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Pogonysheva I.A., Lunyak I.I., Pogonyshev D.A.

ANNUAL DYNAMICS OF DISPERSION MAPPING INDICATORS OF ELECTROCARDIOGRAM TRACING IN STUDENTS WITH DIFFERENT CHRONOTYPES

Погонышева И.А., Луняк И.И., Погонышев Д.А.

ГОДОВАЯ ДИНАМИКА ПОКАЗАТЕЛЕЙ ДИСПЕРСИОННОГО КАРТИРОВАНИЯ ЭЛЕКТРОКАРДИОГРАММЫ У СТУДЕНТОВ РАЗНЫХ ХРОНОТИПОВ

Abstract. The paper examines the annual profile of fluctuating microalternations of some ECG parameters in healthy students who live in northern conditions and have different chronotypes. The main method of the research was the dispersion mapping that helped assess the energy and metabolic processes in myocardium. Among male and female students, 14,3% had the morning chronotype, 50,7% had the arrhythmic chronotype, and 35% had the evening chronotype. Previously published research results showed a similar distribution of chronotypes among the population of the north: individuals with the arrhythmic chronotype dominate in the sample, the evening chronotype is the second most common, and the morning chronotype can be found in a smaller number of people. The seasonal dynamics of dispersion mapping indicators in students was analyzed. The analyses revealed an increase in the values of the Myocardium Index in students of all chronotypes in spring, with no significant deviations to be noted. The maximum values of the Heart Rate and Rhythm indicators in the annual dynamics in all students were noted in spring, and the minimum values, in summer, with significant deviations observed. The Rhythm integral indicator pointed to the signs of tension of adaptation mechanisms in the subjects with the evening chronotype in spring. Increased ECG microalterations (Myocardium, Heart Rate, Rhythm) in male and female students in spring may indicate the influence of climatic conditions that put a greater stress on the cardiovascular system in the transitional seasons. It is manifested by a change in the electrophysiological properties of the myocardium. In the subjects with the evening chronotype, the circadian rhythms of the circulatory system were more sensitive to the hypocomfortable conditions of the north.

Keywords: students, biorhythm, chronotype, seasonal dynamics, dispersion mapping, ECG signal, ECG microalternations, electrophysiological properties, myocardium.

About the authors: Pogonysheva Irina Alexandrovna, ORCID: 0000-0002-5759-0270, Ph.D., Nizhnevartovsk State University, Nizhnevartovsk, Russia, severina.i@bk.ru; Lunyak Inna Igorevna, ORCID: 0000-0003-3479-9829; Nizhnevartovsk State University, Nizhnevartovsk, Russia, luniak_inna@mail.ru; Pogonyshev Denis Alexandrovich, ORCID: 0000-0001-8815-1556, Ph.D., Nizhnevartovsk State University, Nizhnevartovsk, Russia, d.pogonyshev@mail.ru

Аннотация. Исследование посвящено изучению годичного профиля колебаний микроальтернаций некоторых показателей ЭКГ-сигнала у здоровых студентов разных хронотипов, проживающих и обучающихся в условиях севера с использованием технологии дисперсионного картирования, позволяющей судить об энергетических и обменных процессах в миокарде. Утренний хронотип был определен у 14,3% студентов, аритмичный хронотип выявлен у 50,7%, вечерний хронотип отмечался у 35% юношей и девушек. Ранее опубликованные результаты исследований показывают аналогичную ситуацию распределения хронотипов среди населения севера: в выборке доминируют представители аритмичного хронотипа, далее вечерний хронотип и меньшее количество обследуемых относятся к утреннему хронотипу. Анализ сезонной динамики показателей дисперсионного картирования у студентов выявил повышение значений индекса «Миокард» в весенний период, применительно к обследуемым всех хронотипов, значимые отличия не отмечены. Максимальные значения показателей частоты сердечных сокращений и «Ритм» в динамике годичных наблюдений у всех студентов были отмечены в весенний период, минимальные летом, выявлены значимые отличия. Признаки напряжения механизмов адаптации, согласно значениям интегрального показателя «Ритм» отмечены у представителей вечернего хронотипа в весенний сезон. Увеличение показателей микроальтерации ЭКГ-сигнала («Миокард», ЧСС, «Ритм») у юношей и девушек в весенний период может свидетельствовать о влиянии климатических условий, требующих большего напряжения сердечно-сосудистой системы в переходные сезоны года, что проявляется изменением электрофизиологических свойств миокарда. У обследуемых вечернего хронотипа циркадианные ритмы параметров системы органов кровообращения были более чувствительны к гипокомфортным условиям северных территорий.

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

Сведения об авторах: Погонышева Ирина Александровна, ORCID: 0000-0002-5759-0270, канд. биол. наук, Нижневартовский государственный университет, г. Нижневартовск, Россия, severina.i@bk.ru; Луняк Инна Игоревна, ORCID: 0000-0003-3479-9829, Нижневартовский государственный университет, г. Нижневартовск, Россия, luniak_inna@mail.ru; Погонышев Денис Александрович, ORCID: 0000-0001-8815-1556, канд. биол. наук, Нижневартовский государственный университет, г. Нижневартовск, Россия, d.pogonyshev@mail.ru

Introduction. In biorhythmology, researchers pay significant attention the rhythm of cardiac activity. The circulatory system is especially sensitive to the influence of the external environment. It enters upon the adaptation reactions rather early and can be considered as an indicator of the adaptive reactions of the whole organism. Compared to other organs and systems of the human body, the circulatory system has the clearest circadian organization. The daily rhythm is inherent in all indicators of the cardiovascular functioning, but the nature of rhythmic processes in biological systems remains largely unclear [1; 6; 7; 8; 10; 15; 16].

Individuals with different chronotypes demonstrate dissimilar features of the autonomic regulation of the cardiovascular system and dissimilar adaptive responses to changes in meteorological elements [3]. Borisenkov found that the circadian system in individuals with the evening chronotype is more sensitive to the hypocomfortable conditions of the north [2]. Botoeva and Gonobobleva reported the signs of adaptation stress in response to climatic changes in individuals with the evening chronotype, while in individuals with the other chronotypes these changes were less pronounced [3]. The seasonal functional activity of the cardiovascular system parameters is considered as an indicator of health status, while rhythm disturbance is as an indicator of pre-pathological conditions and dysfunctions. Botoeva and Urumov revealed inter-season variations in heart rate in students, and pointed to significant tension of the adaptive mechanisms of the subjects in winter [4]. The seasonal changes in the indicators of electrocardiogram (ECG) dispersion mapping should be studied because it expands the understanding of the role of biological rhythms in ensuring adaptation and homeostasis processes. It is quite relevant to use of the chronobiological approach to identify premorbid conditions preceding the clinical manifestation of dysfunctions.

The indicators of ECG dispersion mapping of electrocardiogram in the population of different ages were studied in the north of European Russia [13; 14]. However, there seems to be no publications on the analysis of electrical microalternations of the ECG signal in the inhabitants of the Middle Ob region who have different chronotypes. Therefore, this study has a certain novelty.The study aimed to identify seasonal fluctuations of microalternations of the ECG signal by dispersion mapping data in students with different chronotypes.

Materials and methods. One hundred and forty conditionally healthy students of the Nizhnevartovsk State University, Nizhnevartovsk, Khanty-Mansi Autonomous Okrug – Yugra, Russia, participated in the study. Young men and women were examined in the course of their educational activities unrelated to examinations. The average age was 18,8±1,5 years.

An effective method for early detection of electrophysiological changes in the myocardium is ECG dispersion mapping [9; 12]. 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 (https://clck.ru/VN6i7). The device can perform the dispersion analysis of the low-amplitude oscillations in ECG, and thus identify abnormalities in the cardiac function in the early stages and make a three-dimensional image of the cardiac function, individual for each student.

The ECG dispersion mapping was performed four times per year, once in each season (winter, spring, summer, autumn). The following three 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 CardioVisor-06s software package. The Myocardium integral indicator was calculated in per cent, where a value of less than 15% corresponded to the absence of significant deviations, 15 to 21% indicated borderline cases, and the indicator over 21% was a significant electrophysiological deviation. The following gradations were taken for the Rhythm index (%): < 15% – normal, 15 to 50% – slight deviation, 51 to 80% – a borderline case, > 80% – a pronounced deviation.

The circadian typology (the chronotypes) was determined by Horne and Ostberga's method [18]. According to the survey results, the respondents were divided into three groups: arrhythmic chronotype, the moderate evening and definite evening types were combined into the evening chronotype group, the moderate morning and definite morning types were categorized into the morning chronotype group.

The results were statistically processed using the Statistica 8.0 software. The data in Table 1 below are presented as mean value ± standard error (M±m). 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 [5]. 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 study.

Results and discussion. According to the obtained survey data, 14,3% of students had the morning chronotype, 50,7% had the arrhythmic chronotype, and 35% of the surveyed men and women had in the evening chronotype. Previously published research results showed a similar distribution of chronotypes among the population of the north: individuals with the arrhythmic chronotype dominate in the sample, the evening chronotype is the second most common, and the morning chronotype can be found in a smaller number of people. There is a hypothesis the altered photoperiodism influences the chronotype distribution in residents of northern territories, which determines a smaller percentage of persons with the morning chronotype [11; 17].

Table

Annual dynamics of the MMI indicator (M±m)

Chronotype	MMI values in different seasons (%)			
	winter	spring	summer	autumn
morning	13.8±0.9	14.6±0.5	13.4±0.8	13.7±0.6
arrhythmic	13.9±0.6	14.4±0.8	13.3±0.7	13.6±0.5
evening	14.8±1.1	15.8±0.7	13.6±1.4	13.9±0.8

The analysis of the indicator dynamics revealed an increase in the MMI values in spring in subjects of all chronotypes. The Myocardium index in most of the subjects was within the standard range, with the exception of the subjects with the evening chronotype in spring in whom the MMI exceeded the upper limit of the physiological norm. The subjects with the evening chronotype had higher MMI values than the other groups in spring and winter seasons, with no significant variations observed. The MMI values were maximum in spring. The subjects with the evening chronotype had the highest Myocardium value (15,8±0,7%). The subjects with the morning chronotype had 14,6±0,5%, and the subjects with arrhythmic chronotype had 14,4±0,8%. No significant variations were found. The minimum MMI values were observed in summer. The subjects with the evening chronotype had 13,6±1,4%, the subjects with arrhythmic chronotype had 13.3±0.7%, and students with the morning chronotype demonstrated 13,4±0,8%. No significant variations were found (Table 1).

According to published studies, at the end of winter and spring, the indicators of myocardial activity in conditionally healthy subjects are at the upper limit of the physiological norm and its functional reserves are depleted, while in summer the reserves are sufficient. Spring and autumn are transitional seasons when the state of vascular tone has a greater impact on the functional activity of the heart [1; 15; 16].

The maximum values of the Heart Rate and Rhythm indicators in the annual dynamics were observed in all subjects in spring (Figs. 1&2). These indicators in most of the subjects were within the norm. The examined students had a balanced ratio between the parasympathetic and sympathetic activity of the autonomic nervous system. The exception was the subjects with the evening chronotype in spring when the Heart Rate reached to the upper limit of the physiological norm (Fig. 1) and Rhythm pointed to the stress of the adaptation mechanisms of the regulatory systems (Fig. 2).

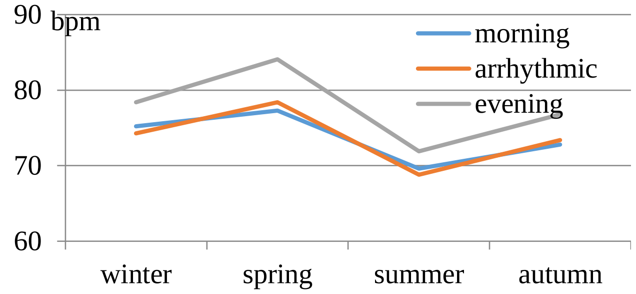

Fig. 1. Seasonal changes in heart rate in students with different chronotypes (M±m)

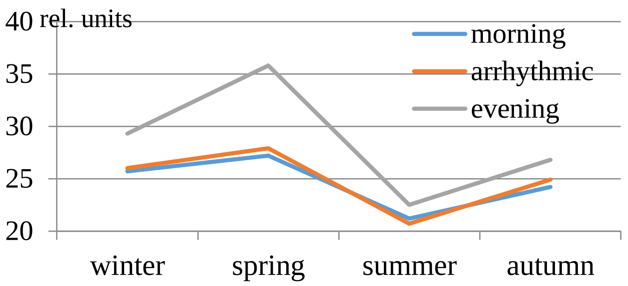

Fig. 2. Seasonal changes in Rhythm in students with different chronotypes (M±m)

The subjects with the evening chronotype had the highest Heart Rate value in spring (84.1±2.3 bpm), the subjects with the arrhythmic chronotype had 78.4±2.1 bpm, and the examined students with the morning chronotype demonstrated 77.3±2.5 bpm. Significant seasonal variations were observed ($p < 0.05$, Fig. 1). The maximum values of the Rhythm indicator occurred in students with the evening chronotype in spring (35.8±1.9 relative units). The subjects with the morning chronotype (27.2±1.5 relative units) and the subjects with the arrhythmic chronotype (27.9±1.8 relative units) had these values lower ($p < 0.05$, Fig. 2).

The minimum values of the dispersion mapping indicators were observed in summer. The subjects with the evening chronotype had the lowest heart rate in summer (71,9±2,5 bpm), the subjects with the arrhythmic chronotype had 68,8±2,8 bpm, and the subjects with the morning chronotype had 69,6±2,4 bpm. Significant seasonal variations were observed ($p < 0{,}05$, Fig. 1). The minimum values of the Rhythm indicator were noted in summer season in students with the evening chronotype (22,5±1,5 relative units). The subjects with the morning chronotype (21.2±1.6 relative units) and the arrhythmic chronotype (20,7±1,9 relative units) had these values lower ($p < 0{,}05$, Fig. 2).

Conclusion. The study revealed seasonal fluctuations of the ECG microalternations by the dispersion mapping data obtained from students of different chronotypes. The increased indicators of ECG microalteration (Myocardium, Heart Rate, Rhythm) in spring may indicate the influence of climatic conditions on students. It puts a greater tension of the body’s functional reserves, which is manifested by a change in the parameters of the cardiovascular system. According to the Rhythm values, the signs of tension of adaptation mechanisms were observed in the subjects with the evening chronotype in spring. The changes in meteorological conditions during the transition from winter to spring affect the the myocardium of northerners and cause stress to the regulatory systems. An imbalance in the autonomic regulation of the heart rate has an adverse effect on the electrophysiological properties of the myocardium. In spring, the number of subjects with possible electrophysiological changes in the myocardium increased.

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