Characteristics of the neurohormonal control of static muscle activity in children

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Abstract

Objective of the study was to investigate the reaction of the sympathetic-adrenal system to localized static strain in children with distinctive autonomic control.

Methods and structure of the study. The scientific work was attended by children aged 7 and 9 years of both sexes. The initial vegetative tone (IVT) was determined by the method of variational heart rate monitoring using the automated cardiopulmonological complex REACARD, on the basis of which the children were divided into groups – sympathotonics, normotonics, vagotonics. The urgent adaptation of the sympathoadrenal system (SAS) to static stress was studied by shifting the excretion of catecholamines (CA) and DOPA in urine portions in response to a dynamometric test.

Results and conclusions. Metered local static load in schoolchildren aged 7 and 9 causes changes in the functional state of the SAS, the nature of which depends on the IVT, age and gender of the children. In boys aged 7 years, sympatho- and vagotonic, isometric efforts are accompanied by unfavorable shifts, indicating the immaturity of the mechanisms of urgent adaptation of children of this age to static muscular activity. In 9-year-old boys, neurohumoral adaptive adjustments acquire a stable character, accompanied by positive, unidirectional shifts in the excretion of CA and DOPA in all IVT groups studied. Unlike girls, whose SAS reactions are more balanced at the age of 7, and at the age of 9 they are accompanied by a decrease in reserve capabilities, which is most pronounced in the state of sympathicotonia.

Keywords: *catecholamines, initial vegetative tone, local static load, schoolchildren aged 7, 9 years.*

Introduction. Educational activities, especially during the adaptation period, can have a negative impact on the child's body and, in particular, static loads that prevail in the daily life of a schoolchild. A special role in the neurohumoral regulation of the functions of the child's body, its adaptation to muscular activity is played by the sympathetic-adrenal system (SAS), which exerts its effect through catecholamines (CA) [1, 3]. It is known that the nervous and endocrine regulation of the functions of the child's body, its adaptation to physical activity is characterized by functional instability, manifested in physiological fluctuations in the production of hormones and mediators [4, 5]. At the same time, the issues of age-gender characteristics of the SAS response to static physical activity remain poorly understood. A comprehensive study of the functional state of the SAS and the features of the autonomic regulation of the heart rate in children with static muscular loads will allow us to record early shifts in the state of neurohumoral regulation of vegetative functions that precede pathological reactions of the body [2].

Objective of the study was to investigate the reaction of the sympathetic-adrenal system to localized static strain in children with distinctive autonomic control.

Methods and structure of the study. The scientific work involved 65 boys and girls aged 7 and 9 years, belonging to health groups I and II. The initial vegetative tone (IVT) was determined by the method of variation pulsometry using the automated cardiopulmonary complex REACARD, based on which the boys were divided into groups by IVT - sympathotonics, normotonics, vagotonics. The state of the SAS was assessed by the level of excretion of CA - adrenaline (A), noradrenaline (NA), dopamine (DA), DOPA in por-

tioned urine based on the fluorometric method using the BIAN-130 (M-800) device and CA standards from Sigma. The test with a local static load was carried out in a sitting position of the subject, by squeezing a hand dynamometer with the left hand with a force equal to 50% of the maximum voluntary force for 1 min. Urine collection was performed before the functional test and one hour after it.

Results of the study and discussion. It was found that in 7-year-old sympathotonic boys, against the background of relatively high pre-load values of NA excretion, in response to static effort there is a significant increase, which is 39,49% in relation to rest ($p < 0,05$), and the release of DOPA, the formation of which is a limiting link in the biosynthesis of CA, becomes 1,37% lower, that is, adaptive shifts in the SAS are accompanied by a decrease in its reserve capabilities (Figure 1). In boys in a state of vagotonia, static load is accompanied by a decrease in the reactivity of the SAS. Despite the lower background level of NA excretion, its values after the load in these schoolchildren have a negative trend, decreasing by 15,84% compared to rest, while DA excretion becomes 12,55% lower ($p < 0,05$). The release of A also decreases from 14,83±0,42 ng/min to 11,03±0,46 ng/min ($p<0,05$), only a compensatory increase in DOPA is noted, which, however, does not provide an adequate increase in the level of CA. Thus, the vagotonic variant of IVT in 7-year-old schoolchildren is accompanied by a relatively low activity of the SAS at rest and a decrease in its reserves after static effort, which may be a manifestation of fatigue and asthenia of the child's body during the period of adaptation to educational activities.

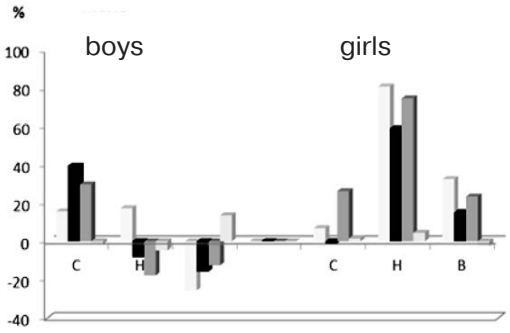

Figure 1. Changes in the excretion of catecholamines and DOPA in response to local static load in 7-year-old schoolchildren with different initial vegetative tone (%)

Note: S – sympathotonics, N – normotonics, V – vagotonics

A NA DA DOPA

It is noteworthy that in 9-year-old boys, the most adequate reactions of the SAS in response to isometric exercise were noted by us in the vagotonic group, where there is a simultaneous increase in the level of excretion of NA by 61,162% ($p<0,01$), DA and DOPA – by 22,52% ($p<0.05$) and 5,44%, indicating sufficient reserve capacity and economization of the SAS functions (Figure 2).

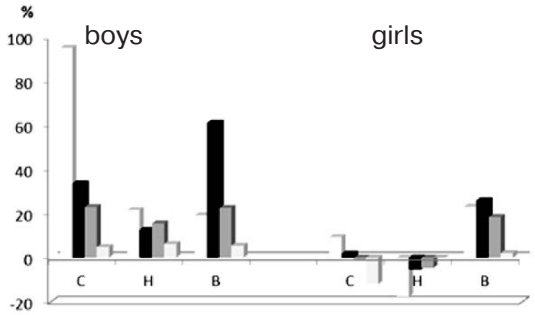

Figure 2. Changes in the excretion of catecholamines and DOPA in response to local static load in 9-year-old schoolchildren with different initial vegetative tone (%)

Note: S – sympathotonics, N – normotonics, V – vagotonics

A NA DA DOPA

In 7-year-old girls, compared to boys, the reaction of the SAS to a local static load is estimated by us as more favorable (Figure 1). In the state of sympathicotonia against the background of increased activity of the SAS at rest, a tendency to a decrease in the level of NA excretion after the load by 2,07% is noted, while the excretion of DA increases. In girls in a state of normotonia, a dosed static load causes the maximum increase in CA excretion compared to other studied groups – the excretion of A increases by 79,34%, NA – by 60,46%, DA – by 74,95%, and DOPA by 4,09%, which is manifested against the background of moderate activity of the SAS at rest and may indicate its sufficient functional and reserve capabilities. A different picture is observed in 9-year-old girls (Figure 2). In the group of schoolgirls with sympathico- and normotonic variants of IVT, a local static load causes no positive shift in NA excretion. The excretion of A changes similarly, its values become 1,59 ng/min and 0,64 ng/min lower than at rest ($p<0,05$). This is combined with a decrease or absence of a shift in the content of DA and DOPA - the excretion of DA decreases by 22,73 ng/min and 30,72 ng/min ($p<0,05$), while the excretion of DOPA does not change.

Conclusions. Dosed local static load in schoolchildren aged 7 and 9 causes changes in the functional state of the SAS, the nature of which depends on the IVT, age and gender of the children. In 7-year-old boys - sympatho- and vagotonics, isometric efforts are accompanied by unfavorable shifts, indicating the immaturity of the mechanisms of urgent adaptation of children of this age to static muscle activity. In 9-year-old boys, neurohumoral adaptive changes acquire a stable character, accompanied by positive, unidirectional shifts in the excretion of CA and DOPA in all studied IVT groups. In contrast to girls, in whom at 7 years old the SAS reactions are more balanced, and at 9 years old they are accompanied by a decrease in reserve capabilities, which is most clearly expressed in the state of sympathicotonia. Thus, the obtained results indicate the need to dose static physical loads for children aged 7 and 9 years, taking into account their age, gender and the state of the autonomic nervous system.

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