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SHORT COMMUNICATION

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Direct Current Potential of Brain as a Stress Marker on Different Stages of Adaptation in Northern Climates

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Abstract

Background: The main changes in the parameters of functional systems in the process of adaptation occur in the first year of living in new conditions, and the main role in regulating human life support systems is played by the central nervous system. The brain's role in regulatory processes can be assessed by examining the levels of direct current potentials (DCP) in various brain areas by the Neuroenergy Mapping (NEM) method. The aim of this study was to assess the brain's DCP in a group of Indian students living in the Arctic region (Arkhangelsk city) for the first 6 months after arrival.

***Methods and Results*:** The study involved 106 young people aged 19–21 years. Registration, processing, and analysis of DCP were carried out in the following groups: 34 of the participants who lived in Arkhangelsk for less than 3 months at the time of the study (Group 1, short-term adaptation); 37 participants who lived in Arkhangelsk more than 6 months (Group 2, long-term adaptation); and in 35 participants who were born and are permanently residing in Arkhangelsk (Group 3, control). To study neurometabolism, the electrophysiological NEM method was used based on measuring the level of DCP. The highest functional activity among Indian students of Group 1 was found in the central (Cz) and parietal (Pz) regions. In Indian students of Group 2, on the contrary, a critically low total rate of DCP for the cerebral cortex was recorded, which indicates a decrease in the activity of the cerebral cortex. Potential values in all departments of the right hemisphere were recorded higher than the corresponding values of the left hemisphere. In Group 3, which included students living for a long time in extreme climatic and geographical conditions of the Arctic zone, there was also a stable right-hemispheric dominance with a predominance of activity in the central, parietal, and occipital regions of the cerebral cortex. The total value of DCP in the whole cortex was within the normal range, which indicates well-formed mechanisms of adaptation to extreme climatic conditions of the Arctic zone.

Conclusion: Indian students, depending on the time spent in the climatic conditions of the Arctic Circle, reveal various features of cerebral metabolism. Thus, the acute stage of adaptation to a cold climate shows inadequate responses to stress caused by new environmental conditions, such as a significant increase in DCP throughout the cerebral cortex with a maximum in the central leads. After 6 months of living in a new climate, the DCP level decreases, which indicates signs of an adaptive disorder of brain function.**(International Journal of Biomedicine. 2023;13(4):360-363.**

Keywords: direct current potential • brain • Arctic climate • adaptation

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Introduction

The process of adaptation in new climatic conditions generally places the strongest stress on the functional systems of the body, with difficult compensation,[1,2] and often has a compromise nature, i.e., ensuring the effectiveness of some physiological systems leads to a decrease in the efficiency of regulation of others.[2,3] Adaptability is achieved by reducing some of the body's resources. The stage of short-term adaptation to the specific conditions of the Arctic is characterized by increased anxiety, reduced mental and physical performance, boundary shifts in hormonal status, and activation of emotional information in memory processes.[4,5] Long-term persistence of this status increases the risk of developing diseases. The duration of this stage, in which the compensatory and regulatory mechanisms of homeostasis are destabilized, according to most sources, takes about six months.

In the short-term adaptation process, the body's homeostatic systems are activated, and two opposite processes occur. On the one hand, when the sympathetic part of the nervous system is activated, catabolic reactions occur, which provide the body with the necessary energy. On the other hand, a wide range of neurohormonal factors directly affect metabolism and activate protein synthesis in various organs and tissues of the body.[3,5,6]

The age period of 18-21 years is characterized by both the maximum adaptive reserves of the body and the greatest psychological stress. Often, the beginning of studies at a university or college is accompanied by a move to new regions with dramatically different climatic conditions from the usual ones. It is known that the main changes in the parameters of functional systems in the process of adaptation occur in the first year of living in new conditions, and the main role in regulating human life support systems is played by the central nervous system.[7,8] The brain's role in regulatory processes can be assessed by examining the levels of direct current potentials (DCP) in various brain areas by the Neuroenergy Mapping (NEM) method.[7,9] This method is cheap and non-invasive and may be used in any subject independent of health, age, and gender. NEM allows us to visualize the metabolic process in different brain structures in various clinical situations. The DCP level correlates with various biochemical parameters of the brain tissues, allowing resulting data to be used for diagnosing various pathophysiological conditions.

The aim of our study was to assess the brain's DCP in a group of Indian students living in the Arctic region of Russia (Arkhangelsk city) for the first 6 months after arrival.

Materials and Methods

The study involved 106 young people aged 19–21 years. We formed comparison groups to level out the age and gender characteristics of the subjects for an objective assessment of differences in metabolism and infraslow activity of the cerebral cortex at short-term and long-term stages of adaptation to new socio-climatic conditions.

In our study, registration, processing, and analysis of DCP were carried out in the following groups: 34 of the participants who lived in Arkhangelsk for less than 3 months at the time of the study (Group 1, short-term adaptation); 37 participants who lived in Arkhangelsk more than 6 months (Group 2, long-term adaptation); and in 35 participants who were born and are permanently residing in Arkhangelsk (Group 3, control).

To study neurometabolism, the electrophysiological NEM method was used based on measuring the level of DCP. DCP was recorded in the first half of the day, in a room with a comfortable air temperature; the time from the last meal was at least 2 hours, and the subjects were in a state of emotional rest. The study was conducted on a hardware-software complex for topographic mapping of the electrical activity, with 12 channels for recording DCP. The active electrodes were placed on the head using a 10×20 pattern; the reference electrode was placed on the left wrist. DCP processing was carried out using specially developed, licensed NEK-12 software. The values given in the study represent the average DCP level.

Statistical analysis was performed using the statistical software IBM SPSS Statistics 23. The normality of the distribution of traits in the groups was assessed using the Shapiro-Wilk criterion. Median (Me) values were presented with interquartile (IQ) ranges (IQR; 25th to 75th percentiles). Mann-Whitney U test was used to compare differences between two independent groups. A value of $P<0.05$ was considered significant. A Bonferroni correction was used to adjust for multiple testing, with a significance criterion of $P<0.017$ used for each primary analysis (i.e. 0.05/3).

The study was approved by the Ethics Committee of the Northern State Medical University (Arkhangelsk). Written informed consent was obtained from all participants.

Results and Discussion

The DCP levels for the cerebral cortex topographic areas in the study groups are presented in Table 1. According to the results obtained, the highest functional activity among Indian students of Group 1 was found in the central (Cz) and parietal (Pz) regions, which coincides with the normative dynamics of DCP in the cerebral cortex. The trend of transition was to right-hemispheric dominance: The functional activity of the parietal and temporal regions in the right hemisphere began to predominate. At the same time, the greatest activity in the frontal and central regions of the cortex was recorded in the left hemisphere. The higher total indicator of DCP in Group 1 indicates increased activity of cortical centers at the initial adaptation stage.

In Indian students of Group 2, on the contrary, a critically low total rate of DCP for the cerebral cortex was recorded, which indicates a decrease in the activity of the cerebral cortex. The functioning of any physiological system of vital activity is of a compromise nature. Removal of tension from the cerebral cortex indicates a more active inclusion of subcortical structures at the long-term stage of adaptation. The highest values are observed in the central, right-central, and right-parietal leads (Cz, Cd, Pd). In this case, the frontal structures are turned on, which is indicated by a relatively high level of potential, compared with other values, in the frontal (Fz) lead. The neurons of the parietal and frontal associative fields form the mechanisms of short-term memory, the key element of which is intracortical reverberation. As a result of this, there is probably a sharp decrease in the potential of other areas of the cerebral cortex with the transition of activation to subcortical structures. In addition, in the sixth month of their stay in the new climatic and geographical conditions, students formed a stable right-hemispheric dominance. Potential values in all departments of the right hemisphere were recorded higher than the corresponding values of the left hemisphere. Several authors suggest the presence of adaptation centers in the right hemisphere. In addition, it is known that it is the right hemisphere responsible for regulating the endocrine glands, as well as immunity. It is more autonomous and less subject to various corrective influences.

Table 1.
The DCP levels (mV) for the cerebral cortex topographic areas in the study groups.

Lead	Group 1 [1]	P_{1-2}	Group 2 [2]	P_{2-3}	Group 3 [3]	P_{1-3}	Norm
Fpz	11.08 (3.21; 22.64)	0.021	5.22 (-2.79; 12.41)	0.128	9.05 (2.69; 15.35)	0.080	8.80
Fd	12.28 (1.06; 22.85)	<0.001	-0.11 (-5.75; 8.64)	0.022	8.01 (-0.05; 14.66)	0.166	5.80
Fs	16.09 (4.16; 23.87)	<0.001	-1.45 (-6.15; 8.64)	0.001	7.46 (-0.01; 15.56)	0.159	7.20
Cd	16.55 (5.88; 32.04)	<0.001	8.66 (-1.31; 19.31)	0.245	15.78 (6.69; 21.83)	0.734	9.00
Cz	21.99 (9.09; 34.76)	<0.001	8.57 (1.56; 18.62)	0.028	15.81 (7.10; 25.19)	0.253	12.00
Cs	16.99 (4.45; 29.63)	<0.001	2.64 (-7.17; 14.83)	0.020	8.84 (4.43; 19.19)	0.089	9.00
Pd	16.97 (5.49; 29.58)	<0.001	6.40 (-2.05; 17.39)	0.041	14.43 (5.41; 20.18)	0.072	9.50
Pz	21.61 (7.85; 29.86)	<0.001	2.37 (-5.46; 12.13)	0.002	11.62 (4.16; 20.05)	0.027	10.90
Ps	16.07 (4.57; 23.77)	<0.001	5.36 (-2.53; 19.91)	0.025	8.81 (3.81; 18.07)	0.093	9.50
Oz	17.87 (11.62; 29.27)	<0.001	2.82 (-4.91; 12.09)	0.003	11.60 (4.55; 17.30)	0.010	9.60
Td	16.18 (2.37; 25.78)	<0.001	1.42 (-4.51; 10.70)	0.003	10.98 (2.05; 18.34)	0.143	9.00
Ts	14.99 (4.57; 24.85)	<0.001	0.42 (-5.92; 10.35)	0.013	7.60 (0.51; 15.39)	0.021	10.50
Sum	222.07 (56.68; 328.55)	<0.001	39.69 (-29.50; 171.91)	0.004	112.91 (75.92; 196.38)	0.884	111.10

"Norm" - DCP levels obtained from young people of a comparable age group living in the climatic conditions of Central Russia. Fpz - frontal central lead, Fd - right frontal lead, Fs - left frontal lead; Cz – central lead, Cd - right central lead, Cs - left central lead; Pz - central parietal lead, Pd - right parietal lead, Ps - left parietal lead; Oz - occipital lead; Td - right temporal lead, Ts - left temporal lead.

In Group 3, which included students living for a long time in extreme climatic and geographical conditions of the Arctic zone, there was also a stable right-hemispheric dominance with a predominance of activity in the central, parietal, and occipital regions of the cerebral cortex. The total value of DCP in the whole cortex was within the normal range, which indicates well-formed mechanisms of adaptation to extreme climatic conditions of the Arctic zone.

One of the signs of the normal distribution of DCP in the cerebral cortex is the principle of "dome," in which there is a gradual decrease in DCP in the sagittal and transverse planes from the maximum values in the vertex region and increased values in the leads of the left hemisphere, compared to the right.(7) The distribution of DCP in the studied groups is shown in Figure 1. As can be seen, the dome principle is violated to a greater or lesser extent in all groups. Indian students in short-stage adaptation had high values of DCP in the central and parietal regions with a sharp decrease toward the periphery. Indian students in the long-term adaptation had a bias in the maximum DCP values in the frontal region and a decrease in DCP in the parietal and occipital regions. Among northern students, the violation of the principle of "dome" was manifested in the shift of higher rates of DCP to the right hemisphere. Higher DCP values in the right leads, according to the studies of Gribanov et al.,(4,10,11) are a distinctive feature that characterizes the redistribution of the DCP level in people living in the North.

It is now known that humans living in uncomfortable climatic conditions are accompanied by an increased functioning of certain body systems. With insufficient autonomous support for the organism's life, the mobilization of strategic reserves is carried out with the participation of central regulatory mechanisms.(12)

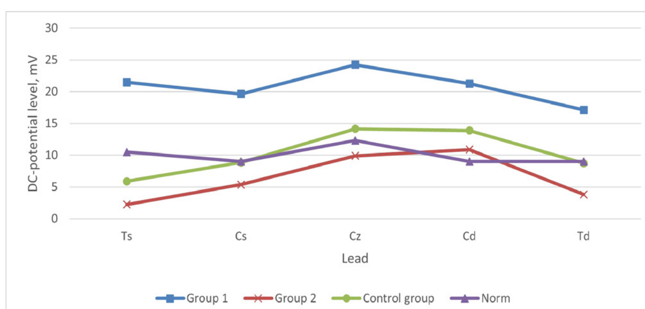

Fig. 1. *DCP distribution in coronal plane.*

Conclusion

Thus, Indian students, depending on the time spent in the climatic conditions of the Arctic Circle, reveal various features of cerebral metabolism. Thus, the acute stage of adaptation to a cold climate shows inadequate responses to stress caused by new environmental conditions, such as a significant increase in DCP throughout the cerebral cortex with a maximum in the central leads. After 6 months of living in a new climate, the DCP level decreases, which indicates signs of an adaptive disorder of brain function.

Competing Interests

The authors declare that they have no competing interests.

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