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VARIATIONS OF CARDIAC RHYTHMS IN CHILDREN OF INDIGENOUS AND NEWCOMER POPULATION LIVING IN THE ARCTIC OF THR EUROPEAN PART OF RUSSIA

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The article presents the results of analysis of heart rate variability in preschool children (3-7 years old) living in the Arctic region of the European part of Russia. The study was conducted in three districts of the Murmansk region that differ by ethnic sotav, and also have contrasting climatic conditions. A comparative assessment of the state of the cardiovascular system of pre-school children of the indigenous and non-indigenous population in the Murmansk region showed that there were no pronounced differences between these contrasting groups. The most pronounced differences are observed in representatives of the non-indigenous population in the form of reduced spectral characteristics (TP and HF), which are manifested in children with all four types of vegetative regulation.

Keywords: heart rate variability, preschoolers, polar regions, indigenous and non-indigenous populations.

Introduction. One of the factors that affect the human body in high latitudes is the specific natural conditions that pose a threat to the health of the local population [3]. The impact of high-latitude environmental factors on the human body is reflected at all hierarchical levels of the body [4, 2, 5]. At the same time, the child's body is the most vulnerable to external environmental influences [7, 9]. therefore, early diagnosis and detection of abnormalities in the cardiovascular system in children of the Arctic region will not only identify predictors of adaptation failure, but also help in the development of methods to increase resistance to extreme exposure.

The population of the Murmansk region is a product of complex interethnic hybridization. It can be divided into two conditional groups: the indigenous (Sami and Pomor) and the non-indigenous population. Despite the assimilation processes that have developed in the region over the past decades, the population of Lovozersk and Tersk districts have managed to maintain their ethnic differences. In addition, they are distinguished by contrasting living conditions and critical morbidity of children and adults.

A comparative assessment of the heart rate variability of children of indigenous and foreign populations of these regions will lay the foundation not only for theoretical ideas about the mechanisms of human adaptation in the Arctic, but also for the methodology for creating new health-saving technologies for high-latitude regions.

Objects and methods. The study was conducted in the settlements of the Murmansk region: Lovozero, Umba, and Apatity. In total, we examined 347 preschool children aged 3-7 years. In Lovozero, 122 children were examined, in Umba – 108 children, in Apatity-117 children. The study was approved by the Bioethics Council of the RCHAA KSC RAS. According to the principles of medical ethics approved by the UN General Assembly (1992) and the Council of Europe Convention on Bioethics (1997), all parents of the examined children were informed about the purpose and conditions of the study and gave their written consent to the participation of their child in this study.

The electrocardiogram (ECG) and heart rate variability (HRV) were taken using the complex KFS-01.001 «Cardiometer-MT». HRV analysis was performed according to the standards adopted by the European Society of Cardiology and the North American Society of Electrical Stimulation and Electrophysiology in 1996 [12]. To HRV assess were used temporal (RRNN, SDNN, RMSSD, Amo, MxDMn, pNN50) and spectral (HF, LF, VLF, TP) indicators. In addition, the tension index of the regulatory systems was evaluated (SI).

Statistical analysis was performed using the software "STATISTICA 6.0". To identify the significance of inter – group differences, the Mann-Whitney U test was used. The criterion U represents the median of possible differences between the elements of one and the second sample, and the level of significance of the differences, which in this study corresponded to $p < 0.05$.

Results and discussion. Assessment of cardiohemodynamic parameters was performed using HRV and ECG analysis. According to the ECG results, 30 people were excluded from the HRV analysis. Due to the fact that the assessment of the average HRV indicators of subjects with different types of regulation is not considered reliable and may lead to a false interpretation of the results, we determined the thresholds of the functional norm of heart rate variability (HRV) indicators, taking into account the type of vegetative regulation proposed by I. N. Shlyk [8]. Therefore, at the first stage, all children were preliminarily grouped into 4 groups according to the type of vegetative regulation (VR): type I-moderate predominance of central regulation, type II-pronounced predominance of central regulation; type III-moderate predominance of autonomous regulation; type IV-pronounced predominance of autonomous regulation.

A comparative analysis of heart rate variability (HRV) indicators showed that no significant differences were found between children of the indigenous and non-indigenous population in terms of temporary HRV indicators (RRNN, SDNN, RMSSD, Amo, pNN50, CV) (Table 1). Mainly significant differences are observed only in the spectral characteristics of HRV.

Children with a moderate predominance of the central regulatory circuit

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Table 1

HRV indicators in children 3-6 years old, by type of vegetative regulation, (M±m)

HRV type	I			II			III			IV		
City	Lovozero	Umba	Apatity	Lovozero	Umba	Apatity	Lovozero	Umba	Apatity	Lovozero	Umba	Apatity
Quantity	n=37	n=30	n=30	n=10	n=12	n=15	n=53	n=41	n=36	n=15	n=14	n=24
Heart rate, bpm	98.4 ±1.5	98.6 ±2.5	97.5 ±2.3	105.9 ±3.9	105.9 ±4.3	108.9 ±1.6	89 ±0.6	86.9 ±1.0	89.7 ±1.5	78.7 ±2.9	78.4 ±2.5	81.2 ±4.3
RRNN, ms	610.3 ±9.2	599.6 ±7.8	616.8 ±6.3	559.6 ±16.1	568.7 ±13.5	552.9 ±17.2	674.9 ±21.9	694.4 ±39.7	667.5 ±6.7	761.7 ±60.3	762.3 ±71.6	736.1 ±183.1
Amo	37.2 ±0.9	36.7 ±3.3	38.5 ±0.6	54.6 ±1.3	53.1 ±2.7	57.2 ±4.1	26.9 1±0.6	26.3 ±0.8	28.2 ±0.4	19.2 ±0.3	18.3 ±0.8	20.3 ±0.7
SDNN, ms	42.5 ±0.8	55.5 ±1.2	40.5 ±0.7	33.1 ±29.2	26.8 ±26.4	24.9 ±10.6	60.8 ±0.8	59.4 ±1.4	60.9 ±2.2	94.8 ±0.5	92.7 ±2.6	**90.9 ±0.3** *,**
MxDMn, мс	210.5 ±4.0	210.4 ±5.0	206.4 ±2.7	132.6 ±9.2	142.1 ±12.1	136.6 ±17.8	280.2 ±6.9	270.7 ±3.6	292.5 ±5.3	362.3 ±2.5	389.8 ±3.1	374.8 ±3.0
RMSSD, ms	37.7 ±2	36.9 ±2.7	36.6 ±1.1	21.9 ±6.8	20.5 ±6.0	18.7 ±5.9	61.3 ±4.0	61.8 ±6.5	61.5 ±9.5	101.9 ±3.6	101.7 ±2.8	**98.3 ±6.4** *,**
pNN50, %	16.9 ±2.3	16.4 ±3.2	15.4 ±2.8	3.6 ±6.6	3.0 ±3.1	2.2 ±4.6	38.2 ±5.2	38.4 ±1.1	35.8 ±1.7	61.5 ±5.2	60.6 ±5.3	**57.2 ±8.0** *,**
TP, ms ^{2}	1683.4 ±47.7	1694.9 ±73.3	**1563.7 ±63.9** *,**	666.1 ±67.1	673.3 ±47	**578.7 ±53.3** *,**	3414.70 ±283.5	3444.50 ±205.8	2980.8 ±277.5	8707.7 ±3127.7	8157.7 ±3450.3	**6607.6 ±1203.6** *,**
HF, ms ^{2}	599.9 ±51.2	563.3 ±51.2	**411.7 ±36.8** *,**	235.4 ±28.8	216.7 ±24.1	**124.1 ±34.6** *,**	1403.00 ±129.1	1234.50 ±84.7	1060.50 ±55.2	3952.5 ±479.8	3353.4 ±759.8	**2776.6 ±826.0** *,**
LF, ms ^{2}	543.1 ±23.3	585.9 ±37.9	560.2 ±39.2	216.3 ±9.2	193.6 ±12.1	226.9 ±17.8	1188.20 ±129.1	1158.20 ±84.7	989.3 ±55.2	2629.0 ±271.4	2704.7 ±564.3	2416.9 ±784.4
VLF, ms ^{2}	540.4 ±32.4	545.7 ±44.3	591.8 ±38.7	214.4 ±52.6	263.0 ±51.2	227.7 ±41.7	823.5 ±83.3	1051.8 ±91.0	931 ±121.6	2126.2 ±182.2	2099.6 ±287.4	1414.1 ±196.6
IS, y.e.	158.1	159.3 ±12.8	165.2 ±9.2	399.8 ±35.8	377.2 ±34.8	437.1 ±26.0	76.4 ±4.8	75.0 ±7.7	78.1 ±1.4	33.5 ±1.3	33.4 ±2.0	43.7 ±3.8

Note-Significance of differences (according to the Mann-Whitney test): *1 - between lovozer and Apatity; *2 - between Umba and Apatity;

(type I) from Apatita have lower values of the total power of the spectrum (TR, ms2) compared to children from Lovozero (U=135.0; p<0.022) and Umba (U=4393.5; p<0.024). The same pattern is present in children with a pronounced predominance of the central regulatory circuit (type II) U=239.0 (p<0.038) and U=4359.0 (p<0.019), respectively. The total power (TP, ms2) decreases due to lower values of its high-frequency component (HF, mc2).

As a result, in children from Apatity (non-indigenous population), there is a decrease in the contribution to the total spectrum of the power of respiratory waves (HF, ms2) and an increase in vasomotor (LF, ms2) (Fig. 1), which leads to an increase in sympathetic influence and a decrease in the tone of the vagus nerve.

Thus, it can be assumed that the children of the non-indigenous population with the predominant influence of the sympathetic nervous system (type I and II) have a more pronounced stress

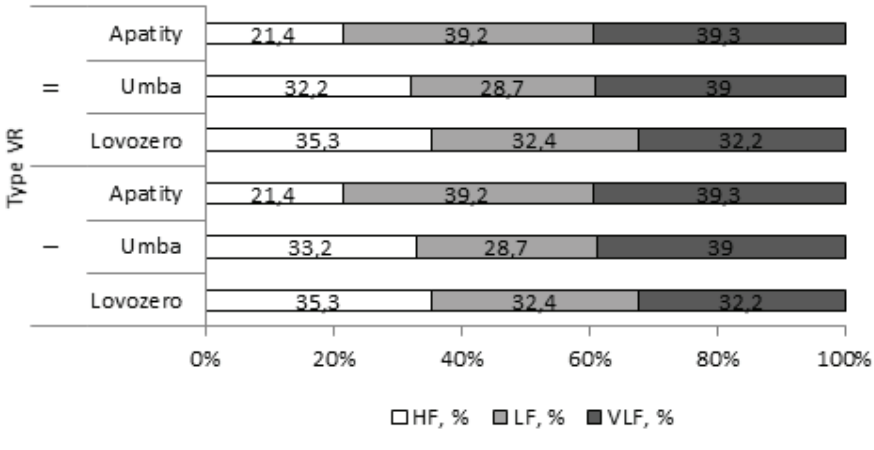

Fig. 1. Contribution of spectral parameters to the total power spectrum (TP, ms^2)

of regulatory mechanisms, manifested in an increase in the SI stress index, which leads to a decrease in the adaptive potential. Detection of type II regulation in children primarily serves as a marker of prenosological conditions, overstrain and overwork. And also requires the need for additional medical examination.

The moderate predominance of the autonomous circuit of regulation (type III) is characterized by the completion of the improvement of cardioregulatory mechanisms, as a result of which HRV indicators of this group are considered to be the physiological norm [1]. In spite of the fact that there were no significant

Table 2

Assessment of the prevalence of ECG syndromes in examined children aged 3-6 years, %

ICD-10-CM	Apatity	Umba	Lovozero
Other conduction disorders (I45)	2.6	1.9	2.5
Atrioventricular and left bundle-branch block (I44)	8.5	4.6	5.7
Atrial fibrillation and flutter (I48)	0.9	-	-
Abnormalities of heart beat (R00)	3.4	0.9	0.8
Other cardiac arrhythmias (I49)	3.4	3.7	1.6
Abnormal results of cardiovascular function studies (R94.3)	13.7	19.4	13.1

Note. The codes are given according to the International Classification of Diseases of the 10th revision (ICD-10) https://mkb-10.com/

differences in HRV indicators between children of the alien population and the indigenous population, children from Apatity have lower values of the total power spectrum (TR, ms2) and its components HF, LF and VLF (ms^2).

A comparative analysis of children with a pronounced predominance of the autonomous circuit of regulation (type IV) showed that in this group the most pronounced differences in HRV indicators. This may be due to the fact that children with type IV regulation are characterized by pronounced heart rate variability, which is determined by a significant predominance of parasympathetic influences on the heart rate and a sharply reduced activity of the sympathetic centers of vascular regulation. This may indicate an imperfect central regulation and autonomic dysfunction. This is especially pronounced in children from Apatity (Table 1). Significant differences are noted in the total power of the spectrum (TR, ms2) compared to children from Lovozero and Umba (U=526.0 p<0.031 and U=182.0 p<0.001, respectively) due to a decrease in its high-frequency component HF, ms2 (U=242.0 p<0.014 and U=453.0 p<0.024, respectively). The decrease in the influence of the parasympathetic system on vegetative regulation is reflected in lower values of temporal indicators SDNN (U=211,0 p<0,003; U=377.0 p<0,001), RMSSD (U=226,0 p<0,007; U=231,0 p<0,001) и pNN50% (U=226,0 p<0,007; U=211,0 p<0,001).

Additionally, 40% of children with type IV of VR have a spread of MxDMn values of more than 530 ms, which indicates not only a pronounced inclusion of autonomous regulation, but also a shift in the rhythm driver. Against the background of normocardia or bradycardia, this can be interpreted as an imperfection (immaturity) or dysfunction in the state of regulatory mechanisms. In addition, in children with excessive parasympathetic activity, frequent arrhythmias are not only the result of dysregulation of the central and autonomic nervous systems. It is this group that accounts for more than 50% of deviations from the norm and pathologies ECG associated with rhythm disorders.

Many studies have shown that various disorders and pathologies of the cardiovascular system are associated with heart rate variability. This allows the analysis of HRV disorders to be used for predictive purposes [11, 10]. Among the main deviations from the norm and pathological changes in the ECG in children were noted: rhythm disturbance, AV block, intraventricular conduction disorders (incomplete and complete blockages), etc. (Table 2).

The analysis of electrocardiograms among the examined children showed that the variant of the ECG norm varies from 47% (Apathy) to 72% of the examined children (Umba). The highest percentage of pathologies (16%) was found in children from Apatity, which is reflected in the incidence of the cardiovascular system in the region.

Thus, the differences in HRV indicators in children of indigenous and non-indigenous populations are manifested in spectral indicators (TP and HF), which is confirmed by previous studies, which show that in the adult population living in high latitudes, compared with the average latitudes, the spectral components of HRV are significantly lower, in particular, the total power spectrum (TP, ms2) and its components (HF and LF, ms2) [6].

Results: The studies conducted to identify the features of HRV in pre-school children of the non- indigenous and indigenous population in the Murmansk region showed that there are no pronounced differences in HRV indicators. The nature of the response of the cardiovascular system to external influences in the comparison territories depends more on the type of regulation of the heart rate than on ethnicity. The greatest differences in HRV indicators in children of indigenous and non- indigenous populations are manifested in the spectral characteristics (TP и HF). In children of the non- indigenous population (Apatity), activation of higher levels of regulation is noted, as a result of which the activity of the lower centers is suppressed. This can lead to energy deficiency, disruption of adaptation processes and disorders of the circulatory system.

Thus, despite the fact that there are no pronounced differences between the indicators of heart rate variability in preschool children of the indigenous and non- indigenous population, the cardiovascular system of children of the alien population is exposed to a stronger influence of climatic and geographical factors, leading to a more pronounced stress of regulatory mechanisms.

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