high general anxiety (p=0.001), and non-constructive coping styles (p=0.000). A paradoxical reaction from the parasympathetic side was characteristic of children with high levels of mental tension (p=0.001). Excessive autonomic support for activity correlated with low levels of volitional self-control (p=0.01) and the application of

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non-constructive coping strategies (p=0.000).

Statistical analysis showed that children subjected to the greatest non-curricular loads, including athletes, are characterized by a balanced state of vegetative homeostasis. The observed children, who exercised additionally from 8 to 20 hours per week, noted normal reactivity of the sympathetic and parasympathetic parts of the autonomic nervous system in the first (p=0.008 and p=0.004) and second (p=0.004 and p=0.001) stages, and euthonia (p=0.002) in the third stage of the study. For the vast majority of athletes, adequate sympathetic and parasympathetic reactivity is typical in the first (p=0.002 and p=0.001) and second (p=0.002 and p=0.009) semesters of training, and normal vegetative tone in the third year of training (p=0.001). The absence or minimal level of extracurricular activity (no more than 2 hours per week) was associated with the original sympathetic tonic. The most pronounced correlation was observed in the second stage of the study (p=0,000). For children with low academic performance, a disruption of the vegetative balance is typical, manifesting as an increase in sympathetic and a decrease in parasympathetic reactivity in the first (p=0.04 and p=0.003) and second (p=0.04 and p=0.04) halves of the first year of study. Eutonia (p=0.001) and adequate sympathetic response (p=0.002) are characteristic of children with excellent and good academic performance, which was particularly pronounced in the third stage of the study. We analyzed the characteristics of adaptation and the influence of psychophysiological factors. In the initial period of adaptation to new micro-social and educational conditions, which corresponded to the first half of the academic year, 45 (25.4%) children exhibited an excess of the normative values of the hypertension time index for systolic and/or diastolic blood pressure within the range of 25 to 50% - labile arterial hypertension. Among children with labile hypertension, private school students predominated—39 (32.7%) people. With an increase in the hypertension time index, the following were closely associated: initial sympathic tonicity (p=0.001) in 25 (55.6%) children, increased reactivity of the sympatho-adrenal link of the autonomic nervous system (p=0.003) in 29 (64.4%), and reduced parasympathetic reactivity (p=0.001) in 27 (60.0%) subjects. The presence of labile arterial hypertension is associated (p=0,000) with increased school anxiety, which was noted in 31 (68.9%) children. Children with labile hypertension were characterized by higher performance in the first (p=0,000) and second (p=0,001) stages of the study. Their average score in the first half of the year was 4.5±0.4, and in the second half, it was 4.5±0.3. Along with positive performance, these children demonstrated a high level of general employment in additional education in the first (p=0,000) and second stages of the survey (p=0.001). The total workload in children with labile arterial hypertension in the first half of the year was 8.8±4.7 hours per week: 3.8±4.0 hours of sports and 5.0±1.9 hours of educational activities. Against the backdrop of adaptation completion in the second half of the academic year, arterial hypertension persisted in 6 (3.3%) children, five (4.2%) of whom were students of cadet institutions. After 24 months, hypertension also persisted (registered in 5 children; one child withdrew from the study). Permanently elevated blood pressure was persistently associated with disorders of autonomic homeostasis. At the beginning of the study, after 6 months and 24 months, children with persistent arterial hypertension exhibited initial sympathic tonicity, hyperreactivity of the sympathetic part of the autonomic nervous system, and a paradoxical response to parasympathetic stimulation (Table. 4).

Table 4. Autonomic homeostasis disorders associated with the presence and persistence of arterial hypertension (n=5), abs (%).

predictor	stage		
	1	2	3
Initial sympathicotonia	4(66,7)*	5(83,3)**	5(80,0)**
Hyperreactivity of the autonomic nerv-ous system sympathetic region	6(100)**	6(100)*	4(80,0)*
Paradoxical parasympathetic reactivity	6(100)*	4(66,7)**	5(100)*

Analysis of personal characteristics showed that children with persistent arterial hypertension are characterized by decreased volitional self-control (p=0.03) in 5 (83.3%), independence (p=0.003) in 6 (100%), and low communication activity (p=0.03) in 5 (83.3%).

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At all stages of observation, children with persistent hypertension demonstrated high average scores: 4.5±0.5 in the first stage, 4.4±0.6 in the second, and 4.3±0.2 in the third. The association between the presence of persistent arterial hypertension and academic performance was statistically confirmed only for the second stage of the study (p=0.04). The relationship with the volume of extracurricular work, including sports, was not observed in these children. Two years after the start of the study, 37 (22.6%) observed children were diagnosed with sinus bradycardia for the first time [8]. Since 22 (13.4%) children systematically engaged in sports for 8-14 hours per week, the development of sinus bradycardia was assessed as a manifestation of heart rhythm adaptation to regular training loads. Of the 22 athlete children, 20 (90.9%) were students of a private school; 18 (81.8%) practiced 6-8 hours per week for 2-4 years prior to entering a cadet institution/secondary school. Children with bradycardia that developed against the background of systematic prolonged sports activities primarily noted a balanced state of the autonomic nervous system. Initial eutonia was observed in 9 (37.5%) individuals in the first stage, 16 (66.7%) in the second, and 18 (75.0%) in the third (p>0.05; p=0.000 and p=0.000). Adequate sympathetic reactivity was noted in 19 (79.1%) athletes in the first and second stages, and in 20 (83.3%) in the third (p=0,000; p=0,000 and p=0.001). Normal parasympathetic reactivity was observed in 14 (58.3) individuals in the first half of the academic year, 17 (70.8%) in the second, and 20 (83.3%) in the third year of study (p=0.001; p=0.000 and p=0.000). Athlete children were characterized by high academic performance throughout the entire observation period: 100% (24 children) scored "good" and "excellent" in the first and second stages of the study (average scores of 4.5±0.3 and 4.5±0.2), and 95.8% (23 children) in the third stage (average score of 4.4±0.3). The total number of hours of additional training was significantly higher in each stage of the study (p=0.001; p=0.004 and p=0.002), primarily due to the duration of sports training. In the first half of the year, children studied additionally for 14.7±2.8 hours per week: 12.0±1.9 hours were dedicated to sports training and 2.7±1.8 hours to educational disciplines. Six months later, the total number of additional hours per week was 14.4±2.7: 11.8±1.9 for sports and 2.6±1.9 for educational activities. In the third year of study, the total additional workload for athlete children was 11.6±3.9 hours per week. They spent 10.4±3.9 hours in sports and 1.2±1.4 hours per week in additional education. Sixteen (66.7%) athlete children demonstrated high volitional self-control (p=0.001) and 14 (58.3%) demonstrated a high level of independence (p=0.001). Fifteen (8.5%) children with bradycardia manifestations were not athletes. Sinus bradycardia in them was interpreted as a disruption in the adaptation of the cardiovascular system. Among them were 8 (7.5%) students from the "ICRO" school and 7 (12.0%) schoolchildren; the link between sinus bradycardia and living conditions and the type of education was not significant. Dynamic assessment of the state of the autonomic nervous system in this subgroup (Table. 5) showed that statistically significant predictors of sinus bradycardia identified 24 months before its development were: hyperreactivity of the sympathetic nervous system in 11 (73.3%) children (p=0.00), paradoxical reactivity of the parasympathetic nervous system in 10 (66.7%) children (p=0.00), and excessive vegetative provision in 9 (60.0%) observed individuals (p=0.00).

Table 5. Autonomic homeostasis disorders associated with the development of sinus bradycardia (n=15), abs (%).

Condition of the autonomic nervous system	Stge		
	1	2	3
IVT: eithonia	2 (13,3)	1 (6,7)	1 (6,7)
sympathicotonia	10 (66,7)**	11 (73,3)*	5 (33,3)
wagotony	2 (13,3)	0	1 (6,7)
dystonia	1 (6,7)	3 (20,0)	8 (53,3)*
SR:			
normal	1 (6,7)	1 (6,7)	2 (13,3)
hypersympathetic	11 (73,3)*	7 (46,7)*	2 (13,3)
asympathetic	3 (20,0)	7 (46,7)*	11 (73,3)*
PSR:			
normal	1 (6,7)	1 (6,7)	2 (13,3)
reduced	4 (26,6)	5 (33,3)	11 (73,3)*
paradoxical	10 (66,7)*	9 (60,0)**	2 (13,3)

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VOD:			
Normal	4 (26,6)	2 (13,3)	2 (13,3)
excess	9 (60,0)*	8 (53,3)**	2 (13,3)
insufficient	2 (13,3)	5 (33,3)	11 (73,3)*

Note. * p=0,00; ** 0,00>p<0,05

The initial sympathicotonia noted in 10 (66.7%) children at the first stage of the examination was not significantly associated with the onset of bradycardia. Six months later, the number of predictors for sinus bradycardia development was supplemented by the initial sympathicotony, which was identified in 11 (73.3%) individuals (p=0.00). 7 (46.7%) children with sympathetic hyperreactivity remained; the same number of children exhibited an asympathetic reaction (p=0.00). Paradoxical reactivity of the parasympathetic nervous system persisted in 9 (60.0%) children, and 8 (53.3%) of them exhibited excessive autonomic support (p=0.01 and p=0.01). At the time of sinus bradycardia, a significant decrease in the reactivity of the sympathetic and parasympathetic parts of the autonomic nervous system (p=0.00 and p=0.00) and insufficient autonomic support for activity (p=0.00) were recorded in 11 (73.3%) children. Distonia was noted in 8 (53.3%) individuals during the study of baseline autonomic tone (p=0.00). For children with sinus bradycardia that developed independently of regular sports loads, a decrease in academic performance was characteristic throughout all three stages of the study (p=0,000; p=0,000 and p=0,001). The average score for the first half of the first year of study was 3.5±0.3, for the second 3.5±0.3, and for the first half of the third year 3.6±0.4. Eight (53.3%) children in the first stage and 7 (46.7%) in the second and third stages studied "satisfactorily." At all stages of the study, they exhibited a significantly low level of extracurricular workload (p=0.001; p=0.003 and p=0.006). During the first 6 months of training, the total additional workload was 0.5±0.9 hours per week; this volume included 0.4±0.7 sports and 0.1±0.5 educational hours per week. In the second and third stages, children additionally attended only sports clubs - 0.7±1.4 and 1.0±1.0 hours per week, respectively. The distinctive psychological features of children with sinus bradycardia were low volitional self-control (p=0.001) and low independence levels (p=0.001), which were observed in 13 (86.7%) individuals.

Discussion. With a comparable volume of sports load, additional general developmental classes were more common in private school students during their first year of study. The total time of extracurricular activities decreased significantly in the third year of study. This may be due to the increased complexity of the basic secondary education curriculum. With a general downward trend in the third year of study, the total extracurricular workload among private school students was significantly higher due to physical education and sports activities, which can be explained by the priority given to physical training in private schools [12]. Academic performance in the observed groups did not change significantly during the study period. The higher average score for schoolchildren from private schools is likely due to the specifics of the educational process, which includes a regulated system of life activities and the directed psychological and pedagogical maintenance of a high level of educational motivation within a closed team [13]. Regardless of the learning conditions, adaptation to the new conditions of the social and educational environment in children of this age group was accompanied by tension in autonomic regulation, which was reflected in the predominance of the activity of the sympathetic part of the autonomic nervous system. The obtained data are comparable to the research results of children in other age groups [14–16].

Long-term adaptation was associated with a state of vegetative balance, with vegetative homeostasis indicators comparable to those in healthy adolescents, excluding additional stressful environmental factors [17,19]. Data have been accumulated regarding the relationship between psycho-emotional response and individual predisposition to a specific autonomic response [20]. Individual differences in temperament and the cognitive-emotional sphere modulate the specificity of vegetative manifestations [17]. Analysis of personality traits in our study showed that children with increased activity of the sympatho-adrenal part of the autonomic nervous system are characterized by high emotionality, general anxiety, and mental tension, which is consistent with data from other studies.

There are also descriptions of the relationship between increased emotionality and parasympathetic nervous system tone [18]. According to the results of an observation of 100 rural schoolchildren aged 11-17 [19], sympathicotonia was more frequently recorded in children with high performance. In our study, opposite results were obtained, which is likely related to the special conditions of learning. The association of hypersympathicotonia

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with decreased volitional self-control, independence, and communication activity has not been previously described in pediatric scientific literature. Evaluating behavior aimed at personality adaptation to environmental requirements (coping) revealed that ineffective styles were associated with elevated sympathetic nervous system tone. Similar results were obtained during a survey of middle school students [20] and high school students [20]. Children with balanced vegetative homeostasis are characterized by greater extracurricular activities, including sports, and high academic performance. Low academic performance was more frequent in children with excessive activation of the sympatho-adrenal region and weakening of parasympathetic tone.

Thus, insufficient load tolerance and rapid fatigue occurred in children with sympathetic nervous system hyperfunction, which aligns with the data obtained during the study of adaptation mechanisms in secondary school students and students. In our study, we confirmed the data regarding the influence of personal characteristics on learning success. Maximum extracurricular engagement was associated with increased school anxiety and communication activity. Children with low academic performance used non-constructive adaptive behavioral styles and were characterized by a decrease in volitional self-control, performance, and independence. During the period of unstable adaptation to educational conditions in a private school/ordinary secondary school, labile arterial hypertension was identified in 25.4% of children. Six months later, against the background of a significant normalization of the autonomic sphere, blood pressure normalization was observed in 22.0%, which indicates the successful adaptation of children to conditions of moderate persistent stress. The relationship between the hyperactivity of the sympathetic part of the autonomic nervous system and arterial hypertension has been proven to date in both adults and children. In our study, sympathoadrenal activity predominated in children with labile hypertension. These children were characterized by positive academic performance and high involvement in extracurricular educational activities, revealing a significant increase in school anxiety. Thus, sufficient load tolerance in children with labile arterial hypertension was achieved through significant strain on psychological and vegetative compensatory-adaptive mechanisms. This feature should be taken into account when ensuring psychological and pedagogical support for the educational process. Since high blood pressure reactivity is one of the prognostic markers for the development of arterial hypertension, it is necessary to include blood pressure control in the plan for annual medical examination of children, as well as to ensure the implementation of primary prevention measures for arterial hypertension.

In 2.8% of children, arterial hypertension and the predominance of sympathetic influences were recorded at all stages of the examination. They were characterized by a decrease in volitional self-control, independence, and activity in communication. Within two years of starting school in a private school/ordinary secondary school, 22.6% of children were diagnosed with sinus bradycardia for the first time. This figure significantly exceeds the incidence of this ECG phenomenon in the 12-14 age group (3.3%) [8]. In 13.4% of the examined individuals, the development of bradycardia was associated with regular sports activities lasting from 8 to 14 hours per week. A balanced state of vegetative homeostasis was characteristic of most athlete children during all stages of observation. They more often exhibited high volitional self-control and a high level of independence. Despite significant extracurricular activities, the athlete children were distinguished by high academic performance. In 8.5% of children, sinus bradycardia was not related to sports. The analysis also did not confirm the link between bradycardia and the type of education and living conditions. These children were characterized by decreased tolerance for academic workloads, which manifested as insufficient academic performance in the core curriculum and low involvement in extracurricular educational activities. Poor load tolerance was combined with immature functions of volitional self-control and independence. The development of bradycardia was preceded by the tension of the sympathetic-adrenal canal of the autonomic nervous system. At the time of sinus bradycardia detection in most children, the tension of the sympathetic nervous system was replaced by its exhaustion: a significant decrease in the reactivity of the sympathetic and parasympathetic parts, insufficient autonomic support for cardiovascular activity, and initial autonomic dystonia were recorded. The deficiency of sympathetic influences accompanying the development of bradycardia is confirmed by the published results of previous studies. As a form of cardiovascular system maladaptation, sinus bradycardia less than the 2nd percentile of the age distribution [8] in 50% of children progresses to sinus node weakness syndrome.Therefore, it is recommended to include an assessment of heart rate in various functional states (lying, standing, after minimal physical exertion) and daily ECG monitoring in the annual monitoring of children with sinus

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bradycardia.

Conclusions:

1. The process of adapting 10-12 year-old children to changed educational and environmental conditions, regardless of the type of educational institution, is accompanied by the functional tension of vegetative regulation mechanisms. Its completion is characterized by a balanced state of vegetative homeostasis.

2. Criteria for the optimal adaptation of 10-12 year-old children to new learning conditions are: balance of vegetative regulation systems, good tolerance of learning loads, and successful learning. Deviations in health status, sympathetic orientation of the autonomic nervous system response, reduced tolerance to loads, and insufficient learning efficiency serve as indicators of the tense course of the adaptation process and require psychological-pedagogical and therapeutic-preventive intervention.

3. Factors influencing the success of 10-12 year old children's adaptation include the characteristics of personal and behavioral adaptive resources, which are interconnected with the nature of the vegetative response. Vegetative balance, formed functions of self-control, independence, and constructive coping styles contribute to rapid optimal adaptation. Hyperactivity of the sympatho-adrenal part of the autonomic nervous system, undeveloped self-control, independence, and non-constructive coping styles are associated with a decrease in adaptive capabilities.

4. In order to prevent cardiovascular diseases in children in the future, when preparing recommendations for admission to educational institutions and organizing medical and psychological-pedagogical support for students, the state of autonomic regulation mechanisms, personal characteristics, and behavioral styles implemented by the child to overcome stress should be taken into account.

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