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HEART RATE VARIABILITY IN ASSESSING THE FUNCTIONAL STATE OF THE BODY IN YOUNGER SCHOOL-AGED CHILDREN

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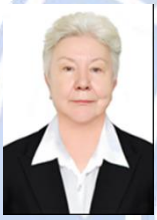

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ABSTRACT

Heart rate variability (HRV) is an important indicator of the functional state of the body in younger school-aged children and reflects the balance between the sympathetic and parasympathetic branches of the autonomic nervous system. Studying HRV is particularly relevant in the context of increasing psycho-emotional and physical stress during the school period when the body's adaptive mechanisms are actively developing and undergoing significant challenges. The method of HRV analysis combined with the active orthostatic test provides a comprehensive assessment of cardiovascular regulation, early detection of maladaptation, and preclinical changes. The use of this approach in screening studies allows for the identification of children at high risk of functional disorders, clarification of the features of autonomic regulation, and the development of personalized preventive measures. The high sensitivity of HRV indicators to stress factors, sleep quality, nutrition, and physical activity makes this method a valuable tool in pediatric practice. Early detection of deviations contributes to timely prevention of chronic diseases and the promotion of a healthy lifestyle in children.

KEYWORDS: Heart rate variability, ECG, cardiography, children.

ВАРИАБЕЛЬНОСТЬ СЕРДЕЧНОГО РИТМА В ОЦЕНКЕ ФУНКЦИОНАЛЬНОГО СОСТОЯНИЯ ОРГАНИЗМА ДЕТЕЙ МЛАДШЕГО ШКОЛЬНОГО ВОЗРАСТА

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АННОТАЦИЯ

Вариабельность сердечного ритма (ВСР) является важным индикатором функционального состояния организма детей младшего школьного возраста и отражает баланс симпатического и парасимпатического отделов вегетативной нервной системы. Изучение ВСР приобретает особое значение в условиях роста психоэмоциональных и физических нагрузок в школьный период, когда адаптационные механизмы организма формируются и подвергаются значительным испытаниям. Метод анализа ВСР в сочетании с активной ортостатической пробой обеспечивает комплексную оценку регуляции сердечно-сосудистой системы, выявление ранних признаков дезадаптации и донозологических изменений. Применение данного подхода в скрининговых исследованиях позволяет определить группы детей с высоким риском развития функциональных нарушений, уточнить особенности вегетативной регуляции и разработать персонализированные профилактические меры. Высокая чувствительность показателей ВСР к стрессовым воздействиям, качеству сна, питанию и уровню физической активности делает данный метод ценным инструментом педиатрической практики. Своевременное выявление отклонений способствует ранней профилактике хронических заболеваний и формированию здорового образа жизни у детей.

КЛЮЧЕВОЕ СЛОВО. Вариабельность сердечного ритма, ЭКГ, КИГ, дети.

КИЧИК МАКТАБ ЁШИДАГИ БОЛАЛАР ОРГАНИЗМИНИНГ ФУНКЦИОНАЛ ҲОЛАТИНИ БАҲОЛАШДА ЮРАК РИТМИНИНГ ЎЗГАРУВЧАНЛИГИ

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АННОТАЦИЯ

Юрак уриш частотасининг вариабеллиги (ЮУЧВ) кичик мактаб ёшидаги болалар организмининг функционал ҳолатини баҳолашда муҳим кўрсаткич ҳисобланади ва вегетатив нерв тизимининг симпатик ҳамда парасимпатик бўлимлари ўртасидаги мувозанатни акс эттиради. Мактаб даврида болаларнинг руҳий-ҳиссий ва жисмоний юкламалари ортиши шароитида ЮУЧВни ўрганиш алоҳида аҳамият касб этади, чунки бу даврда адаптация механизмлари шаклланиб, турли таъсирларга сезгир бўлади. ЮУЧВ таҳлилини фаол ортостатик проба билан биргаликда ўтказиш юрак-қон томир тизими регуляциясини комплекс баҳолаш, дезадаптация ва донозологик ўзгаришларни эрта аниқлаш имконини беради. Бу усулни скрининг тадқиқотларида қўллаш орқали юқори хавф гуруҳларига кирувчи болаларни аниқлаш, вегетатив регуляция хусусиятларини ўрганиш ва индивидуал профилактик чоралар ишлаб чиқиш мумкин. ЮУЧВ кўрсаткичларининг стресс омилларига, уйқу сифатига, овқатланишга ва жисмоний фаоллик даражасига юқори сезгирлиги педиатрия амалиётида ушбу усулни қимматли диагностика воситасига айлантиради. Ўзгаришларни ўз вақтида аниқлаш болаларда сурункали касалликларнинг олдини олиш ва соғлом турмуш тарзини шакллантиришда муҳим аҳамиятга эга.

КАЛИТ СЎЗЛАР: Юрак уриш частотаси вариабеллиги, ЭКГ, КИГ, болалар.

INTRODUCTION. In modern medicine, the study of heart rate variability (HRV) is gaining particular importance as a key indicator of the functional state of the human body. Heart rate, reflecting the strength and frequency of cardiac contractions, is regulated by the sympathetic and parasympathetic divisions of the autonomic nervous system and demonstrates high sensitivity to stress factors. The diversity of clinical manifestations in children is explained by population heterogeneity, expressed through variability in adaptive responses: some children exhibit increased sensitivity, others show resilience or tolerance, and a third group demonstrates an average response level. This variation is associated with genetic polymorphism and differences in the maturation timelines of functional systems [1,2].

According to adaptation theory, the body's defense responses are nonspecific and arise in reaction to any damaging factor. At early stages, these changes remain latent and become clinically apparent only when adaptation mechanisms fail, leading to signs of ecological maladaptation. Y.P. Gichev (2000) illustrated the sequence of adverse health changes caused by chronic exposure to environmental pollutants as follows: environmental contamination → disruption of internal homeostasis → stress of adaptive mechanisms → depletion of physiological reserves → reduction of regenerative and plastic potential → formation of pre-disease conditions → accelerated aging and disease development.

The cardiovascular system plays a critical role in assessing adaptive capacity, serving as a key transport system for tissues and organs and reacting early to homeostatic disturbances under harmful environmental influences. This explains the frequent latent course of cardiovascular pathologies observed in children living in ecologically unfavorable regions such as the Aral Sea area. These children often present not only with cardiovascular developmental abnormalities but also with altered neural regulation, metabolic imbalances, and inadequate exercise responses. Under technogenic exposure, children are prone to autonomic dysfunction syndromes, predominantly characterized by sympathetic overactivity and hypersympathetic reactivity. The incidence of functional cardiopathies in these populations is more than three times higher than average, underscoring the value of the cardiovascular system as an indicator of overall adaptive potential.

Premorbid states include conditions of tension and overstrain of adaptive mechanisms in the absence of overt organic pathology. The predominance of specific over nonspecific changes indicates a transition from a compensated adaptive state to a pre-disease condition, with further progression leading to disease development. Thus, assessing the functional state of the body is complex and requires a comprehensive examination of all organs and systems. However, this is not always feasible in clinical practice, emphasizing the importance of screening methods, including HRV analysis, for early detection of maladaptive processes.

Purpose of the study: to determine the features of heart rate variability in younger school-age children living in the ecologically unfavorable region of the Aral Sea region as an indicator of the body's adaptive capabilities**.**

METHODS: The study included 36 practically healthy children aged 7-11 years living in the Khorezm region. To assess the vegetative status and functional state of the body, a mathematical analysis of cardiac intervals (CIA) based on 5-minute ECG was used. ECG registration was performed at the II standard branch using the EC 12T-01-"R-D" electrocardiograph. Statistical processing of the results was carried out in a Windows environment using Excel and Statistica 6.0 programs. Correlation analysis and Student's t-test were used.

RESULTS AND DISCUSSION: The VSR was studied in 36 children in the first half of the day under conditions of relative rest. To assess the initial vegetative tone, a KIG analysis was performed, determining the average values, individual fluctuations, and confidence intervals. A comparative analysis of the IR indicators in horizontal and vertical positions was also conducted (Table. 1).

Table No1

Analysis of KIG results in primary school children

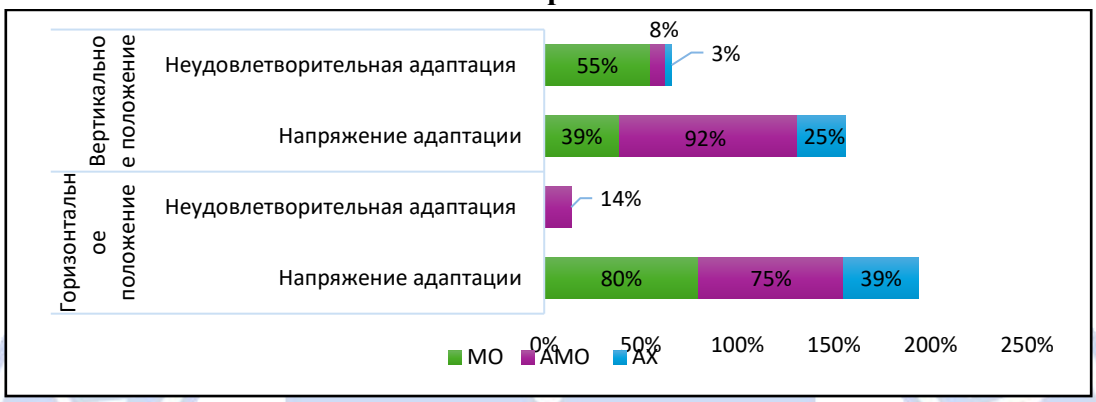
	In horizontal position				**In vertical position**			
Indicators	**AMO**	**MO**	**AH**	**IN**	**AMO**	**MO**	**AH**	**IN**
Tested	21,75±3,44	0,63±0,03	0,20±0,06	97,98±32,88	21,94±2,72	0,54±0,04	0,18±0,06	131,33±50,86

The obtained results indicate that heart rate and mode reflect both the average and most probable level of cardiovascular system activity, while their values vary under the influence of both internal and external factors capable of both increasing and decreasing these indicators. Based on the analysis of the cardiointervalogram (CIG), in particular, Mo indicators and the stress index (ST), we identified four types of vegetative tone: eutonia, vagotonia, sympathicotonia, and hypersympathicotonia. In a horizontal position, eutonia is observed in 20% of children, sympathicotonia in 80%, and vagotonia and hypersympathicotonia are not detected. In the vertical position, eutonia was recorded in 6% of children, sympathicotonia in 94%, and vagotonia and hypersympathicotonia were also not detected. In the vertical position, eutonia was recorded in 6% of children, sympathicotonia in 94%, and vagotonia and hypersympathicotonia were also not detected. Summarizing the obtained data, it can be noted that in a vertical position, the load on the autonomic nervous system increases, which is confirmed by a high percentage of sympathicotonia (94%). The stress index showed the following results: in the horizontal position, parasympathicotonia - 33%, eutonia - 61%, sympathicotonia - 6%, and in the vertical position, parasympathicotonia - 22%, eutonia

- 47%, sympathicotonia - 31%. To assess the state of adaptation in children according to the KIG data obtained in a horizontal position, Mo showed 80% tension adaptation, Amo - 14% unsatisfactory adaptation, 75% - tension adaptation, AH - 39% tension adaptation. In the vertical position, Mo recorded 55% of stress, 39% of tension adaptation, Amo - 8% of unsatisfactory adaptation, 92% of tension adaptation, AH - 3% of unsatisfactory adaptation, and 25% of tension adaptation(diagram 1).

Diagram 1

Assessment of adaptation in children



To assess the functional state of the body, a strain index was calculated, according to which 33% of children in a horizontal position experience a decrease in functional capacity, and the strain of the regulatory mechanism is observed in 6%. In a vertical position, a decrease in functional capabilities was recorded in 22% of children, and tension of the regulatory mechanism - in 28%. Thus, analyzing the indicators of heart rhythm variability and adaptation in children, it can be noted that the change in the activity of the humoral regulatory channel and the influence of the parasympathetic and sympathetic nervous systems on heart rhythm is wave-like.

CONCLUSION: Based on the data obtained, the method of analyzing heart rhythm variability when conducting an active orthostatic test during the pre-associative screening of schoolchildren allows for assessing the adaptive capabilities of the body, taking into account the age-related characteristics of vegetative regulation of blood circulation, and identifying groups of children with changes in the functional state of the body and an increased risk of developing diseases.

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