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SEASONAL MICROALTERNATIONS OF ECG SIGNAL IN STUDENTS OF A NORTHERN UNIVERSITY

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СЕЗОННЫЕ МИКРОАЛЬТЕРНАЦИИ ЭКГ-СИГНАЛА У СТУДЕНТОВ СЕВЕРНОГО ВУЗА

Abstract. The research addresses the seasonal dynamics of electrophysiological properties of the myocardium in students who live and study in the Khanty-Mansi Autonomous Okrug –Yugra, Russia. The main method of the research was the dispersion mapping of low-amplitude cardiocycle oscillations. The indicators of the electrophysiological properties of the myocardium were recorded in the Human Ecology Laboratory of Nizhnevartovsk State University using the CardioVisor-06s computer-based heart screening system. Eighty 2nd and 3rd year students participated in the research. Microalternations of the ECG signal were recorded four times per year, once in each season. The electrophysiological activity of the myocardium was analyzed and showed seasonal dynamics. The myocardial microalternation index and the Rhythm indicator increased from summer to winter and reached maximum in spring. Increased integral indicators of dispersion mapping in spring may indicate the climatic impact. The transitional season puts greater stress on the functional reserves of the body, which was manifested by the observed alternations in the electrophysiological activity of the myocardium. The maximum heart rates in spring indicate a lower efficiency of the heart muscle and the exhaustion of the chronotropic reserve. The increased values of the Rhythm indicator also point to a greater tension in the regulatory system in the cold seasons. At the end of winter and in spring, the myocardial activity in students of Nizhnevartovsk State University reached the upper limit of the physiological norm and their functional reserves were reduced.

Key words: students; seasonal dynamics; dispersion mapping; ECG signal; ECG microalternations; electrophysiological properties; myocardium.

Аннотация. В условиях Ханты-Мансийского автономного округа–Югры – территории, приравненной к Крайнему Северу, с помощью метода дисперсионного картирования низкоамплитудных колебаний кардицикла исследована сезонная динамика электрофизиологических свойств миокарда студентов. Регистрация показателей электрофизиологических свойств миокарда проводилась на базе лаборатории экологии человека Нижневартовского государственного университета с применением компьютерной системы скрининга сердца «КардиоВизор-06с». В исследовании участвовали студенты 2 и 3 курсов в количестве 80 человек. Регистрация микроальтернаций ЭКГ-сигнала проводилась 4 раза (зима, весна, лето, осень). Анализ сезонной динамики показателей электрофизиологической активности миокарда выявил ряд особенностей. Значения индекса микроальтернаций миокарда и индикатора «Ритм», увеличиваясь в динамике от лета к зиме, максимальных значений достигали весной. Увеличение интегральных показателей дисперсионного картирования у студентов в весенний период может свидетельствовать о влиянии климатических условий переходного сезона года, требующих большего напряжения функциональных резервов организма, что проявляется изменением электрофизиологической активности миокарда. Максимальные значения частоты сердечных сокращений в весенний период свидетельствуют о меньшей эффективности работы сердечной мышцы, расходовании хронотропного резерва. О нарастании напряженности в системе регуляции в холодные сезоны года свидетельствует и увеличение значений индикатора «Ритм». В зимний период и весной показатели деятельности миокарда студентов северного вуза находились на верхней границе физиологической нормы, функциональные резервы были снижены.

Ключевые слова: студенты; сезонная динамика; дисперсионное картирование; микроальтернации ЭКГ-сигнала; электрофизиологические свойства миокарда.

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Introduction

Human body has indicator systems that can point to the effectiveness of adaptation mechanisms in marginally comfortable and extreme environmental conditions. The seasonal variation of such indicators in human body should be studied for it is of the most important problems of human ecological physiology. The Khanty-Mansi Autonomous Okrug – Yugra belongs to the regions of the Far North and equated localities due to its uncomfortable continental climate. The severe climatic and geophysical conditions put pressure on the adaptation mechanisms of the northern dwellers. The intensity of environmentally induced stress can be determined by indicators in the functional systems. The cardiovascular system (CVS) plays a leading role in the processes of adaptation of the body to marginally comfortable and extreme environmental conditions. The CVS is the essential energy transport in human body, and it is recognized as the most sensitive indicator of adaptive activity of the body under changing environmental conditions.

Previous studies focused on the CVS adaptive changes in dwellers of the Middle Ob region [11; 13; 20] and in population the European North of Russia [4–6; 10; 16; 19]. The features of adaptation and reserve capabilities of the circulatory system were investigated in dwellers of the northern territories. Studies of seasonal changes in the parameters of the circulatory system in young people living in the northern territories are few, and the available articles note that in the winter season, the CVS in natives of the European North of Russia is in the state of functional tension [4; 7–9; 12; 19].

A number of studies revealed the seasonal effect of photoperiodism on the CVS. It was expressed in changed heart rate, blood pressure, total peripheral vascular resistance, systolic discharge, and cardiac output throughout the annual cycle [8; 9]. Young people, living in the northern conditions, developed tension of adaptive mechanisms in the systemic hemodynamics in the winter season. Also, seasonal variation in the blood supply of the brain was observed. In the beginning of winter, the cerebral blood supply system showed negative trends in the form of decreased tonicity and impaired elastic properties of the blood vessels [18]. Throughout the annual cycle, the highest bioelectric activity of the myocardium in 18 to 22 year old natives of the European North of Russia was observed during the transitional seasons [5]. Alternations in the bioelectric activity of the myocardium may mark not only of age-related changes in the cardiovascular system, but also the impact of climate on the human body [2] and the efficiency of the adaptation process [10]. In [14; 15], the authors analyzed the dispersion mapping of electrocardiograms in various aged population of the European North of Russia. However, publications related to the electrical microalternations of the ECG signal in dwellers of the Middle Ob region in different seasons are unavailable, hence our findings have a certain novelty. The purpose of the study was to identify seasonal changes in the electrophysiological properties of the myocardium in students of Nizhnevartovsk State University, Nizhnevartovsk, Khanty-Mansi Autonomous Okrug – Yugra, Russia.

Materials and Methods

The indicators of the electrophysiological properties of the myocardium were recorded in the Human Ecology Laboratory of Nizhnevartovsk State University using the CardioVisor-06s computer-based heart screening system. Eighty 2nd and 3rd year students participated in the research; forty-five of them were female and thirty-five were male. The average age was 19.8 ± 1.6 years. Each participant gave an informed consent to the diagnostic procedure and processing of personal data. The research was conducted in compliance with ethical standards set forth in the WMA Declaration of Helsinki [17]. The examined men and women had no chronic diseases, were not exempt from classes due to health reasons, and had no health-related complaints at the time of examination.

Microalternations of the ECG signal were recorded four times per year, once in each season (winter, spring, summer, autumn). The hardware and software that was used for the ECG dispersion mapping were developed by Medical Computer Systems LLP, Zelenograd, Russia (<https://mks.ru/netcat>). The ECG dispersion mapping based on the analysis of microalternations of the entire cardiocycle is a proven method for the early diagnosis of myocardial disorders, since it allows detecting disorders even at the stage of metabolic changes in cardiomyocytes. The following indicators were analyzed:

– the index of electrophysiological changes in the myocardium (the Myocardium Index), or the myocardial microalternation index (MMI);

- the Heart Rate;
- the Rhythm index, calculated by heart rate variability indicators.

The statistical data was processed using the Microsoft Excel application package. The arithmetic mean (M) and mean error (m) were calculated. Seasonal variation in the electrophysiological properties of the myocardium was determined by the Student t-test, subject to a normal distribution of the initial values. The differences between mean values were considered statistically significant at $p < 0,05$.

Results and Discussion

The seasonal dynamics of electrophysiological activity of the myocardium was analyzed, and it revealed a number of noteworthy features. The MMI and Rhythm indicators, increasing from summer to winter, reached maximum values in spring (Fig., Table).

The collected data revealed seasonal dynamics of the Heart Rate values in both male and female participants. The Heart Rate values were significantly higher ($p < 0,05$) in spring compared with the values recorded in summer and autumn. In spring, the average Heart Rate in both male and female participants was at the upper limit of the physiological norm: $81,9 \pm 2,6\%$ in females and $82,5 \pm 2,8\%$ in males (Table). On the other hand, Ketkina [7] observed maximum heart rate in young men of the European North of Russia in autumn ($p < 0.05$).

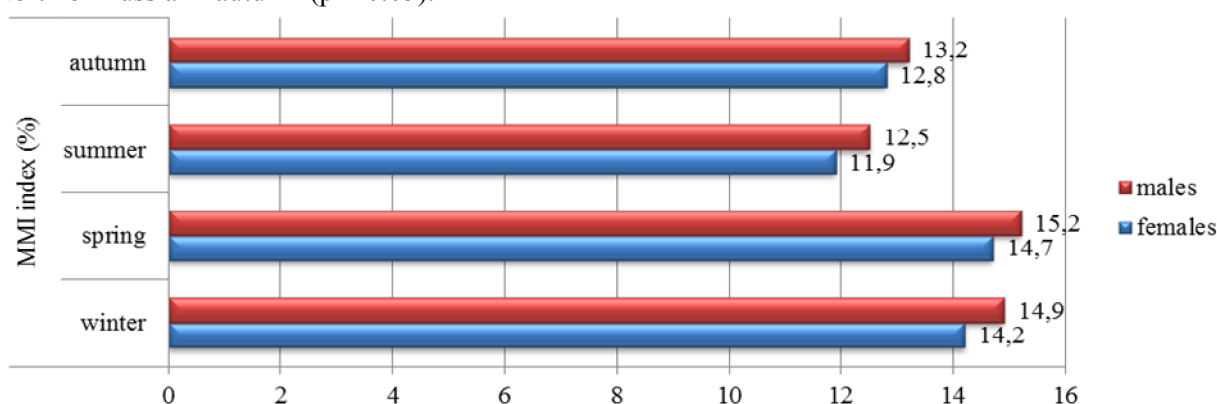


Fig. Seasonal changes in the Myocardium index (M±m)

The electrophysiological changes in the myocardium vary in the range from 0% to 100%. A Myocardium index of 0% means normal functioning of the heart and sufficient functional reserves of the body. If the Myocardium index approaches 100%, it indicates pathological processes. The MMI value from 1 to 15% is considered normal; the value from 15% to 25% indicates stress in the heart and the need for additional diagnostics; the value of more than 25% points to significant dysfunctions. The analysis of dispersion mapping indicators revealed that the maximum values of the Myocardium index occurred in spring. The average MMI was higher in young men than in their peers of the opposite sex: it was $15,2 \pm 0,5\%$ in males and $14,7 \pm 0,6\%$ in females. The trend of increasing MMI in young men manifested itself in other seasons, too. No significant gender variation was detected. In winter, the Myocardium index was $14,2 \pm 0,5\%$ in young women and $14,9 \pm 0,3\%$ in young men. In autumn, it was $12,8 \pm 0,5\%$ in male participants and $13,2 \pm 0,5\%$ in female participants. The minimum MMI values were observed in summer: $11,9 \pm 0,4\%$ in young women and $12,5 \pm 0,7\%$ in men. No significant interseasonal variation was detected (Fig.).

Table

Seasonal changes in the dispersion mapping indicators (M±m)

Season	winter		spring		summer		autumn	
	Hear rate (bpm)	Rhythm (%)	Hear rate (bpm)	Rhythm (%)	Hear rate (bpm)	Rhythm (%)	Hear rate (bpm)	Rhythm (%)
females	79,5±2,4	28,7±1,8	81,9±2,6*	29,8±1,5*	72,6±2,4	24,5±1,3	73,8±2,6	24,8±1,8
males	80,3±2,6	27,0±1,5	82,5±2,8*	27,7±1,6*	73,9±2,8	21,8±1,7	75,6±2,7	22,9±1,2

Note: *significant interseasonal variation in the integral indicators in spring in comparison with the values recorded in summer and autumn ($p < 0,05$).

According to previously published data [1; 3], at the end of winter and in spring, the myocardial activity indicators in relatively healthy people reach the upper limit of the physiological norm, the functional reserves get depleted, and in summer, the reserves come back to being sufficient.

The cardiac rhythm variation was assessed, too, for it gives an idea of the intensity of the stress load on the cardiovascular system. If the condition of the examined person is normal, and the sympathetic and parasympathetic influences on the cardiac rhythm are balanced, then the Rhythm index varies from 0 to 20%. In case of vegetative dysfunction, this index is above 20%. The maximum Rhythm values were observed in spring, and they were $29,8 \pm 1,5\%$ in young women and $27,7 \pm 1,6\%$ in young men. Significant interseasonal variation was noted in spring as compared with the values recorded in summer and autumn in both groups of participants ($p < 0,05$). In summer and autumn, the average values of the Rhythm indicator in the examined females were within the physiological norm and amounted to $24,5 \pm 1,3\%$ and $24,8 \pm 1,8\%$, respectively. The young men had lower Rhythm indicator values: $21,8 \pm 1,7\%$ in summer and $22,9 \pm 1,2\%$ in autumn. No significant gender variation was found (Table). The signs of strain of the adaptation mechanisms were observed in both groups throughout the year. The average values of the Rhythm index were higher than 20%. In winter and spring, these phenomena were more pronounced (Table).

To summarize, seasonal variations of ECG microalterations were discovered in the examined students by dispersion mapping. In the dynamics of annual observations, the integral indicators in all examined persons reached maximum in spring and minimum in summer. Significant variation ($p < 0,05$) was revealed in the Heart Rate and Rhythm indicators (Table).

Conclusion

The findings of this study complement the current understanding of adaptive seasonal changes in young people who live in the north of Western Siberia. The analysis of the electrophysiological properties of the myocardium in both males and females indicates dynamics throughout the year. In cold season, the cardiovascular system of northern university students is in a state of functional tension, and the integral indicators of dispersion mapping increase in both males and females. Increased microalteration of the ECG signal (Myocardium, Heart Rate, Rhythm) in students in spring may indicate the climatic impact. The transitional season puts more stress on the functional reserves of the body, and it is manifested by changes in the electrophysiological activity of the myocardium. An increased heart rate indicates a lesser efficiency of the heart muscle and the exhaustion of chronotropic reserve of the heart. The growing strain on the adaptive system in cold season can be seen in the increased Rhythm index. At the end of winter and in spring, the myocardial activity indicators in relatively healthy people are at the upper limit of the physiological norm, the functional reserves get depleted, but in summer, the reserves of the body are sufficient again. The change in ECG microalterations points to the fundamental mechanism for changing the functional activity of the myocardium in response to the insufficient oxygen consumption.

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дата поступления: 15 февраля 2020 г.

дата принятия: 15 апреля 2020 г.

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