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Element Status of Students with Different Levels of Adaptation

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The element status was studied in students with different levels of adaptation determined by the parameters of cardiointervalography. The content of chemical elements in the hair was measured by atomic emission and mass spectrometry. In students whose autonomic status was characterized by sympathicotonia, the level of cobalt in the hair was significantly higher, while the levels of manganese and magnesium were lower than normal. The content of selenium in the hair was 2.3 times lower in the study group in comparison with the median level in Russia. The content of toxic elements did not exceed the normal. Significant positive correlations between hair content of magnesium and calcium and between potassium and sodium were revealed.

Key Words: *trace elements; adaptation; autonomic status; students*

Students of higher school are exposed to stress factors of different intensity. The adaptation reactions of the body can be evaluated by the parameters of the cardiovascular system that depend to a great measure on the autonomic status. Cardiointervalography is a method for evaluation of adaptation processes associated with autonomic regulation of the cardiac function in humans [1,2,5]. The hormonal and element status can serve as markers of adaptation reactions at the molecular level. The relationship between the element status of various biological substrates of human body and changes in the hormonal profile has been studied previously [12]. Shifts in the element status in various manifestations of adaptation disorders [10] are also in the focus of research, and the search for approaches to correction of adaptation disorders is in progress [3].

Here we studied the element status of the hair in students with various levels of adaptation.

MATERIALS AND METHODS

Students of the Orenburg State University (males; *N*=60; mean age 18.7±.1 years) were included in the study. All students had lived in the Orenburg region for the latest 5 years or longer and had no health complaints during the study; all of them signed informed consent to participation in the study. The students were distributed into two groups by cardiointervalography values. The cardiointervalography method based on R. M. Baevskii concept can be used for studies of the adaptation and compensatory reactions [1].

In group 1 students, the strain index values corresponded to the adaptive shift zone, or normotone (50-150 arb. units). In group 2, the basal index of strain was significantly (1.65 times) higher than in group 1 (>150 arb. units). Hence, the autonomic tone of group 2 subjects could be described as sympathicotonia, which attests to overstrain of the regulatory systems.

Activities of the sympathoadrenal, parasympathetic, central, and humoral mechanisms, their proportions, and strain of the adaptation reaction were evaluated by cardiointervalography [1]. Serum levels of thyroid-stimulating hormone (TSH), free thyroxin (T_4), and testosterone (TS) were measured by the standard methods.

Analysis of the specimens (hair) was carried out at Center of Biotic Medicine (Moscow). Chemical elements were measured in the hairs by atomic emission

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and mass spectrometry on Elan 9000 and Optima 2000 DV spectrometers (Perkin Elmer).

The data were processed by the common statistical methods using Microsoft Excel software. Normality of data distribution was verified by the Kolmogorov—Smirnov test. Quantitative values were presented as the median (Me) and interquartile range (Q_1; Q_3). As $n<30$ and the variables did not conform to the normal distribution, significance of differences (similarity) for the two independent samples was evaluated by the Mann—Whitney *U* test. Analysis of correlations was carried out using Spearman's rank correlation test. The differences were considered significant at $p<0.05$.

RESULTS

At stage 1 of the study, the hormonal status of the students was evaluated. Many factors, including thyroid hormones and TS, are involved in regulation of cardiovascular system activity [8,11]. Analysis of the results has shown no appreciable differences between the groups for TSH, free T_4, and TS (Table 1). All the values are within the normal range.

At the next stage, the element composition of the hairs was analyzed. The content of cobalt in hair samples from group 1 students was significantly (by 1.47 times) higher than in group 2 (Table 2). Cobalt

TABLE 1. Hormonal Parameters of Students (Me(Q_1-Q_3)

Parameter	Normal range (Q_1-Q_3)	Group 1	Group 2
TS, nmol/liter	12-42	18.2 (15.3-21.3)	18.49 (15.3-21.4)
Free T_4, pmol/liter	9-22	15.85 (12.2-18.3)	16.3 (12.5-19.6)
TSH, U/liter	0.4-4.0	2.97 (2.6-3.7)	3.34 (2.8-3.5)

TABLE 2. Hair Levels of Essential Elements (mg/kg) in Students (Me(Q_1-Q_3)

Element	Mean for Russia (Q1-Q3)	Group 1	Group 2
Co	0.04-0.16	0.025 (0.018-0.101)	0.017 (0.015-0.023)*
Cr	0.32-0.96	0.79 (0.52-1.08)	0.78 (0.53-1.08)
Cu	9.00-14.0	10.7 (10.0-12.8)	10.9 (10.1-12.7)
Fe	11.0-24.0	33.6 (27.2-40.2)	34.2 (23.6-37.5)
I	0.27-4.20	1.00 (0.73-1.70)	0.84 (0.73-1.32)
Li	0.00-0.02	0.04 (0.03-0.05)	0.04 (0.026-0.049)
Mn	0.32-1.13	0.73 (0.56-1.36)	1.44 (0.763-1.36)*
Ni	0.14-0.53	0.28 (0.20-0.31)	0.27 (0.172-0.294)
Se	0.69-2.2	0.31 (0.26-0.33)	0.33 (0.27-0.39)
Si	11.0-37.0	26.1 (21.6-32.2)	28.8 (21.8-33.4)
Zn	155.0-206.0	165.2 (122.8-179.3)	177.2 (157.5-188.1)*

Note. Here and in Table 3: *$p<0.05$ in comparison with group 1.

TABLE 3. Hair Levels of Macroelements (mg/kg) in Students (Me(Q_1-Q_3)

Element	Mean for Russia (Q1-Q3)	Group 1	Group 2
Ca	494-1619	786.5 (481.8-1510.1)	705.9 (471.7-1193.2)
K	29-159	110.9 (57.5-168.5)	97.4 (49.2-171.5)
Mg	39-137	117.5 (89.5-190.3)	92.9 (59.5-131.3)
Na	73-331	369.5 (273.1-479.7)	375.5 (327.2-459.7)
P	135-181	154.0 (138.9-161.3)	150.4 (141.4-163.1)

deficit in humans can manifest in vegetative-vascular disorders, general weakness, fatigue; manifest deficit of this element leads to development of anemia [4]. According to some data, cobalt contributes to regulation of the cardiovascular system activity [6].

In group 1 students, hair level of manganese was 2-fold lower that in group 2 students. High level of manganese in the hair can indicate intense discharge of the element occurring, for example, in mental stress [4]. Manganese levels were higher than normally in patients with neurological disorders [7].

No appreciable differences between the groups were detected for other essential elements.

Macroelement analysis of the hairs of youths has shown a significant (1.27 times) decrease in the content of magnesium in group 2 in comparison with group 1 students (Table 3). Low magnesium level manifests by fatigue, irritability, cardiovascular disease [4,9].

The data on the gross and trace element levels in the hairs of students are compared to the mean for Russia values [4]. Virtually all the values are within the range of recommended centile intervals, the detected shifts are negligible. However, low selenium level in the hair is detected. The median values for hair selenium in the youths of both groups are 2.3 times lower than centile 25 of the mean for Russia value.

The content of toxic elements (aluminum, cadmium, mercury, lead, and tin) in the hair are within the normal range of values in both groups. No differences between the groups are detected for toxic elements.

Analysis of correlations has shown some correlations between the element levels. Positive correlations are detected between hair magnesium and calcium (r=0.63 for group 1 and r=0.76 for group 2) and between potassium and sodium (r=0.85 for group 1 and r=0.76 for group 2). These data are in good agreement with numerous studies demonstrating conjugation of the metabolic processes of these elements [4].

Hence, differences in the hair element composition are detected in young people with various adaptation levels. The groups do not differ by the levels of TSH, free T_4, and TS. A significant increase of cobalt and decrease of manganese and magnesium levels in the hair are detected in students with the autonomic status characterized by sympathicotonia.

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