Influence of the arctic climatic conditions of the Kola Peninsula on the reactivity of the sympathetic-adrenal and cardiovascular systems of junior high school children

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Abstract. The growth and development of children aged 7-10 years takes place under conditions of continuous learning, and the level of fatigue increases by the end of the school year. Environmental factors of the Kola Peninsula play a special role here. the process of adaptation of the organism takes place in all age and gender groups. The most obvious is the reactivity of the cardiovascular and sympathetic-adrenal systems to physical load, which enhances the correlation links between indicators of the two active systems. It happens in the following way: by the end of the academic year, in all age and gender groups before the polar day, a proven shift of the observed indicators is recorded. The results obtained provide a comprehensive picture of age-related adaptation changes and increase in the level of fatigue in the arctic climate conditions of the Kola Peninsula. Examinations of children aged 7-10 years showed that age dynamics of cardiovascular and sympathoadrenal systems indicators is non-linear and significantly depends on specific parts of the academic year. This may be due to the periodicity of the polar night, namely, as the functional capabilities of particular systems tend to increase with age, certain indicators have a wave-like character of changes.

1 Introduction

High latitudes are characterized by numerous extreme climatic and geographical, environmental factors that have a significant impact on the human body. The complex of northern environmental factors has a significant impact on the systems and mechanisms of homeostasis [8-14]. peculiarities of changes in the indicators of sympathoadrenal and cardiovascular systems in children living in the Arctic regions remain practically unstudied. From the point of view of physiology, the healthy growth and evolution of the child's body system can only occur in an environmentally clean and sound environment; so the question of researching the adaptive behavior of the child in a nearly extreme environment is very relevant [5].

The reaction to the increased level of information and physical activities throughout the academic process normally goes beyond the innate ("default") adaptation mechanisms, which requires that a new level of adaptation is studied - long-term adaptation in conditions of long-time exposure to school academic activity and special environmental factors [3]. It should be mentioned that in younger school age, when structural and functional changes in various body systems of the individual child's organism occur, including the impact of environmental factors, a special role here is played by the cardiovascular and neuroendocrine systems [1].

There is evidence that at the initial phases of schooling children often demonstrate the following reactions of the body that affect the rate of physical development: psychological stress, decrease hemoglobin levels in the blood, autoimmune disorders [2,4]. Besides, some data show that at the level of humoral regulation in primary school children may retain the tension of hormonal mechanisms [7]. Several authors indicate that studies of phase structures of cardiac cycles have revealed a tendency to unfavorable changes by the end of the school year. cholinergic effects increase with age, but for in younger schoolchildren the chronotropic activity of the heart is regulated mainly by the sympathoadrenal system (SAS) [5, 6]. It has been noted that by the end of the school year, decreased SAS activity is reported, as well as an increase in the influence of the parasympathetic department of the autonomous nervous system on the heart [2,7]. Moderate physical activity reveals the functional reserves of a

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number of systems, the nature of their implementation in the course of adaptation and the dependence on age and gender. The reactivity of the cardiovascular system (CVS) and SAS to a graded physical load in children 7-10 years old, in the dynamics of the school year, in the conditions of the Kola Arctic, has not yet been studied.

In view of the above, the aim of the study was defined as the study of CVS and SAS indicators in the children 7-10 years old and the changes in these indicators during the school year in the state of relative rest and under the influence of physical activity in the environmental conditions of the Kola Polar Region.

2 Research methods and organization

Externally healthy children of primary school age studying in a secondary school of the Kola Peninsula were examined. The study was conducted by age and gender groups three times a year: in October, February and May. A total of 20 boys and 20 girls were examined. Physical development was evaluated according to standard methods. Functional test was dosed for each individual – cycling on bicycle RITM ergometer: 1 W per 1 kg of body weight, pedal frequency – 60 rpm, duration - 3 minutes. The functional state of the CVS was studied by means of electrocardiography, and by the Korotkov sonic method. The excretion of catecholamines was determined fluorometrically [7]. The tests were carried out under laboratory conditions in a state of operative rest at the same time of the day in compliance with ethical standards (Helsinki Declaration and the European Community Directives 8/609 EC). Reliability of the obtained results was confirmed by – using SPSS 15.0. statistical program based on parametric and nonparametric data (t-Student's statistical test and Wilcoxon statistical criterion).

3 Research results and their discussion

the indicators of physical development change gradually with age from 7 to 11 years, becoming higher every year. Changes of CVS and SAS indicators with age have a wave-like character (see Figure 2). it is known that with age there is a decrease in heart rate (HR) and an increase in indicators of stroke volume (SV) and cardiac output (CO). However, as our studies have shown, age-related changes of these indicators are nonlinear.

By age 10, there is an increase in the heart rate in boys, with a decrease occurring at an earlier age. It is also noted that SV and CO change unevenly in children from 7 to 10 years of age, increasing sharply at the age of 8 in boys and at age 9 in girls, then decreasing, although this does not violate the general trend of age-related increases.

When comparing the indicators of the CVS and SAS in the age dynamics with the data of the end of the school year, a significant discrepancy is revealed. Thus, the indicators of the end of the school year reflect the adaptive shift in the indicators of the functional state of the CVS and SAS.

According to our data, by the end of the school year, there is a decrease in systolic (SBP) and pulse (PBP) pressure in all age-gender groups, with the exception of the boys of the first year of study. Shifts in diastolic blood pressure (DPB) do not reach a reliable value. From the beginning to the end of the school year, all age-gender groups also showed a decrease in history, more pronounced in the boys. By the end of the school year, the reliability of the annual dynamics of the HR was found in boys of the first and second years and girls of the third year of study.

By the end of the school year, the SV in boys of the third year and girls of the first, second and third years significantly increased, reaching reliable significance in these groups. But a credible increase in cardiac output occurred only among girls of the third year of study: from 3.64 to 4.41 l/min. The tendency to increased cardiac output was found in boys of the third year of study and girls of the first year of study; boys of the first and second grades demonstrated a slight decrease in CO: from 3.03 to 2.76 and from 4.15 to 4.04 l/min, respectively. This indicator practically did not change in the girls of the second year of study: from 3.19 l/min at the beginning of the school year to 3.18 l/min at the end of it. The pronounced discrepancy between the indicators of age groups and the annual dynamics in younger schoolchildren indicates a substantial influence of the educational load on the CVS at this stage of a child ontogenesis. The intensive nature of the CVS functioning is more pronounced at the end of the school year in boys of the third and girls of the first and third years of study.

Signs of fatigue are most pronounced in boys of the first year and girls of the second year of study.

During the school year there were changes in the CVS reactivity to the graduated exercise. In boys of all age groups, the growth in CO was higher at the end of the school year and was caused by an increase in both chrono- and inotropic effect of the heart. In girls, at the end of the school year, an increase in HR prevailed. The increase in SV was slightly lower than at the beginning of the school year; as a result, there was a slight increase in CO at the end of the school year when exercising. Changes in arterial blood pressure (ABP) in response to exercise both at the beginning and the end of the school year were reliably significant.

The increase in the chronotropic effect of the heart in response to stress at the end of the school year represents a non-conomic type of CVS response as a consequence of hypodynamia. Thus, the functioning of the CVS in primary school children of all age and gender groups under the influence of the graded physical activity at the end of the school year proceeds to a certain extent in a stressful mode. especially significant is not only to estimate the functionality of the system, but also to disclose its reserves, which is possible when studying the regulatory mechanisms of the CVS, in particular the SAS.

According to our data, by the end of the school year there was a decrease in catecholamine excretion (CA) in all age-gender groups, more pronounced in boys. The excretion of adrenaline (A) was significantly

decreased in boys of all age groups and in girls of the second and third years of study; noradrenaline (NA) – in all age groups of boys and girls of the second and third years of study; dopamine (DA) – first and second grade girls; DOPA (D) – in second and third grade boys third grade girls.

Catecholamines (CA)	time of research	7 years old		8 years old		9 years old	
		1	2	1	2	1	2
Adrenalin	October	3.74±0.66	9.67±1.85*	5.02±0.51	11.76± 1.39*	4.22±0.39	8.03±1.03*
	February	4.18±0.64	7.03±0.78*	2.95±0.93	4.81±1.24*	4.67±0.6	8.57±1.29*
	May	3.43±0.4	5.1±0.55*	2.13±0.6	3.22±0.94	3.38±0.67	7.01±1.22*
Noradrenaline	October	8.29±1.25	18.43±1.42*	11.48±1.42	23.50±3.08*	11.42±1.32	18.68±2.89*
	February	17.9±3.43*	19.05±2.19*	9.64±3.02	10.10±2.65	10.19±0.85	17.9±3.43*
	May	8.92±0.93	11.18±1.46	6.04±1.32	7.35±1.46	7.41±1.52	16.02±2.98*
Dopamine	October	106.1±25.83	157.68±43.12	126.85±22.74	242.20±32.55	90.46±15.29	134.16±27.76
	February	124.21±28.26	137.9±19.59	122.23±29.0	232.42±73.58	66.72±16.61	88.32±22.12
	May	55.03±8.33	125.02±28.19*	41.92±5.25	75.7 ± 23.8	84.04±10.47	13.14 ±10.64*
DOPA	October	20.74± 4.11	32.2±4.99*	30.17±3.75	47.28 ± 4.97*	24.49± 1.83	4.89±3.18 *
	February	27.71±4.96	31.14±4.41	23.83±7.32	28.27 ± 5.01	26.55±3.82	33.43±3.33
	May	16.26±2.04	26.24±4.6*	20.5±3.79	17.16±2.4	15.74±2.39	27.16 ±3.26*

Fig. 1. Changes in the excretion of catecholamines (kg/min) under the influence of graded physical activity in primary school children during the school year (M±m).

Note: 1– excretion of CA before graded physical activity, 2 – after graded physical activity

* Reliability of changes in indicators shift under the influence of graded physical activity

The most significant decrease in CA excretion was found in second-grade girls and third-grade boys. The predominant decrease was observed in the final links of SAS – A and NA (please refer to Table 1). boys (first- and second-graders) and girls (second- and third-graders) showed a significant decrease in precursors of DA and D, which probably reflects the growing deficit of DA and D. Only in girls of the 3rd year, the decrease in the excretion of CA was moderate in all stages of the SAS. Decrease in SAS indicators by the end of the school year was typical for all age and gender groups (the result of educational process and environmental and social factors of the Arctic region). Decrease in CA excretion by the end of the school year was indicative of increased fatigue and was manifested by strenuous SAS functioning. The graded exercise revealed some functional reserves of the child's body. The reactivity of the SAS at the end of the school year indicates the lack of balance between the synthesis links (uneven decrease in the growth rate of CA excretion under the influence of the functional test).

Graded physical activity revealed the incompleteness of adaptive changes in the body during the first three years of study, as well as the imperfection of regulatory mechanisms in boys. Higher rates of cardiac output in response to physical activity at the end of the school year and their correlation not only with SV, but also with increased heart rate with decreased CA growth, indicates the presence of CVS reserves, increased sensitivity of the system to hormones and mediators (see Figure 2). At the same time, there is a strenuous functioning of the CVS and a decrease in the reserve capabilities of the SAS (as a result of increasing fatigue against the background of developing adaptation mechanisms). high reactivity of the CVS with decreased reactivity of the SAS to physical load is interpreted as an economization in the work of regulatory mechanisms, which serves as a favorable background. At the end of the school year, such economization reveals the reserves available in younger students. In girls, the growth of CA under the influence of the graded physical load at the end of the school year differs from the growth at the beginning of the school year. The increase of A was lower in the first, second and third grades, but in girls rose to 107.4% for girls in grade three, compared to 90.3% at the beginning of the school year.

The increase in NA in girls of the first and second grades decreased almost fivefold, and became twice as high in third grade. It is noteworthy that in the girls of the first grade at the end of the school year the growth of CA and NA sharply deceased; the excretion of DA increased just as sharply, and excretion of D was almost unchanged. The dynamics of the ratio coefficients of different SAS (CA) links indicates an increased level of use of D, but a decrease (A+NA)/DA (especially in the NA/DA link), while the A/NA indicator increased. Thus, there was a real vulnerability in the DA-NA link. The reactivity of the SAS in primary school students, both at the beginning and at the end of the school year, was at a fairly high level, however, at the beginning of the school year, the increase in A and NA prevailed over DA and D, while at the end of the school year, the increase in DA and D was prevailing over A and NA. This indicates the tension of the system, connection of the reserves, although the effectiveness was most evident in the enhancement of the chronotropic effect of the heart.

In general, s an uneconomical type of response to the presented exercise is observed. The high reactivity and coherence of the SAS links in the girls of the 3rd grade give reason to speak about the significant role of this system in regulation and provision of a high level of performance. All this is an evidence of achieving a certain level of adaptation to the conditions of the educational process in a sub-extreme environment.

Analysis of the correlative relationships between the studied parameters allowed concluding on the conjugacy in functioning of sympathoadrenal and cardiovascular systems.

All this leads to the following recommendations. When organizing educational work, sports training of primary school children, it is necessary to take into account the intense nature of CVS and SAS functioning in children of the first and second year of education, as well as the immaturity of these systems in children of the third grade.

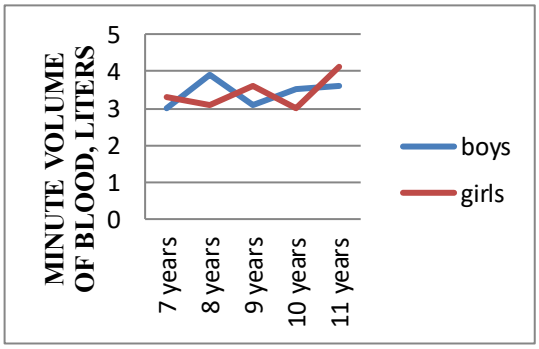

Fig. 2. Age dynamics of cardiovascular system indicators in boys and girls aged 7-10 years.

The regulation of graded load must correlate with the age and year of study: in the 1st year, a moderate and short-term graded load is recommended; in the 3rd year, a long graded load of moderate power is acceptable; in the 4th year, a moderate and short-term graded load at the beginning of the school year, in the middle of it – intensive and short-term graded load, at the end of -50% of PWC170 is an adequate load.

4 Conclusions

1. For younger school children it was found that by the end of the school year, prior to the polar day, catecholamine excretion significantly decreased in the relative resting state in all the groups studied, as well as it increased in response to a dosed physical load as a result of systematic exposure to the educational process.

2. Adaptation to physical exercises and learning activities for younger students is stressful due to increased fatigue levels.

3. the immaturity of the functional systems of younger schoolchildren may be due to the predominance of temporal functional dependencies between the indicators of the cardiovascular, sympathoadrenal systems and physical development. This pattern is a part of research results – by the end of the school year in all age and gender groups, the functional dependencies, both in the state of relative rest, and after physical activity, were weaker.

4. The results of research related to the functional state of the heart have shown that psychophysiological recreation and corrective activities should be provided, for children studying in the first 3 grades of primary schools in the arctic Kola Peninsula both during each school year and at the end of it.

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