Functional Resources and Psychological Comfort of Students from Central Asia Studying at the Northern University

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Abstract

The study of the parameters of the bioelectric activity of the brain, the cardiovascular system and the assessment of psychological comfort to assess their impact on the adaptation of visiting students to the socio-climatic conditions of the Arctic zone of Russia was carried out.

The aim of study was to assess and compare the quality of life and functional resources of students from different regions. Participants were divided in 2 groups of 25 people by region of birth: Central Asia for study group and Arctic zone of Russia for control group. The questionnaire WHOQOL-100 was used for assessment of psychological comfort, electroencephalographic examination of the brain and the system of integral monitoring of the cardiorespiratory system "Simona-111" were used to study bioelectric activity of the brain and cardiovascular system respectively. Statistical processing of the collected data was carried out using the IBM SPSS Statistics 22.0 and included the ANOVA method with addition of the Pearson's $\chi 2$ criterion.

Impact of some physical and environmental aspects of everyday life on psychological comfort was revealed. Significant differences in patterns of external respiration in both groups were described. Significant affection of hyperventilation on rearrangement of brain waves which depends on both gender and birthplace was shown.

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Introduction

Human adaptation to environmental conditions is understood as a complex process of achieving a stable level of activity of functional systems, organs and tissues, as well as control mechanisms that ensure the possibility of long and active life of the human body, its labor activity and the ability to reproduce healthy offspring.

Human adaptation is, on the one hand, a physiological process that is based on compensatory-adaptive mechanisms and the work of the body's regulatory systems that provide its functional reserve. On the other hand, during the adaptation process, changes in the psychophysiological status of a person inevitably occur, arising when he assimilates a new social reality. Consequently, the overall effectiveness of adaptation is determined not only by the functional state of various organ systems, but also by the psychophysiological personality traits formed during this process.[1]

Along with the concept of physiological and psychophysiological adaptation, it is worth talking about a person's subjective assessment of the quality of his life (QOL) in changing environmental conditions. In medical terminology, there is a definition of the quality of life as the degree of satisfaction of human needs. It is determined by the physical, social and emotional factors of a person's life, which significantly affect it. The quality of life is assessed not only by its morphological and functional state, but also by the degree of comfort of the surrounding society.[2] The need to adapt to new environmental conditions significantly complicates the process of teaching students at a university, especially when temporarily living in another country, where there is a complex of climatic and social influences that are sharply different from the usual environmental conditions. In addition, the mechanisms for maintaining homeostasis of northerners and natives of hot countries are very

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different: for example, representatives of the southern regions are characterized by less intense heat production with increased heat transfer, which can lead to frequent hypothermia and the development of acute respiratory diseases when moving to a colder climate. The share of research on the functional state of students who came from hot countries to the circumpolar regions is extremely small, and the available information is mostly related to the temperate climate.[3,4] In addition, often only individual indicators or functional systems are considered, such as the cardiovascular or respiratory system, or psychological adaptation of students to the learning process in another country is considered.[5]

Based on this, the purpose of our study was to assess the indicators of psychological comfort and adaptive resources of the body of students from Central Asia studying at a northern university.

Materials and methods

The study was conducted at the Department of Human Biology and Biotechnical Systems of the Northern (Arctic) Federal University named after M.V. Lomonosov (NArFU). The study group of participants consisted of foreign students (n = 25) of both genders from Central Asia (Uzbekistan, Kazakhstan, Kyrgyzstan). The control group (n = 25) consisted of students from the NArFU. The age of the studied participants had no significant differences ($F_{1,25}$ = 0,831; P = 0,371): 22,4±2,2 y.o. for the study group, 22,9±2,8 y.o. for the control group. The study was conducted in compliance with the requirements of the Declaration of Helsinki. All participating students gave informed consent to participate in the study. The assessment of the quality of life, as an indicator of the subjective mental state of the study participants, was carried out using the WHO QOL-100 questionnaire in 6 main domains with 24 base facets: physical, psychological, level of independence, social relationships, environment, and spirituality. Examination of the cardiovascular system (physiological component) was carried out using the hardware-software complex "Simona-111" («Oculus 2000», Russia) according to the method recommended by the developer of the system[6]: rheographic electrodes were installed on the neck in the projection area of the carotid arteries and along the middle axillary line at the level of the xiphoid; disposable electrodes of ECG lead I were installed 1 intercostal space above chest rheographic electrodes; the pulse oximeter was installed on the middle finger of the right hand; the cuff for measuring blood pressure was placed in the middle third of the left shoulder.

The following parameters of the cardiovascular and respiratory systems were analyzed: heart rate, respiratory rate (RR), mean arterial pressure. Registration was carried out for 15 minutes simultaneously with the registration of the bioelectrical activity of the brain.

Brain bioelectrical activity was recorded using electroencephalography with the hardware-software complex Neuron-Spectrum 5 («Neurosoft», Russia). The encephalogram was recorded monopolarly from 19 active electrodes located on the scalp surface according to the international system "10% -20%"[7]. Divided ipsilateral ear electrodes were used as reference (A1, A2). The recorded bioelectric signal was digitized with a sampling rate of 500 Hz and filtered in the transmission range from 3 to 30 Hz. During the first five minutes, an electroencephalogram was recorded in a resting state with closed eyes, and then during a series of standard stress tests aimed at determining the functional state of their brain. They included a test with opening and closing the eyes, a test with rhythmic photic stimulation at frequencies of 3, 5, 7, 9, 15, and 20 Hz (10 seconds each) and two-minute hyperventilation. After each of the tests, an electroencephalogram of recovery was recorded for one minute. When analyzing the obtained records, artifact-free areas of electroencephalograms with a duration of 4 seconds (at least 30 areas for each functional test) were selected in manual mode, for which the mathematical procedure of fast Fourier transform and the construction of spectrograms were subsequently applied. The main analyzed parameter was the rhythm index (theta - 4-8 Hz, alpha - 8-13 Hz and beta - 13-30 Hz), reflecting the percentage of fluctuations of the indicated frequency ranges in the general spectrum of the encephalogram. For the analysis of the functional test with photic stimulation, the frequency for which the response of rhythm assimilation was expressed to the greatest extent was also assessed.

Statistical processing of the collected data

was carried out using the IBM SPSS Statistics 22.0 (IBM Corp., Armonk, New York, U.S.) software. The analysis of variance (ANOVA) was used as the main method for testing statistical hypotheses, where the gender and home region of the study participants were the intergroup factors, and the functional tests used were selected as the intragroup factor. The analysis of the proportional ratio of the studied characters was carried out using the Pearson's χ^2 criterion, and to identify correlations between the variables, the calculation of the Pearson's r correlation coefficient was used. Differences in the analyzed parameters were considered statistically significant if the probability of erroneous acceptance of the null hypothesis was $p < 0,05$.

Results

The assessment of the quality of life revealed a statistically significant difference in the general level of the quality of life: among persons permanently residing in the Arctic region, the assessment of the quality of life is significantly higher than among visitors from the Southern regions ($F_{1,25}$ = 6,396; P = 0,018). When assessing the contribution to the overall quality of life of each of the domains, a statistically significant effect of the home region on the difference in the following domains is highlighted: physical ($F_{1,25}$ = 5,139; P = 0,032), environment ($F_{1,25}$ = 10,634; P = 0,003). When assessing the components of the facets, the influence of the regional factor on the following facets was found: physical sphere: pain and discomfort ($F_{1,24}$ = 14,332; P = 0,001); environment: home environment ($F_{1,25}$ = 10,022; P = 0,004), opportunities for acquiring new information and skills ($F_{1,25}$ = 18,101; $P < 0,001$), participation in and opportunities for recreation ($F_{1,25}$ = 8,880; P = 0,006) (Table 1).

When assessing the function of the cardiorespiratory system, a statistically significant difference in the respiratory rate was found: in boys, regardless of the region of birth, the values of the RR are lower than in girls ($F_{1,24}$ = 8,807, P = 0,007).

There is also a statistically significant combined effect of the factors "Gender" and "Region" on the values of the RR ($F_{1,24}$ = 5,466 P = 0,028). For persons permanently residing in the Arctic region, the difference in this indicator for boys (7,6±0,6 bpm) and girls (10,6±0,5 bpm) is pronounced, while for boys (9,2±0,5 bpm) and girls (9,6±0,6 bpm), who came from the southern regions, it is practically absent.

Domain/ Facet	Quality of Life, %		Statistics	
	Arctic zone of Russia	Central Asia	*F*	*P*
Physical	71,3±2,6	63,1±2,6	5,139	0,032
Pain and discomfort	16,1±0,6	12,7±0,6	14,332	0,001
Environment	73,5±1,9	64,8±1,9	10,634	0,003
Home environment	15,1±0,6	12,4±0,6	10,022	0,004
Opportunities for acquiring new information and skills	17,0±0,5	14,3±0,5	18,101	< 0,001
Participation in and opportunities for recreation	15,5±0,7	12,9±0,6	8,880	0,006

Table 1. Domains and facets impacting on overall quality of life, m±SD.

Analysis of the reorganization of the bioelectrical activity of the brain of the surveyed respondents in response to a functional test with opening the eyes did not reveal the regional specificity of the observed reaction ($F_{1,23}$ = 0,079; P = 0,781). All study participants, regardless of gender and region of birth, recorded a decrease in the alpha-rhythm index during the transition from a resting state with closed eyes to a state with opened eyes by an average of 17% ($F_{1,23}$ = 48,016; $P < 0,001$) (Table *2*).

Rythm	Rhythm index, %			
	Arctic zone of Russia		Central Asia	
	men	women	men	women
Resting state				
Theta	17,3±4,9	14,2±4,3	14,1±3,5	18,6±6,0
Alpha	41,8±10,7	41,0±13,2	43,3±18,8	40,9±16,7
Betha	21,9±7,1	25,0±11,1	21,5±10,8	19,8±7,1
Hyperventilation				
Theta	21,4±8,9	15,7±4,1	15,0±3,5	16,9±4,4
Alpha	40,9±9,9	40,4±12,3	41,8±18,7	39,7±12,8
Betha	19,6±8,7	22,6±9,6	19,5±10,3	21,7±11,2

Table 2. Characteristic of bioelectric activity of the brain of the examined groups of students in the hyperventilation process, m±SD.

When analyzing the results of photic stimulation, it was found that the frequency at which the most pronounced reaction of rhythm assimilation was recorded statistically significantly differed in the compared groups of

the examined (χ^2 = 5,143; *df* = 1; *P* = 0,023). Thus, for 70% of students born and permanently residing in the Arctic zone of the Russian Federation, higher synchronization frequency values were characteristic, corresponding to the natural rhythm of the adult brain in the range above 8 Hz. At the same time, students who came to study in the Arctic region from the countries of Central Asia most often demonstrated a rhythm assimilation reaction in the low-frequency range of 3-5 Hz.

The most interesting picture of the interaction of the studied factors was found when analyzing the rearrangements of the bioelectrical activity of the brain of students in response to two-minute hyperventilation (Table *3*).

Sources of variation (*df* = *24*)	Theta rhythm		Alpha rhythm		Beta rhythm	
	F	*P*	*F*	*P*	*F*	*P*
Hyperventilation (HV)	6,607	**0,017**	1,945	0,176	3,953	0,058
Sex	0,094	0,761	0,056	0,815	0,166	0,687
Region	0,292	0,594	0,004	0,948	0,167	0,686
HV × Sex	8,575	**0,007**	0,031	0,861	2,618	0,119
HV × Region	12,863	**0,001**	0,124	0,727	3,907	0,060
Sex × Region	4,140	0,053	0,018	0,895	0,119	0,733
HV × Sex × Region	0,001	0,971	0,002	0,965	2,955	0,098

Table 3. Sources of parametres variation of the bioelectrical brain activity of examined groups of studens during hyperventilation.

First, it was shown that this functional test did not affect the proportion of alpha and beta waves of the electroencephalogram, but significantly increased the slow-wave theta rhythm index from 16,1% to 17,2% ($F_{1,24}$ = 6,607; *P* = 0,017). Secondly, the gender characteristics of functional rearrangements arising during hyperventilation were found ($F_{1,24}$ = 8,575; *P* = 0,007). In the surveyed sample of students, regardless of the region of birth, the greatest changes in the theta rhythm index during hyperventilation were demonstrated by young men, their average proportion of slow waves increased from 15,7% to 18,2%. Finally, a functional test with hyperventilation revealed the regional specificity of the electrical activity of the brain in the study participants ($F_{1,24}$ = 12,863; *P* = 0,001). The most striking rearrangements in the slow-wave range of the electroencephalogram were registered in students born and permanently residing in the Arctic region of the Russian Federation: when performing hyperventilation, their theta rhythm index increased by an average of 2,7%. In this regard, it is especially worth noting that the additional correlation analysis between the indicators of external respiration and the bioelectrical activity of the brain of the examined students made it possible to find statistically significant feedback of the respiratory rate with the proportion of slow waves on the electroencephalogram (*r* = -0,403; *P* = 0,037).

Discussion

The study of the quality of life of two groups of students was carried out to assess the subjective perception by migrants of aspects of daily life in the Arctic region by migrants from southern countries.

Based on the results of assessing the physical pain and discomfort of the survey participants, we can confidently say that when living in northern latitudes, foreign students experience more significant physical discomfort than local ones. In this case, this can be attributed to the harsh climatic conditions of the north, such as the lower average annual temperatures and the cycles of day and night characteristic of northern latitudes. This is in line with proven evidence for the effect of daylight hours on circadian rhythms and melatonin secretion, which also affects mood.[8,9]

Assessment of the home environment characterizes the comfort of living conditions. Mostly students from other countries and cities live in the dorms. Despite the presence of comfortable dorms, more than half of them are fairly old buildings, often remote from the campus, with many problems of a domestic nature. And although no more than two people live in rooms and, in general, friendly relations are established between students in dormitories, the limited ways to improve the individual comfort of the living space also affect the quality of life.

Despite the fact that in a pandemic it is impossible to confidently talk about the reasons for the decrease in opportunities for recreation and entertainment, one cannot ignore their effect on the decrease in the general mood of a person. The main reason for the differences in the perception of opportunities for recreation can be attributed to the different mentality of the study participants. Residents of southern

countries often prefer collective ways of recreation, for example, with a large circle of friends, while it is believed that northerners are more withdrawn, and it is easier for them to find opportunities for entertainment in conditions of social constraints.

Thus, the subjective perception of limitations and discomfort described by the above-mentioned facets can serve as the main reason for the decrease in the ability to acquire new information and skills. With a general deterioration in the quality of life, a person's perception is more focused on improving the negative aspects of their activities, while the desire to learn and learn something new often fades into the background, if there are no prerequisites for improving life in the short term.

The results of the examination of the cardiovascular system showed that there are no statistically significant differences between students from different regions. This can be explained by the fact that the functional reserves of the cardiovascular system of healthy young people are sufficient to compensate for the direct impact of the harsh climate.

In turn, the found differences in the respiratory rate between boys and girls from different regions reflect different variants of respiratory adaptation to low temperatures, which in these latitudes can last up to six months or more. Thus, girls living in the north showed an increased respiratory rate, characteristic of shallow breathing. This breathing method helps to prevent hypothermia of the lung tissue to a greater extent. The slow breathing pattern of northern youths allows them to inhale more air, heating it in the process to a safe temperature, which is also an option to reduce the negative impact of a cold climate. In turn, students from southern countries demonstrate the absence of gender differences, which is explained by the lack of negative effects of low temperatures throughout their lives.

Functional tests carried out during registration of the bioelectrical activity of the brain were aimed at identifying the features of the thalamo-cortical interaction and the stability of rhythmogenic structures of the brain to external stimulation and changes in the blood gas composition.

The obtained results convincingly prove that the nature of thalamo-cortical interactions, described by the ratio of alpha and beta rhythm on the electroencephalogram, does not depend on the gender and region of birth of the study participants. Changes that occur in the work of rhythmogenic structures during the transition from a resting state to active wakefulness are associated with the opening of the eyes of the subject and the flow of visual information, which begins to be processed in the corresponding areas of the cerebral cortex.[10] On the recording, these changes are reflected in the form of a decrease in the proportion of fluctuations in the range of the alpha rhythm and arise as a result of the activation of sensory-specific cortical zones from the thalamus.[11,12] The speed and severity of the development of the activation reaction (desynchronization of the alpha rhythm) may reflect the nature of thalamo-cortical interactions. Rapid and vivid changes in the representation of alpha waves that occur when the eyes are opened and closed indicate a balance of the excitatory and inhibitory effects of the thalamus on the cerebral cortex.

The results of our study demonstrate an adequate nature of the activation reaction: the opening of the eyes was accompanied by a decrease in the proportion of the alpha rhythm by 15-20%, while the studied factors (gender and region) did not affect the specificity of this process. Thus, it can be assumed that the features of thalamo-cortical interaction in the brain are a fundamental characteristic that forms the overall picture of its bioelectrical activity, regardless of a person's gender and adaptation processes to unfavorable environmental factors.

Completely different conclusions can be made based on the analysis of the results of a functional test with photic stimulation. The differences in the frequency bands at which the maximum assimilation of the rhythm of light flashes was recorded indicates the presence of regional specificity in the work of the rhythmogenic structures of the brain.

Rhythmic photic stimulation is traditionally used in electroencephalographic studies in order to identify the phenomenon of rhythm assimilation - the appearance on the recording of harmonic and subharmonic oscillations with a frequency equal or multiple to the frequency of light flashes. This reaction is not pathological and is most clearly recorded in the occipital areas of the cerebral cortex, which are directly related to the processing and analysis of visual information. In this case, the frequency at which the

maximum assimilation is recorded has a diagnostic value. It is believed that the stability of the rhythmogenic structures of the brain reflects the assimilation of the rhythm in the range of alpha and beta oscillations (8-30 Hz), that is, at frequencies typical for a resting state and active wakefulness. Registration of harmonic and subharmonic oscillations outside this frequency range indicates the weakness of rhythmogenic structures, their inability to resist the imposition of an external rhythm.[13,14]

The obtained results indicate that in most of the surveyed students who came to study at the university from the countries of Central Asia, the most pronounced reaction of mastering the frequency of light flashes is observed at the lower limit of the recorded frequency range (3-5 Hz), which distinguishes them from their peers. permanently residing in the Arctic zone. Such features of the rhythm assimilation reaction may reflect the instability of the rhythmogenic structures of the brain and be associated with the processes of active adaptation in visiting students. We assume that the expansion of the range of harmonic and subharmonic oscillations in this group of subjects may indicate the depletion of the resources of the central nervous system under conditions of white nights, when in the period from May to July at the latitude of Arkhangelsk the day length exceeds 18 hours. Such conditions adversely affect the activity of the rhythmogenic structures of the brain, disrupting the established circadian cycles and leading to excessive excitation of the central nervous system, followed by its depletion.

Assessment of the stability of rhythmogenic structures of the brain to changes in the gas composition of the blood using a functional test with hyperventilation revealed not only regional, but also sex characteristics of the arising rearrangements. Obviously, the quality of hyperventilation, in which the state of respiratory alkalosis arises due to the washing out of carbon dioxide from the blood, is directly related to the parameters of external respiration, its volumetric and speed characteristics, which have a pronounced sexual dimorphism. In this regard, the results obtained are quite expected: young men with greater functional and anatomical abilities for hyperventilation and having a significantly lower respiratory rate showed more striking changes in the nature of bioelectrical activity compared to girls.

One way or another, regardless of the gender or region of birth of the study participants, hyperventilation led to a natural slowdown in the overall rhythm of the electroencephalogram, which was reflected in an increase in the proportion of slow theta waves. This reaction is typical for this functional test and reflects the general sensitivity of the central nervous system to developing hypocapnia.[15] Regional specificity, manifested in the absence of pronounced rearrangements in the process of hyperventilation in students from Central Asia in comparison with students from the control group, can also be associated with the peculiarities of their external respiration. We assume that the results obtained do not indicate any significant resistance of visiting students to hypocapnia, but only indicate the insufficient functional reserves of their cardiorespiratory system to ensure the formation of respiratory alkalosis through the hyperventilation procedure.

Conclusions

Thus, the results of our study revealed a number of physiological, psychophysiological and psychological characteristics that distinguish students who came to study in the Arctic zone of the Russian Federation from Central Asian countries from local residents from the same social group. In particular, foreign students are characterized by less sharp differences in the respiratory rate between boys and girls with reduced abilities to perform breathing maneuvers, which is reflected in the performance of a functional test with hyperventilation. In addition, the bioelectric activity of the brain in students from this group is characterized by a wide range of assimilation of the frequency of light flickers, which may indicate the instability and instability of the work of rhythmogenic structures. Subjectively, foreign students rate their quality of life lower in comparison with their peers who were born and permanently residing in the Arctic zone of the Russian Federation. First of all, this concerns the level of their physical comfort and the comfort of interacting with the environment.

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Declaration of Interest

The authors report no conflict of interest.

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