EVALUATION OF ADAPTIVE POTENTIAL IN MEDICAL STUDENTS IN THE CONTEXT OF SEASONAL DYNAMICS

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Abstract

The aim of this work was to assess the functional reserves of the body to quantify individual health; adaptation, psychophysiological characteristics of the health quality of medical students in different seasons of the year. When studying the temporal organization of physiological functions, the rhythm parameters of physiological functions were determined, followed by processing the results using the Cosinor Analysis program, which reveals rhythms with an unknown period for unequal observations, evaluates 5 parameters of sinusoidal rhythms (mesor, amplitude, acrophase, period, reliability). The essence of desynchronization is the mismatch of circadian rhythms among themselves or destruction of the rhythms architectonics (instability of acrophases or their disappearance). Desynchronization with respect to the rhythmic structure of the body is of a disregulatory nature, most pronounced in pathological desynchronization. High neurotism, increased anxiety reinforces the tendency to internal desynchronization, which increases with stress. During examination stress, students experience a decrease in the stability of the temporary organization of the biosystem and the tension of adaptive mechanisms develops, which affects attention, mental performance and the quality of adaptation to the educational process. Time is shortened and the amplitude of the “initial minute” decreases, personal and situational anxiety develops, and the level of psychophysiological adaptation decreases. The results of the work are priority because they can be used in assessing quality and level of health.

Keywords: Desynchronization; biorhythms; psycho-emotional stress; mesor, acrophase; amplitude; individual minute.
I. Introduction

The relevance of this work is to develop an idea of the temporary organization of psychophysiological functions and their role in the educational process of medical students. At present, the identification of preclinical health disorders (pre-illness state) is characterized by a decrease in the adaptive reserves of the body. Man is an open system, constantly exchanging information, energy, etc. with the surrounding space. He is integral within himself and with the surrounding world. Desynchronization of internal cyclic processes can cause pathology. Desynchronosis can be internal, in which mismatch of rhythms develops inside the body, for example, when disturbance in the rhythm of nutrition relative to the rhythms of sleep and wakefulness develops, irritability, distemper, lack of appetite, insomnia appear, and external that occurs when the synchronization of biorhythms and phases of the environment influence are disturbed (for example, change of time zones), and can be acute and chronic, physiological and pathological [XV, IX, X]. This view allows more thoroughly and completely assess the levels of health, diagnostic criteria for desynchronosis, the contribution of the latter to preclinical health disorders of students. A living organism is a biological system “pierced through by biological rhythms”, the main is the circadian rhythm, inherent in all types of biological organization and forms the temporary basis necessary for the organization of complex biological systems. It connects all the oscillatory processes into a single temporal system of the human body and forms its adaptation to the environment [XVIII, VIII, XXI]. Rhythms dominate in nature and encompass all manifestations of the living. According to the level of biosystems organization cellular, organ, organismic, population rhythms are distinguished. The nature of biorhythms is based on the principle of synchronization of endogenous (internal) and exogenous (external) biorhythms. It has been proved that the main mechanism responsible for biorhythms is at the cellular and subcellular levels and determined by a specific genetic program in the “chronome”, which is a part of DNA from which RNA transcription occurs for a period of about 24 hours, therefore, organisms possess innate internal mechanisms allowing to measure time. At present, DNA polymorphisms is widely studied. The human genome consists of three billion pairs of nucleotides, and it is believed that at least every thousandth nucleotide is polymorphic, that is, differs from person to person among healthy people. DNA polymorphisms are used as markers of a genetic predisposition to certain diseases, which primarily concerns polygenic disorders which develop as a result of the interaction of many genes and environmental factors, for example, disorders associated with cardiovascular pathology [XXIII, XVII, VII]. Health and longevity depend on maintaining the rhythmic work of organs and body systems. Biological rhythms of organs and systems are interdependent in time and disturbance of one organ leads to a gradual mismatch of biorhythms of the whole organism [XII, XIII].

It is proved now that quality and level of students’ health is reduced, due to high mental, informational and psycho-emotional stresses, indicators of preclinical disorders are increasing [XXI, IX]. Preclinical disorders are studied by a new direction in medicine, chronopathophysiology, chronomedicine, which studies the
levels of individual health of people, develops ways to preserve and strengthen it through a system of health measures based on the chronobiological approach [XXII, X], using chrononalysis of assessing the level of health and its structure according to the rhythms of physiological indicators and psychophysiological functions, when the only manifestation of pathology is a disturbance of rhythm coordination, i.e. development of desynchronosis [XV, X, XVI].

The physiological desynchronosis (state of stress or search for adaptation) is adaptive in nature under the influence of changing environmental conditions, in particular, change of time zones, state of acute stress. In this state, the proportion of reliable rhythms moderately decreases (up to 50%), the amplitude decreases, acrophases shift and their wandering area enlarges. If the system does not achieve successful adaptation and is not harmonized, the desynchronization process increases and disturbances lead to pathological desynchronosis. Pathological desynchronosis (a state of unsatisfactory adaptation) occurs upon repeated exposure to stress factors and is characterized by a decreased capacity of the adaptive capabilities of the biosystem [X, III]. It is known that prolonged psycho-emotional stresses in healthy persons can cause preclinical health disorders, and subsequently, various somatic diseases [VIII, IV].

The main causes of students' health problems in education process are increased academic, prolonged mental stress in combination with physical inactivity, disturbed sleep and wakeful rhythms, and nutrition which lead to reduced adaptation to the learning process [XXIV, V]. Now computer technology is being introduced into all spheres of human activity. The computer program “Health Sources” is intended for the quantitative assessment of the functional reserves of human health (the main body systems – cardiovascular system (CVS), respiratory, central nervous system, neurohumoral system and psychoemotional sphere) based on the objective results of the examination and subjective sensations of the patient using such tests as color choices, Spielberg, SAN, Leontiev, Garkavi psychological test (psychological block), allows to determine the resistance of the body [II].

The aim of the study: Assessment of the functional reserves of the body for the quantitative assessment of individual health; adaptation, psychophysiological characteristics of the quality of students' health, taking into account gender and seasons.

II. Materials and Methods

120 3rd year students of SOGMA were examined (2016-2017 in the winter-spring seasons), 72 - girls and 48 young men. Their mean age was 19.38 ± 0.15. The examination was carried out using standard research methods (medical history, questionnaires, clinical and paraclinical examination, anthropometry), autorythmometry (AP r / l, mAP r / l, PP r / l, Heart rate r / l, t ° p / l). The measurements were carried out for 3 consecutive days, at equal 4-hour time intervals for each parameter. “sense of time” using individual minute test (IM); variants of genetically determined internal biological rhythms that are not dependent on external living conditions (chronotype) using the adapted Estberg questionnaire, consisting of 21 questions, were determined. To determine the chronotype, the total score was...
calculated: over 84 - clearly expressed morning type; 69-83 - mild morning type; 50-68 indifferent type; 34-49 mild evening type; below 33 – clearly expressed evening type; degree of anxiety was determined using the Spielberg-Khanin questionnaire. Personal anxiety (PA) is a stable individual characteristic showing the subject's predisposition to anxiety and suggesting that he has a tendency to perceive a sufficiently wide “fan” of situations as threatening, responding to each of them with a specific reaction. Situational anxiety (SA), or reactive anxiety as a condition of subjectively experienced emotions: tension, anxiety, concern, nervousness. This condition occurs as an emotional reaction to a stressful situation and can be of different intensity and dynamic in time. Determination of anxiety level by the Spielberger test was carried out in full accordance with the author's methodology adapted by Yu.L. Khanin. The questionnaire includes 40 judgment questions, 20 of which are designed to assess the level of SA and 20 to assess the level of PA. The final indicator can range from 20 to 80 points. Moreover, the higher the final indicator, the higher the level of anxiety (situational or personal), up to 30 points - low; 31-44 points - moderate; 45 and more - high; determination of psychoemotional status using the SAN test consisted of filling in a form with 9 pairs of words (simplified version) of the opposite concept, reflecting various features of a person’s subjective state: three pairs characterize well-being, three pairs indicate activity, three pairs indicate mood. Between pairs of words are numbers - estimated points 3-2-1-0-1-2-3, which the subject marked according to his condition at the time of the study. On the hardware-software complex (HSC) "Health Sources", testing was carried out by means of color selections, which is a modification of the Lusher shortened test in L.N. Sobchak interpretation. In HSC quantitative indicators of anxiety, emotional stability and stress resistance are calculated. The total manifestation of compensation and anxiety is calculated as the sum of all conditional points corresponding to the positions of the primary and secondary colors in the secondary set. If any of the primary colors (1-blue, 2-green, 3-red, 4-yellow) is in the last three places in a series of preferences, then it is considered abnormal and indicates the presence of anxiety. If any of the secondary colors (5-violet, 6-brown, 7-black, 0-gray), except violet, appears in the first three places in the preference row during the second choice, this means that there are compensations; the study of mental performance was carried out by the Ivanov-Smolensky proofreading method using Attention tables. The number of correctly crossed out letters (in this case, the letters "K N E R"), the number of letters viewed and skipped during 5 minutes served as criteria of attention. The subjects could complain of weakness, fatigue, frequent headaches, memory loss. The data obtained were processed by the method of variation statistics, taking into account the coefficient of variation of the dynamic series, the distribution of the series for normality using the Microsoft Excel analysis package with the AtteStat add-in.

III. Results

The analysis of the questionnaire results with the use of the adapted Estberg questionnaire, showed that indifferent chronotype prevailed in students of the medical university (61% in group 1; 58% in group 2) (according to Fig. 1).
Anthropometric results showed that the body mass index of the examined boys (25.3) and girls (20.6) corresponded to a normal level. According to the results of the auto-rhythmometry, chronoanalysis of biorhythms was carried out and individuals with physiological and pathological desynchronosis were identified. The prevalence of circadian rhythms (72%) over ultradian (18%) with epy predominance over infraradian (10%) in individuals with physiological desynchronosis was found. Further, the health structure was presented as follows: I health level - successfully adapted persons - 40%; II health level - individuals with physiological desynchronosis - 35%; III health level - persons with pathological desynchronosis - 25%. Students with pathological desynchronosis were not subsequently taken into account. The result of an individual chronoanalysis of a temporary organization of physiological functions in the examined M.V., 19 years old, indifferent chronotype with physiological desynchronosis may serve as an example of such a state (Fig. 2).

Fig.1: Distribution of chronotype in students due to Estberg questionnaire

| Rhythm parameters | GIRLS | YOUNG BOYS |
|-------------------|-------|------------|
| Clearly expressed morning type | 61%   | 58%        |
| Poorly expressed morning type  | 6%    | 10%        |
| Indifferent chronotype        | 3%    | 4%         |

| Rhythm parameters | S&B | DBP | Heart rate | t* | IM |
|-------------------|-----|-----|------------|----|----|
| Period            | 23.06| 23.292| 24.100    | 24.185 | 19.784 |
| Mezor             | 126.78| 84.294| 80.195    | 36.724 | 62.105 |
| Amplitude         | 2.91  | 3.69 | 8.06      | 0.28  | 6.20 |
| Acrophase         | 12h3m| 21h52m| 16h21m    | 15h52m | 5h18m |
| reliability p*    | 0.907| 0.713| 0.99      | 0.99  | 0.89 |

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Fig. 2: Individual rhythms analysis indicators of physiological functions M.V., 19 years old, with physiological desynchronosis (spring 2017).

There are 60% of reliable rhythms, an increase in the area of acrophases wandering, changes in amplitude, scores decrease in the SAN test (well-being-activity-mood) (by 2-3 points), complaints of sleep disturbance and increased fatigue occurring after rest. Seasonal physiological desynchronosis is an independent type of physiological desynchronosis, which reflects disturbances periodically occurring in a healthy body - smoothing of circadian rhythms associated with the transitional seasons of the year - in spring and autumn, when acrophases shift occurs from summer to winter and vice versa. In summer and winter, the phases of circadian rhythms occur during the day with a difference of up to several hours. This is due to the different velocity of various rhythms adjustment. Seasonal desynchronosis can serve as a factor provoking exacerbation of a number of hidden pathological processes. During periods of psychoemotional overstrain, changes in the chronostructure of the temporal organization of physiological functions were revealed (Table 1).

Table 1: Biorhythms spectrum indicators of physiological functions examined during exam stress

| Rhythms of indicators: Heat rate, SBP, DBP, mAP, PP, t° | Reliable rhythms | unreliable |
|---|---|---|
| | total | ultradian | circadian | infradian | abs | % | abs | % | abs | % | abs | % |
| n=120 | 36 | 42.8 | 14 | 38.9 | 16 | 44.4 | 6 | 16.7 | 48 | 57.2 |

The part of reliable rhythms is significantly lower than unreliable. Circadian rhythms prevail over ultradian and infradian rhythms (44.4% - 38.9% - 16.7%), and this pattern was observed in young men and girls. The analysis of the functional reserves of the body due to PC express diagnostics “Health Sources” revealed unreliable parallel increase in the adaptation and stability of resistance in young men in all seasons of the year, increase in situational anxiety in winter-spring season by 9 -
10% (Fig. 3). Reduction of all indicators in young men in autumn is also should be mentioned.

**Fig. 3:** Indicators of functional reserves of the body due to PC express-diagnostics “Health Sources” in young men in autumn, winter and spring seasons (p<0.03, n=21).

Differences in the indicators of emotional stability (ES) in young men (59%) and girls in the winter season (52%) are significant. Significant increase was noted in girls in the spring season of the year (Fig. 4).

**Fig. 4:** Indicators of functional reserves of the body due to PC express-diagnostics “Health Sources” in girls in autumn, winter and spring seasons (p<0.03, n=45).

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Larisa A. Merdenova et al

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Physical abilities of the body and CNS functional reserves increase in young men in the spring season by 8-10% compared with the autumn season. It was noted that these indicators change in the opposite direction in girls on the background of increased anxiety.

The analysis of mental working ability by corrective test revealed the increase of all indicators in the winter season. Significant changes in the autumn and winter seasons of the year were noted in young men (Table 2). Productivity and attention intensity are also reduced in both groups, especially in the autumn season of the year. Decrease in indicators of memory and attention probably show inhibitory process in CNS in the autumn and spring seasons of the year.

### Table 2: Indicators of mental performance in students in autumn, winter and spring

|                              | Girls n = 166 |                | Young boys n =56 |                |
|------------------------------|---------------|----------------|------------------|----------------|
|                              | autumn | winter | spring | autumn | winter | spring |
| **Productivity of attention** |        |        |        |        |        |        |
| M               | 234.70 | 276.70 | 238.21 | 243.43* | 265.5* | 244.94 |
| m              | 5.63  | 8.65  | 4.87   | 9.91    | 18.57  | 8.91   |
| **Stability of attention**   |        |        |        |        |        |        |
| M               | 31.22  | 35.47  | 32.35  | 24.18   | 23.37  | 25.07  |
| m              | 2.41  | 4.15  | 2.07   | 3.39    | 6.28   | 3.00   |
| **Intensivity of attention** |        |        |        |        |        |        |
| M     | 717.40 | 794.24 | 723.69 | 745.65** | 721.25** | 744.92 |
| m     | 13.24  | 22.58  | 11.86  | 24.60   | 39.90  | 2.73   |
| **Mean memory coefficient**  |        |        |        |        |        |        |
| M     | 40.97  | 48.04  | 40.992 | 43.85*  | 48.42*  | 43.96  |
| m     | 1.22   | 2.01   | 0.94   | 2.08    | 4.60   | 1.89   |

Note: p*<0.001; p**<0.012

### IV. Discussion

The basic rhythm of the temporary organization of living systems is the circadian rhythm, which performs an integrative and regulatory function and adapts the body to changing environmental conditions. This was proved in the works [XVIII, XXII, VIII, X, XXIV]. Unfavourable environmental factors (stressors) results in different damages to the biological rhythms of the body, i.e. to the development of desynchronosis, mismatch in the work of the basic life supporting systems on the basis of a temporary organization, which is a pathogenetic basis and indicator of
adaptation disorders in the event of stress. Desynchronization of bio-rhythms refers to damage to the regulation of CNS functional state, contributes to the occurrence of preclinical health disorders: impaired neurohumoral regulation, vascular-vegetative dysfunction, changes at the level of information processes in the biosystem, decreased capacity of the adaptive capabilities of the biosystem, the fact confirmed by the works of the above authors.

Chronotype is an important component of the biorhythmological status, which represents circadian dynamics of indicators characterizing the general condition of the body by the day period, which is proved in the works [III, XIII, VI, XX, XIV, I]. During the exam stress period, students showed a pronounced dependence of psychophysiological functions on the chronotype. Psycho-emotional stress is a generalized reaction of the body. Researchers have shown the usefulness of a moderate stress, which is manifested by a beneficial effect on performance, increased human productivity in various activities, improved short-term memory in students during the session, suggesting that moderate emotional stress increases performance and this was confirmed by the results our study. Increase or decrease in the amplitude of the initial oscillations, lengthening of the period and a decrease in the frequency of the rhythm, and damage to the phase architectonics of the circadian rhythm system are the signs of biorhythm restructuring under stress. In stress, in a state of high level strength, the biosystem tends to increase the period of oscillatory processes in order to prolong the recovery period, accumulation of energy and plastic reserves necessary for their subsequent increased consumption. Stress promotes the increase of the amplitudes of rhythms of well-being, activity, mood and reactive anxiety, thus contradicting to our data, in which these indicators are reduced except the indicators of personal and situational anxiety, and this can lead to a decrease in the general nonspecific resistance of the body and the development of psychosomatic and somatic disorders. Anxiety allows to mobilize strength to achieve results. Complete lack of anxiety hinders normal adaptation, and an excessively high level of anxiety is regarded as a dysadaptive reaction. Prolong high anxiety, according to the literature, is a risk factor for the development of neurosis, autonomic dystonia, psychosomatic and somatic diseases, contributes to a decrease in attention and memory, mental performance and academic performance. The exam period promotes the increase of student anxiety. In works [VIII, XVI, XVII, V, XI, XIX].it was found that the subjective assessment of the duration of time intervals (TI) clearly correlates with the adaptive abilities of the body and is a necessary prerequisite for successful adaptation. Violation of the determination of the duration of time intervals indicates a decrease in the adaptive capacity of functional systems and preclinical health disorders. It has been found that individuals characterized by a high level of anxiety shorten the duration of an individual minute, which is confirmed by our experiment. Subjective acceleration of time flow indicates information overload, stress of adaptive mechanisms and can serve as one of the criteria for the early diagnosis of subclinical failure of adaptation.

The period of tests and exams has a negatively influence the activity and emotional state of a person, which leads to a mismatch between his abilities and objective requirements of reality. In most students, when facing with a stressful
situation, requiring decision-making and taking active actions can be manifested by an emotional and physiological reaction, increased anxiety, and internal tension.

Students make up a special social group of the population because they belong to a high-risk group due to high and prolonged psycho-emotional stress.

V. Conclusion

The state of general and functional reserves of students changes depending on external and internal factors and is reflected in attention, mental performance and the quality of adaptation to the educational process in the winter season, which is explained by the increased stress influence of the upcoming exam tests. During examination period (summer-winter), the stability of the temporary organization of the biosystem decreases, and the tension of adaptive mechanisms develops. During exam stress, time shortening, decrease in “IM” amplitude, accompanied by a decrease in SAN test scores, increase in personal and situational anxiety, and a decrease in the level of psychophysiological adaptation, are more pronounced in girls.

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