Hair Trace Elements, Hematological and Psychological Parameters of Students with Different Diets

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Abstract — The effects of fast food, instant food and semi-finished products on trace element status, hematological and psychological parameters of students were studied. Students who consumed fast food, instant and convenience foods (the 1st group), as well as students who consumed nutrient-enriched health food (the 2nd group) took part in research (30 participants). Significant decrease in Co, Zn and K content by 1.5, 1.4 and 2.8 times respectively was found in the 1st group. Also in the 1st group significant increase in Cu and Na content was determined. Se content in the hair of all participants was lower than normal. The content of toxic elements in all respondents was in the normal range. Lower hemoglobin values were found in students with unbalanced nutrition, but these values did not indicate anemia. For psychological test questionnaire "Well-being, activity, mood" was used. For 27% students with unbalanced diet current psychological state was determined as unfavorable and only for 33% - as favorable. At the same time, the integral indicator of questionnaire “Well-being, activity, mood” positively correlated ($r = 0.807, p <0.05$) with the hair Zn level.

Keywords — hemoglobin, nutrient-enriched health food, operating costs, psychological parameters, hematological parameters

I. INTRODUCTION

The consumption of fast food, instant food and convenience products increases with each passing year. Preliminary industrial and culinary processing leads to significant change in products’ nutritional value. The logical result of this situation is the growing interest in the problem of food quality. Scientists from different countries conduct extensive sociological and biomedical research on the effects of fast food on the body of children and adults [1]. For example, Fulkerson J. A. [2] in his study highlights the fast food market in America and notes that the fast food industry, thanks to huge funds and advertising, hinders the best efforts of scientists and doctors to achieve healthy nutrition and health goals. The interrelation of socio-economic status [3], geographical availability of fast food outlets and the amount of fast food consumed [4], as well as the impact of fast food products on the development of obesity [5] are being studied.

One of the important indicators of the nutritional status of the organism is the trace element composition of tissues [6]. Despite a controversial assessment of the clinical and scientific significance of the hair trace element analysis, at present hair is considered a reliable indicator of long-term effects on the body. This tissue, being an appendage of the skin, can be used, inter alia, to assess nutritional status. The undoubted advantage is the availability of hair, painless sampling, non-invasive procedures, storage and transportation simplicity of the collected material [7].

The aim of the work was to study the effect of fast food, instant food and semi-finished products on the element status, hematological and psychological parameters.

II. MATERIALS AND METHODS

2.1 Subjects

Male students, age $18.7 \pm 0.3$, took part in the survey.
92 students were interviewed to assess the intake of fast food, instant food and semi-finished products.

Than 30 participants were chosen and divided into 2 groups. Students from the 1st group (15 participants) had a diet with a predominance of fast food and semi-finished products, student from the 2nd group (15 participants) had nutrient-enriched health food. All respondents lived in the Orenburg region for at least 5 years. The exclusion criteria were the presence of chronic and acute diseases at the time of the study. The informed consent of the participants was obtained. The work complied with the ethical principles of the World Medical Association Declaration of Helsinki.

2.2 Study Instrument

24-hour diet recall was used to study participants’ diets. The data obtained were entered into the database and processed using the nutritional assessment program (ASPON-nutrition, St. Petersburg Medical Academy, BIMK-D, 1996, approved by the Federal State Statistics Service of the Russian Federation for Social Intelligence in the Russian Federation in 1996), as well as using reference tables of the chemical composition of food products and data presented on food packaging. To assess the data obtained, “Norms of physiological needs for energy and nutrients for various groups of the population of the Russian Federation” (MR 2.3.1.24.32-08) were used.

Anthropometric measures were carried out according to the accepted World Health Organization (WHO) standards and using standard measuring devices. Body mass index (BMI) was calculated by dividing the weight in kilograms by the height squared in meters (kg/m²).

2.3 Biochemical studies

Hematological (complete blood count test) and biochemical (total protein, bilirubin, glucose, creatinine, ALT, AST) studies were assessed in the Orenburg State University Student Clinic.

2.4 Trace element analysis

The element composition of hair was assessed by atomic emission and mass spectrometry with inductively coupled argon plasma (AES-ICP and MS-ICP) in the testing laboratory of ANO "Center for Biotic Medicine” Moscow (accreditation certificate - GSEN. RU. COA. 311, the registration number in the state register - Ross. RU 0001. 513118 dated May 29, 2003; Registration Certificate of ISO 9001: 2000, Number 4017-5.04.06). Analysis of the studied samples was carried out on 25 chemical elements. The results were compared with the reference values of trace elements in the hair [8].

2.5 Psychological research

To assess the current psychological state, the test "Well-being, activity, mood" was used. The study was performed on the hardware-software complex "NS-PsychoTest" (Neurosoft Company, Russia, Ivanovo). The diagnostic material of the test "Well-being, activity, mood" consists of 30 pairs of definitions that are opposite in meaning. It includes 3 scales: well-being, activity, mood. Interpretation of the results on each scale is carried out as follows: less than 4 points - an unfavorable state, 4-5 - a moderate state, more than 5 - a favorable state. Then the index of the integral psychological state is calculated by finding the arithmetic average of the three scales.

2.6 Statistical analysis

Processing of the material obtained was carried out using conventional statistical methods (program "Statistica 10.0"). Parameters of descriptive statistics for quantitative indicators are provided in the form of a median (Me) and interquartile range (25th; 75th percentile - Q1; Q3). Mann-Whitney U-test was used to estimate the significance of the similarity (difference) of two independent samples. The difference was considered significant at p <0.05. Correlation analysis was performed using the Spearman correlation coefficient.

III. RESULT AND DISCUSSION

The diet of 1st group students was characterized by a higher calorie content, as well as a higher content of fats and carbohydrates (Fig. 1). At the same time, the caloric intake in both groups did not exceed the recommended values (2450 Kcal / day) and amounted to 2430 (2301 - 2640) Kcal / day for the first group and 2347 (2270 - 2475) Kcal / day for the second group.

![Fig. 1. Daily macronutrients intake among students](image-url)
The anthropometric parameters of the respondents on average corresponded to centile intervals of this age group. However, in the 1st group BMI exceeded the recommended values for 27% of students.

Hematological and biochemical blood parameters of all respondents were within the reference values provided to us by the laboratory. When assessing intergroup differences, a significantly lower hemoglobin content in the blood of 1st group students (139 (132-145) g / l) was detected (p = 0.017) compared with the second group (148 (139-155) g / l).

The analysis of the element composition of students' hair revealed significant intergroup differences for a number of macro- and essential elements (Table 2 and 3). Significant increase in hair Na content of the 1st group students was found. Such results seem logical, since the 1st group respondents' sodium consumption exceeded the WHO recommended value of 2 g / day [9].

The value of potassium in the 1st group were lower by 2.8 times compared to the 2nd group, although it was not lower than the references value. The recommended potassium intake is 1.8 - 2.0 g / day, however, in the diet with a predominance of fast food products, an insufficient amount of potassium was found. The problem of excess sodium intake against the background of regular consumption of fast food products was again confirmed that selenium deficiency is typical for Orenburg background of many publications related to nutrition [10].

Significant reduction in the content of cobalt (1.5 fold) than the reference values. Such data once more confirms that selenium deficiency is typical for Orenburg area. Further evidence of cobalt influence on erythropoiesis [12].

There is evidence of cobalt influence on erythropoiesis [11]. There is evidence of cobalt influence on erythropoiesis [12]. However, in our study, no correlation was found between hair cobalt content and hemoglobin level.

The selenium content in the hair of students of both groups was lower (2.3-fold) than the reference values. Such data once again confirms that selenium deficiency is typical for Orenburg.

### TABLE I. ANTHROPOMETRIC PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Norm</th>
<th>The 1st group</th>
<th>The 2nd group</th>
<th>MWU</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>171.5 – 181.5</td>
<td>173 (169 – 177)</td>
<td>171 (170 – 181)</td>
<td>0.617</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>59.8 – 74.0</td>
<td>71 (68 – 79)</td>
<td>67 (65 – 71)</td>
<td>0.032*</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>19 - 24</td>
<td>23.9 (23.1 - 26.4)</td>
<td>22.5 (20.5 - 24.6)</td>
<td>0.025*</td>
<td></td>
</tr>
</tbody>
</table>

Data presented as median (25-75); **MWU**=p values as assessed by Mann-Whitney U-test

* -difference significant at p<0.05

### TABLE II. CONTENT OF MACROELEMENTS IN STUDENTS' HAIR

<table>
<thead>
<tr>
<th>Elements</th>
<th>Reference values</th>
<th>The 1st group</th>
<th>The 2nd group</th>
<th>MWU</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>494 - 1619</td>
<td>772.9 (537.8 - 1069.1)</td>
<td>751.9 (447.3 - 1834.7)</td>
<td>0.678</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>39 - 137</td>
<td>123.95 (87.0 - 164.9)</td>
<td>113. (97.8 - 264.7)</td>
<td>0.709</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>135 - 181</td>
<td>147.4 (130.9 - 163.8)</td>
<td>155.0 (140.56 - 167.7)</td>
<td>0.263</td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>73 - 331</td>
<td>388.2 (237.46 - 550.9)</td>
<td>211.6 (178.3 - 292.1)</td>
<td>0.028*</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>29 - 159</td>
<td>47.4 (37.3 - 66.5)</td>
<td>132.2 (41.7 - 198.7)</td>
<td>0.031*</td>
<td></td>
</tr>
</tbody>
</table>

Data presented as median (25-75); **MWU**=p values as assessed by Mann-Whitney U-test

* -difference significant at p<0.05

### TABLE III. CONTENT OF ESSENTIAL ELEMENTS IN STUDENTS' HAIR

<table>
<thead>
<tr>
<th>Elements</th>
<th>Reference values</th>
<th>The 1st group</th>
<th>The 2nd group</th>
<th>MWU</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>0.04 - 0.16</td>
<td>0.028 (0.015 - 0.038)</td>
<td>0.043 (0.032 - 0.048))</td>
<td>0.003*</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>0.32 - 0.96</td>
<td>0.646 (0.506 - 0.851)</td>
<td>0.66 (0.511 - 0.864)</td>
<td>0.820</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>9 - 14</td>
<td>17.6 (13.2 - 22.5)</td>
<td>11.69 (10.17 - 16.88)</td>
<td>0.038*</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>0.27 - 4.2</td>
<td>1.14 (0.46 - 2.23)</td>
<td>0.895 (0.613 - 2.050)</td>
<td>0.868</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>11 - 24</td>
<td>19.4 (15.09 - 27.78)</td>
<td>26.51 (21.71 - 38.96)</td>
<td>0.089</td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>0.00 - 0.56</td>
<td>0.067 (0.045 - 0.078)</td>
<td>0.064 (0.042 - 0.18)</td>
<td>0.917</td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>0.00 - 0.2</td>
<td>0.031 (0.025 - 0.043)</td>
<td>0.036 (0.024 - 0.043)</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.32 - 1,13</td>
<td>0.634 (0.352 - 0.998)</td>
<td>0.763 (0.513 - 1.3)</td>
<td>0.213</td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>0.14 - 0,53</td>
<td>0.19 (0.175 - 0.229)</td>
<td>0.22 (0.17 - 0.367)</td>
<td>0.407</td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>0.69 - 2,2</td>
<td>0.306 (0.211 -0.348)</td>
<td>0.303 (0.264 - 0.362)</td>
<td>0.648</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>11 - 37</td>
<td>30.92 (24.75 - 38.32)</td>
<td>26.22 (18.99 - 33.1)</td>
<td>0.229</td>
<td></td>
</tr>
</tbody>
</table>

Data presented as median (25-75); **MWU**=p values as assessed by Mann-Whitney U-test

* -difference significant at p<0.05
region residents. Many researchers note that selenium consumption varies greatly in different geographic regions. According to Margaret P Rayman, the consumption of selenium in the world, unlike most other trace elements, ranges from 7 μg per day to 4990 μg per day. The author notes that in the countries of Eastern Europe, selenium consumption is significantly lower compared with the countries of Western Europe and the United States [13].

The content of Zn in the 1st group students’ hair was 1.4 times lower compared with the second group. Current epidemiological studies show that more than 20% of people around the world actually suffer from zinc deficiency [14].

Zn plays an important role in the immune system, it affects lymphopoiesis, activity and viability of almost all types of mature immune cells, cytokine production and polarization of T-helper subgroups [15, 16]. Therefore, Zn deficiency has serious immunological consequences and is associated with allergic, infectious, autoimmune diseases, and can also lead to renal and cardiovascular pathologies [17].

Simultaneously with a decrease in the content of Zn, an increase in the content of Cu in the 1st group students’ hair was revealed. It is known that many trace elements affect each other’s homeostasis. In particular Zn and Cu compete for intestinal absorption, binding with metallothioneins and the bivalent metal transporter (DMT1) [17].

The content of toxic elements in the hair of all respondents was in the normal range.

### TABLE IV. CONTENT OF TOXIC ELEMENTS IN STUDENTS’ HAIR

<table>
<thead>
<tr>
<th>Elements</th>
<th>Reference values</th>
<th>The 1st group</th>
<th>The 2nd group</th>
<th>MWU/P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.02 - 0.12</td>
<td>0.02 (0.016 - 0.035)</td>
<td>0.024 (0.014 - 0.033)</td>
<td>0.819</td>
</tr>
<tr>
<td>Al</td>
<td>6 - 18</td>
<td>12.73 (10.82 - 16.11)</td>
<td>13.28 (10.83 - 19.82)</td>
<td>0.740</td>
</tr>
<tr>
<td>Pb</td>
<td>0.38 - 1.4</td>
<td>0.346 (0.289 - 0.635)</td>
<td>0.369 (0.267 - 0.508)</td>
<td>0.772</td>
</tr>
</tbody>
</table>

Data presented as median (25-75); MWU/P= p values as assessed by Mann-Whitney U-test

According to psychological study 27% of in the first group had unfavorable current psychological state and 33% students - favorable. Among students who consume a balanced diet 73% of respondents had high scores of the integral indicator of the “Well-being, activity, mood” questionnaire and their psychological state was defined as favorable. Since numerous studies associated mood disorders with Zn metabolism [18], we conducted a correlation analysis of the indicators of the “Well-being, activity, mood” scale and the Zn content in the students’ hair (Figure 2). A reliable positive relationship between the integral indicator of this scale and the Zn content was found.

**IV. CONCLUSIONS**

Thus, the features of the element composition of the hair of students who consume fast food, instant and convenience foods are revealed. A significant decrease in Co, Zn and K content was found (1.5, 1.4 and 2.8 – fold, respectively). Cu and Na contents were increased. Se content in the hair of all the participants was lower than normal. The content of toxic elements in all respondents was in the normal range. Lower hemoglobin values were found in students with unbalanced nutrition, but these values did not indicate anemia. For psychological state assessment questionnaire “Well-being, activity, mood” was used. For 27% students with unbalanced diet current psychological state was determined as unfavorable and only for 33% - as favorable. At the same time, the integral indicator of questionnaire “Well-being, activity, mood” positively correlated (r = 0.807, p <0.05) with the hair Zn level.

**Acknowledgments**

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**References**


prevalence in students and its association with general and abdominal obesity J. of preventive medicine and hygiene, 2018, vol. 59(3) , pp. E236


