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Study of the influence of mobile phones on the functional condition of students' cardiovascular system during the examination period by Holter methods

Abstract: Excessive physical and mental discomfort, nervous breakdown work stress, inappropriate eating behavior accompanied with disproportionate use of mobile phones lead to various functional disorders and illnesses. Mobile phones, often used by the student community for examinations, social adaptation and self-identification in the future profession, can endanger human health, and might consequently lead to disorders of vegetative regulation of cardiovascular system, including the rising frequency of heart contraction, increase in arterial pressure, muscle and psycho-emotional stress. Holter monitoring based on electrocardiogram (ECG) methodology was used to study the physiological state of the heart within the period of 24 h in students with mobile phones overuse. This monitoring system consists of the MT-101 registry block and MT-200 computer-assisted analyzer. Nine students aged 20-21 years old served the objects of the study. ECG rates recorded in the pre-examination learning process were considered as control, and ECG indicators, recorded during the examination period, were considered as experimental. ECG was studied throughout the day during the learning process and in the examination period to esteem the effects of electromagnetic fields caused by stress situations and mobile phones and identify the frequency of ventricular depolarization (Q, R and S wave or QRS) and heart rate. Both in normal conditions and during the examination period the frequency of heart rate and QRS scores are higher in comparison with the nighttime, at night low values are registered depending on the body's relaxation period. Moreover, it was found that statistical reliability ($p<0.05$) during the period of examinations increased simultaneously in the nighttime in comparison to control.

Key words: examination period, mobile phones, Holter monitoring, frequency of heart contraction, QRS complex, electromagnetic field.

Introduction

The main purpose of higher education institutions is to help individual to become a well-educated, highly professional and cultured person. Education in higher education requires special attention to students' health. Frequent use of mobile phones by students has a significant impact on their academic progress and health [1; 2]. Mobile phones are the most frequently used devices for student communication with their friends and families. These devices are constantly kept "online" and it is hard to imagine whether they cannot be used in the library or at the university, in places where we eat, or in cars. Scientists from different countries are studying its effects on the body, including Dr. Magda Havas, Associate Professor of Environmental and Resource Studies at Trent University, Canada, who has proven that electromagnetic radiation from mobile phones has a profound effect on human brain and skin [3-5].

Students are a special social group with a certain age, life and working conditions. Excessive physical and mental stress, breakdown of work, rest, diet schedule, as well as over-use of mobile phones adapt the process that reduces the effectiveness of the learning process and leads to various functional disorders and illnesses. Frequent occurrence of nervous and psychological fatigue due to time scarcity in processing and receiving information and evening work co-occupancy affect their somatic health and mental conditions [6; 7]. Adaptation to a new set of factors is a complex multi-level social-psycho-physiological process accompanied by the system of compensatory formation in student bodies. During the last 10-15 years, the flow of information load has increased significantly. During the examination period, due to the excessive load on the intellectual and emotional state of students it was found that the tendencies of excitation of the central nervous system were high [8; 9]. This can be particularly noted in students' learning as the features of neurovegetative regulation during the examination period roves the necessity to develop a strategy for strengthening students' health [10]. First steps in higher education are characterized by the influence of several new factors in student bodies, among them the features of educational process, new surroundings, living environment and nutrition are the main part of the educational process. At the same time, according to various literature sources, especially at the initial stages of study (earlier course) destruction of a high potential of psychosocial adaptation of students can be a consequence of examination, change of address and social relationships, chronic illnesses. Clearly psychosocial adaptation can adversely affect the ability of mind, memory and cognitive mental processes. At the same time, during the examination period, there was a decrease in short-term memories and long-term recurrence of the words in the background of the increased workload and attention of the earlier course students. This proves that adaptive reactions of earlier course students are much more complicated due to the information flow, where the adaptive nature should be directed to increase of general activity. However, stress situations for them are significantly different and characterized by increased brain capacity and long-term memory [12-14].

In recent years, studies have been conducted to study the effect of examination stress and mobile phones overuse on the nervous system, cardiovascular system and immune system. In recent years, the incidence of cardiovascular diseases in the Republic of Kazakhstan has risen by 5-7 times and our country takes one of the first places in terms of morbidity and mortality. We may say the main reason is that people do not pay attention to their health, though negative environmental impacts are also significant [16-23].

During the examinations period, disorders of vegetative regulation of cardiovascular system were registered among students in schools and universities along with increased frequency of heart contraction, increase of arterial pressure, rising of muscle strength and psychoemotional resilience [24; 25]. Being under the influence of continuous mobile phones use and the examination period stress makes a physiological load on the body; this load can cause any illness in the body as a whole. Investigating the consequences of this load on heart function, especially control of the heartbeat within 24 h, is a topical issue today [26-29].

Materials and methods

Study of the functional state of cardiac system in student bodies by Holter method during the examination period was completed at the scientific laboratory of Chronobiology and Ecological Physiology of the Department of Biophysics and Biomedicine at the Faculty of Biology and Biotechnology, Al-Farabi Kazakh National University. Mobile phones in the hands of each student are considered as sources of electromagnetic fields in the environment.

Nine students aged 20-21 years old served the objects of the study. ECG rates recorded in the pre-examination learning process were considered as control, and ECG indicators, recorded during the examination period, were considered as experimental. ECG was studied throughout the day during the learning process and in the examination period to esteem the effects of electromagnetic fields caused by stress situations and mobile phones and identify the frequency of ventricular depolarization and heart rate, for which the Holter monitoring was applied.

Electrocardiogram of cardiac work was registered with clinical and physiological methods of electrocardiography without interruption for 24 h at the SHILLER MT-200 HOLTER-ECG apparatus. Schiller Holter monitoring system consists of two parts: MT-101 registry block and MT-200 computer-assisted analyzer. Registrations provided by MT-101 registry block were transferred to the MT-200 computer-assisted analyzer, after which it was possible to save these signals and provide the complete analysis. In order to provide quality ECG registrations, it is necessary to check the quality of the ECG signals. Upon the completion of the registration, specially installed MT-200 computer-assisted analyzer provides the information transfer from the registry block to the personal computer and completes the ECG analysis [15].

Based on recorded electrocardiogram, FHC and QRS score were revealed. The results obtained were statistically calculated; Student's t-test was used to examine the validity of the data.

Results and discussion

During the learning process, the maximum heart rate – 101.0±2.8 beats/minute was registered at 03:00 pm, minimum rate – 61.0±4.2 beats/minute registered at 5:00 am in the morning. Dynamics of the heart rhythm spectrum is observed within 24 hours with frequency of 77.0 – 101.0 beats/minute heart contraction in normal conditions, noticeably increasing during the period from 08:00 to 11:00 am. Heart rate decreases down to 75.0 beats/minute from 01:00 to 7:00 am. The decrease in heart rate depends on body rest. According to the results, a high intensity of heart rhythms depends on the activity of the organism in the daytime, and low intensity of the heart rate due to the rest of the body during the nighttime (Table 1).

Table 1 – Dynamics of the daily spectrum of heart contractions of students in normal conditions

Time, h	FHC, beats/minute	Time, h	FHC, beats/minute
12:00 pm	86.0±4.2	00:00 am	77.0±1.4
01:00 pm	89.0±1.4	01:00 am	68.5±3.5
02:00 pm	92.5±9.2	02:00 am	68.5±3.5
03:00 pm	101.0±2.8	03:00 am	66.0±2.8
04:00 pm	97.0±1.4	04:00 am	62.5±2.1
05:00 pm	87.5±9.2	05:00 am	61.0±4.2
06:00 pm	85.5±9.2	06:00 am	63.5±2.1
07:00 pm	89.0±1.4	07:00 am	64.5±4.9
08:00 pm	96.5±6.4	08:00 am	92.0±8.5
09:00 pm	88.5±6.4	09:00 am	95.5±4.9
10:00 pm	85.0±1.4	10:00 am	76.5±2.1
11:00 pm	82.0±1.4	11:00 am	83.5±3.5

During the examination period, the analysis of changes of heart rate fluctuations in students reveals the maximum frequency of heart contraction in students – 107.0±3.1 beats/minute registered at 5:00 pm, minimum rate – 75.0±5.6 beats/minute registered at 08:00 am. Fluctuations in dynamics of the daily spectrum of the student heart rhythm in normal conditions are observed in between 12:00 pm and 12:00 am with frequency of heart contractions of 77.0 – 101.0 beats/minute. During the daytime from 12:00 am to 12:00 pm and at 08:00 until 12:00 am of the next day the frequency of heart contraction increased and decreased. Of course, these changes can be attributed to the active body functions.

If we compare the frequency of heart contraction of students during their daily classes and examination period, anomalies in FHC are observed from normal conditions. During the daytime, high-low fluctuations are registered, while high values are determined at nighttime.

Compared to normal conditions, it was found that the relative increase in frequency of heart contractions is observed during the nighttime. Normally, it is equal to the minimum value between 01:00 and 07:00 am, and at the time of examinations, it was observed that there was a relative increase than the normal condition between 01:00 and 07:00 am. That is, the increase in the frequency of heart contraction depends not on the body's calmness (Table 2).

If we compare studied values of heart contractions during the examination period and in normal conditions, differences are observed within 24 h. From the time taken to study if at 05:00 pm – 107.0±3.1 beats/minute and at 06:00 pm – 106.0±9.2 beats/ minute, at 09:00 pm – 100.0±7.1 beats/minute, at 12:00 am – 85.0±2.1 beats/minute, at 01:00 – 84.0±4.2 beats/minute, at 02:00 am – 80.0±4.9 beats/minute, at 03:00 am – 79.0±5.1 beats/minute, at 04:00 am – 80.0±4.2 beats/minute, at 05:00 am – 82.0±4.5 beats/minute, at 06:00 am – 79.0±1.4 beats/minute, at 07:00 am–80.0±2.1beats/minute, at 08:00 am – 75.0±5.6 beats/minute, at 10:00 am – 107.0±8.1 beats/minute, at 11:00 am – 98.0±0.7 beats/minute with statistical accuracy ($p<0.05$) significantly higher than in normal conditions.

Table 2 – Dynamics of the daily spectrum of heart contractions of students during examinations

Time, h	FHC, beats/minute	Time, h	FHC, beats/minute
12:00 pm	96.0±6.4	00:00 am	85.0±2.1*
01:00 pm	94.0±71	01:00 am	84.0±4.2*
02:00 pm	101.0±1.4	02:00 am	80.0±4.9*
03:00 pm	103.0±3.5	03:00 am	79.0±5.1*
04:00 pm	101.0±7.3	04:00 am	80.0±4.2*
05:00 pm	107.0±3.1*	05:00 am	82.0±4.5*
06:00 pm	106.0±9.2*	06:00 am	79.0±1.4*
07:00 pm	89.0±7.1	07:00 am	80.0±2.1*
08:00 pm	88.0±4.2	08:00 am	75.0±5.6*
09:00 pm	100.0±7.1*	09:00 am	88.0±7.1
10:00 pm	86.0±2.8	10:00 am	107.0±8.1*
11:00 pm	83.0±2.8	11:00 am	98.0±0.7*

Note: * – statistical reliability in comparison to control, p<0.05

High FHC values of the active physiological state of the organism and its low values during the rest synchronously altered in terms of normal conditions.

The QRS set was studied as a chronostructural indicator of the cardiovascular system in normal conditions, that is, during the daily study. The QRS set represents the formation of the potential dynamics of the excitation in the abdominal muscle of the heart.

As can be seen from the Table 3 in the normal condition, QRS fluctuations are observed between 12:00 pm and 12:00 am with 5408.5±589.01 ÷ 4982.0±172.5 values registered in the period of 08:00–11:00 am.

QRS set results in maximum value of 6002.5±204.3 numeric unit registered at 03:00 pm and 5758.0±46.7 registered at 04:00 pm, and minimum value of 3798.5±130.8 registered at 04:00 and at 05:00 am with the value of 3687.0±213.5 (Table 3).

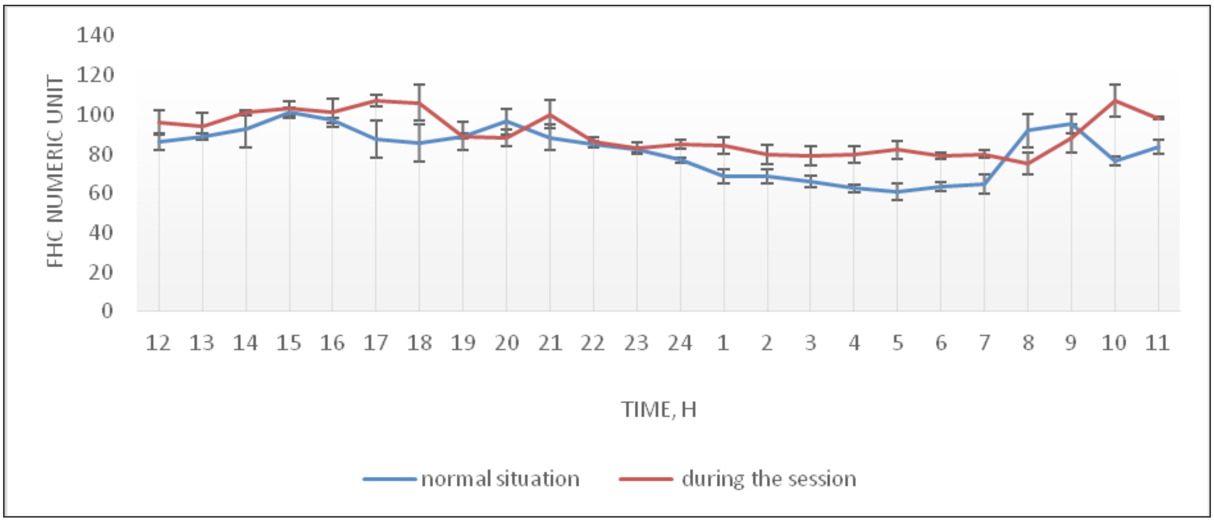

Figure 1 – FHC values in students during the examination period and in normal conditions

Table 3 – QRS set of students in the normal condition

Time, h	QRS	Time, h	QRS
12:00 pm	5156.0±227.7	00:00 am	4612.0±130.1
01:00 pm	5322.0±63.6	01:00 am	4137.0±216.4
02:00 pm	5548.5±539.5	02:00 am	4151.5±171.8
03:00 pm	6002.5±204.3	03:00 am	3987.0±162.6
04:00 pm	5758.0±46.7	04:00 am	3798.5±130.8
05:00 pm	5252.5±495.7	05:00 am	3687.0±213.5
06:00 pm	5139.5±536.7	06:00 am	3822.0±114.5
07:00 pm	5285.5±58.7	07:00 am	3877.5±273.6
08:00 pm	5801.5±403.7	08:00 am	5408.5±589.01
09:00 pm	5319.5±311.8	09:00 am	5627.0±288.5
10:00 pm	5129.0±113.1	10:00 am	4619.0±104.6
11:00 pm	4902.0±1.4	11:00 am	4982.0±172.5

Considering the QRS set of students during the examinations, maximum values from the received data are 6420.0±412.9 numeric unit at 03:00 pm and 5917.5±499.9 at 05:00 pm, but minimum values are 4197.5±272.2 at 08:00 am and 4321.0±406.5 at 03:00 am.

Table 4 – QRS set of students during the examination period

Time, h	QRS	Time, h	QRS
12:00 pm	5124.0±758.01	00:00 am	5340.0±115.2
01:00 pm	4968.5±740.3	01:00 am	4620.0±241.1
02:00 pm	5950.0±67.1	02:00 am	4500.0±271.5
03:00 pm	6420.0±412.9	03:00 am	4321.0±406.5
04:00 pm	5381.0±988.5	04:00 am	4430.0±239.7
05:00 pm	5917.5±499.9	05:00 am	4320.0±307.5*
06:00 pm	5148.5±1481.5	06:00 am	4410.0±88.3*
07:00 pm	4738.5±866.2	07:00 am	4800.0±66.4*
08:00 pm	5037.5±225.5*	08:00 am	4197.5±272.2*
09:00 pm	5363.5±825.2	09:00 am	4584.0±886.7*
10:00 pm	5250.0±172.5	10:00 am	5837.0±671.7*
11:00 pm	5120.0±181.01	11:00 am	5802.0±9.8

Note: * – statistical reliability compared to normal condition, $p < 0.05$

During the examination period, QRS set of students fluctuating anomalies are observed between 12:00 pm and 12:00 am, fluctuates between 5124.0±758.01 ÷ 5340.0±115.2 values. Meanwhile, from 01:00 to 09:00 am, decreased values 4620.0 ± 241.1 ÷ 4584.0 ± 886.7 were registered. At 10:00 – 11:00 am hours, the following values demonstrate a high return of 5837.0 ± 671.7 ÷ 5802.0 ± 9.8 QRS.

Compared with the normal situation, it was determined that the QRS aggregation, which displayed high and low values during the examination period, varies from time to time. At 08:00 pm – 5037.5±225.5 beats/ minute, at 05:00 am – 4320.0±307.5 beats/ minute, at 06:00 am – 4410.0±88.3 beats/ minute, at 07:00 am – 4800.0±66.4 beats/ minute, at 08:00 am – 4197.5±272.2 beats/ minute, at

09:00 am – 4584.0±886.7 beats/ minute, at 10:00 am – 5837.0±671.7 beats/ minute, at 11:00 am – 5802.0±9.8 beats/ minute with statistical accuracy ($p<0.05$) significantly higher than normal (Table 4).

In the first stage of stress, the heart of a person is often beated. In Europe, millions of people die each year due to stress from cardiovascular system disorders.

In normal days and during the examination period, there is an abnormality in total heart rate changes in the daytime compared to the FHS performance of students. From 12:00 pm-12:00 am and 07:00 am-12:00 pm the following day, when compared to the normal examination period, the value of both decreasing and higher values was observed. It is clear that during the examination period, at 12:00 am and 6:00 am, relative elevation was observed.

From normal to normal, the FHS in the normal examination period and at the sessions at 08:00, 09:00, 10:00 am on the following day at 05:00, 06:00, 09:00 pm with significant statistical reliability ($p\leq0.05$). At the same time, it can be seen that there are times when it is not reliable.

QRS reliability indicators correspond to the times when the FHS is subject to change. QRS is a rhythm of a moderately concave ventricle, taking the FHS as an indication of the overall heart rate.

Stress can lead to heart disease and stroke. This can lead to heart attacks if a person is experiencing a severe stress, an intense stress or a sad day. Stress also comes when a person is happy. If a person gets into some stress, first of all, heart rate changes, blood vessels tone is broken and other physiological changes. In severe stress, the tone of the heart muscle changes, which is called heart failure or cardiomyopathy.

Thus, in moderate daytime, i.e., when the body is active, it is equal to the higher values, and at night, low values are registered depending on the body's calmness. At night, during the examination period, it was higher than normal, but synchronously fluctuated values were registered.

During the examination period, the student body was not in the state of calmness; therefore, the values are higher than the normal one.

Conclusion

Dynamics of the daily spectrum of the heart rhythm of students with normal conditions there are anomalies are observed in the fluctuations from 12:00 pm to 12:00 am at night, the results of frequency of heart contraction during the examination period were different from the results of normal condition. During the examination period, QRS set of students fluctuating anomalies are observed between 12:00 pm and 12:00 am. Compared with the normal situation, it was determined that the QRS aggregation, which displayed high and low values during the examination period, varies from time to time. The data of the heart activity of students, which are accepted as a normal case, are consistent with standard accepted indicators. At the same time, during the examination period, students' thoughts along with psychosomatic stress, considering that as a physical load it does not remain inactive, as well as results of research work shows long-term effects on the electromagnetic field will also affect the heart function. The FHS and QRS concentration indicators are also characterized by moderate discontinuous changes in both calm and susceptible state (sleeping) identified synchronously increasing than normal times at night. Students during the examination period with the aim of focusing on heart function calming itself need to do training by exercises to overcome stress.

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