Conference Paper

Indicators of Mineral Metabolism Depending on the Body Mass Index

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Abstract

In this study, the elemental status of the hair of adolescent girls in the Orenburg region (n=120) with different levels of body mass index was studied and their average daily diet was evaluated. A nutrition assessment program was used to study the diet. Estimation of the element status was carried out through the study of the chemical composition of the hair by ICP-AES and ICP-MS. It was found that there was a general imbalance of elements in the diet of all of the studied groups, and students with obesity had lower consumption levels of all elements, except Mg and Se. Similarly, obese students had lower levels of all elements in their hair except Se, P, and Zn. Thus, changes in the level of body mass index, as well as geochemical features of the territory of the Orenburg region, affect the content of most macro- and microelements.

Keywords: metabolic syndrome, trace elements, body mass index

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1. Introduction

There are various definitions of metabolic syndrome (MS) offered by numerous health organizations (for example, NCEP, IDF, AACE, and others), but in most cases the differences are insignificant. The world health organization (WHO) defines MS as a pathological condition characterized by abdominal obesity, insulin resistance, hypertension and hyperlipidemia. [1] People with MS have an increased risk of developing cardiovascular diseases and type 2 diabetes [2-5]

The global prevalence of MS can be estimated at about one–quarter of the world's population, which is more than a billion people [1]

Analysis of literature data shows that obesity is the basis of most cases of metabolic syndrome, being a marker of adipose tissue dysfunction [2, 6-7]. This statement also confirms the fact that the prevalence of metabolic syndrome often coincides with the

prevalence of obesity and the incidence of type 2 diabetes [1] It is important to note that the growth rate of this problem continues to increase [8]. Research in recent years shows that more than 1.9 billion adults worldwide are already overweight and 650 million are obese. Approximately 2.8 million deaths are reported as a result of being overweight or obese [9]. One of the diagnostic indicators of obesity is the body mass index (BMI), which allows us to assess the degree of compliance of a person's weight and height, and thus indirectly judge whether the mass is insufficient, normal or excessive [10-11].

. A group of Israeli scientists has shown that a normal BMI makes it possible to exclude the presence of metabolic syndrome in men and women at any age [12]. Thus, current research shows that BMI, along with other factors, is an easy–to–use indicator that is a predictor of metabolic syndrome [13]

There are a number of studies that analyse the possibility of using the content of trace elements in various biosubstrates as biomarkers of MS, as well as their use as food additives for metabolic correction [14, 15]. The results of numerous studies indicate that obesity–related metabolic disorders can be mediated by changes in the levels of trace elements in the body [16]. This is due to the fact that trace elements play an important role in the normal functioning of carbohydrate and lipid metabolism [15, 18]. The functioning of the body with an unbalanced diet can cause the development of various pathological conditions, including obesity and MS [14]. It is especially important to take this into account in adolescence, since this age period is characterized by a physiological restructuring of the body and is accompanied by a significant strain of functional systems [19]. In this regard, the purpose of this study was to study the elemental hair status of adolescent girls with different BMI levels and assess their average daily diet.

2. Methods and Equipment

The study involved healthy girls from 15 to 18 years old, college students in Orenburg. Groups of 800 students were selected for the study (n=100). After performing anthro-pometric studies (weight, height), three groups were formed depending on BMI: group I (n=40) – BMI value from 18.5 to 24.9 (normal body weight), group II (n=40) – BMI value from 25 to 29 (overweight – pre – obesity) and group III (n=20) – BMI value from 30 to 35 (obesity). The interpretation of BMI indicators used was in line with WHO recommendations [20]

The actual nutrition assessment program was used to study nutrition. The elemental status was assessed by studying the chemical composition of hair using ICP–AES and ICP–MS methods in the laboratory of the ANCO «Center for Biotic Medicine».

The statistical processing of digital material was carried out using the application «Excel» and «Statistica 6.0». The statistical significance of differences between the groups was assessed using the Mann–Whitney U–test.

3. Results

Table 1 shows the indicators of physical development of students with normal body weight (group I), overweight (group II) and obesity (group III).

TABLE 1: The indexes of physical development, Me $(Q_{25}-Q_{75})$

Indicator	Group I (BMI 18.5–24.9)	Group II (BMI 25–29)	Group III (BMI 30–35)
Body mass	56 (52.2–60)	74 (67.2–75.5)[b]	84.5 (83.2–85.7)[b]
Body height	1.7 (1.6–1.72)	1.6 (1.58–1.7)	1.6 (1.59–1.65)
BMI	20.3 (19.5–21.6)	26.6 (25.3–28.9)[b]	33 (32.5–33.5)[b]

[a] Reliability of differences in performance with group I – $p<0.05$;

[b] Reliability of differences in performance with group I – $p<0.01$.

The values of student growth in all groups were almost the same. The studied anthropometric indicators of weight and BMI in groups II and III significantly changed when compared with group I, reflecting the dependence of BMI on weight.

The analysis of diets allowed us to conclude that the diet is unbalanced in terms of macro – and microelements consumption in all the study groups (table 2).

Consumption of Na, P, Ca, Mg and Zn corresponded to the norms of physiological needs in all the study groups. Groups I and II showed the most pronounced excess consumption of K (by 12 and 13 %), Fe (by 37 and 42 %), Cr (by 28 and 6 %) and Cu (by 18 and 6 %). In all three groups, there was a trend towards increased Mg consumption (Q75 above the recommended values by 52, 112 % and 66 %). The supply of other chemical elements in the diet was insufficient. In all groups of students surveyed, there was a tendency to insufficient consumption of Se (by 99 %) and I (by 31%). In group III, there was a deficit in Cu (2 %) and Mn (50 %) consumption. It should be noted that with a general imbalance, students with obesity had lower values of the level of consumption of all studied macro–and microelements, except Mg and Se.

The results of the study of macro– and microelements in the hair of students are presented in table 3.

TABLE 2: The content of elements in the diet, mg/day, Me (Q_{25}–Q_{75})

Element	Group I (BMI 18.5–24.9)	Group II (BMI 25–29)	Group III (BMI 30–35)	Normal range[1]
Na	932.6 (700.5–1 500)	1 122 (857–1 726)	719 (474–964)	200–1300
K	2 822 (2 278–3 667)	2 848 (2 112–3 842)	1 574 (1 323–1 824)[a]	400–2500
Ca	497.3 (362.2–662.2)	594.5 (406.5–803.5)	421.5 (278.7–564.3)	400–1200
Mg	363.9 (242.8–608)	402.4 (317.1–851.2)	519 (371.2–666.8)	55–400
P	974.1 (796.8–1 215)	1 088 (737.3–1 261)	538.4 (381.3–695.7)	300–1200
Fe	24.7 (20.1–32.2)	25.6 (20.6–33.5)	15.3 (14.7–15.9)[a]	4–18
Cr	0.045 (0.029–0.063)	0.037 (0.032–0.050)	0.020 (0.016–0.024)	0.011–0.035
Cu	1.18 (0.941–1.54)	1.06 (0.762–1.37)	0.49 (0.40–0.58)[a]	0.5–1
Se	0.0039 (0.0026–0.0061)	0.004 (0.0026–0,01)	0.0052 (0.0034–0.0071)	0.01–0.05
Zn	6.81 (5.07–8.66)	6.64 (4.28–7.57)	3.16 (2.49–3.82)	3–12
Mn	2.45 (1.80–3.72)	2.29 (1.73–3.59)	1.11 (0.77–1.46)	2–5
I	0.041 (0.029–0.056)	0.041 (0.026–0.054)	0.032 (0.019–0.045)	0.06–0.15

[1] «Norms of physiological needs in energy and food substances for various groups of the population of the Russian Federation» (Mr 2.3.1.24.32–08);

[a] Reliability of differences in performance with group I – $p < 0.05$;

[b] Reliability of differences in performance with group I – $p < 0.01$.

TABLE 3: Content of elements in hair, mg/kg, Me (Q_{25}–Q_{75})

Element	Group I (BMI 18.5-24.9)	Group II (BMI 25-29)	Group III (BMI 30-35)	National average[1]
Na	79.1 (49.1–143.7)	85.6 (41.2–119.1)	54 (44.6–63.4)	18–1720
K	25.5 (15.4–46.7)	27.6 (20.3–42.4)	19.6 (16.1–23.1)	150–663
Ca	1 834 (1 198–3 008)	2 477 (1 594–3 647)	1 433 (1 252–1 614)	200–2000
Mg	205 (138.2–371.2)	252.4 (141.3–320.7)	148.3 (138.1–158.5)	19,0–163
P	128 (119.3–143.1)	120.4 (111.1–126. 7)[a]	137.9 (137.2–138.5)	75–200
Fe	16.5 (12.6–22.7)	15.8 (11.3–21.2)	12 (11.1–12.9)	5.0–25
Cr	0.26 (0.20–0.36)	0.27 (0.22–0.31)	0.19 (0.18–0.20)	0.1–20.0
Cu	12 (9.7–15.9)	11.2 (9.3–13.4)	12.05 (10.4–13.6)	7.5–80
Se	0.33 (0.23–0.42)	0.31 (0.20–0.41)	0.40 (0.34–0.47)	0.5–1.5
Zn	177.7 (161.6–198.4)	161.1 (148.3–172.1)[a]	188.9 (180.3–197.4)	100–250
Mn	0.77 (0.51–1.85)	1.28 (0.80–1.70)	0.44 (0.40–0.47)	0.1–2.0
I	0.38 (0.17–0.99)	0.34 (0.12–0.59)	0.08 (0.07–0.1)	0.27–4.2

[1] Bertram P., 1992; Skalny A.V., 2000;

[a] Reliability of differences in performance with group I – $p < 0.05$;

[b] Reliability of differences in performance with group I – $p < 0.01$.

The content of Na, P, Fe, Cr, Cu, Zn, Mn and I in all groups of students was within the recommended values. In groups I and II, there was an increase in Mg level (by 25 and 54 %) and an increase in CA level in group II (by 23 %). In all three groups, there was a

downward trend in the levels of K (83, 82 and 87 %) and Se (34, 38, and 19 %). Group III students had lower values of all studied macro– and microelements in hair, except Se, P and Zn.

4. Discussion

Microelements are important for the prevention of a number of diseases and for improving overall health due to their diverse biological role in the body. Even a small number of them interact with macromolecules, including prohormones and biological membranes. Since most trace elements are not formed endogenously or are formed in insufficient quantities, they must be supplied to the body with a balanced and varied diet [21]. It is important to note that with a general imbalance of trace elements in the diet of all three groups studied, it was students with obesity who had the lowest values of the level of consumption of all the studied macro–and microelements. A group of scientists from the United States explain these results by the fact that, despite the increased caloric content of food, the diet of obese people often does not meet the recommended dietary requirements for the consumption of micronutrients [22].

Recent studies have shown that an imbalance of certain trace elements in the body may be associated with the frequency of obesity and increased fat deposition [23-24]. For example, a low concentration of Zn in the blood has been shown to be associated with dyslipidemia, an inflammatory condition, and insulin resistance in overweight patients [25]. Data from the national health and nutrition survey in China provide epidemiological evidence that blood trace elements are associated with childhood and adolescent obesity [13]. However, hair is often used as a biosubstrate to study the content of elements. This method is characterized by ease of collection of the study sample and non–invasiveness. It is assumed that the content of elements in hair can provide useful prediagnostic information about the risk of developing obesity and MS [26]. It was found that people suffering from obesity are characterized by a lower content of a number of micro–and macronutrients in the hair relative to people with normal body weight [16]. This fact is also observed in our study, students with obesity recorded lower values of the content of all studied macro–and microelements in hair, except Se, P and Zn. The detected elevated concentrations of Ca and Mg in the hair of normal and overweight students may indicate their pre–deficit state in the body [27]. The total lack of Se in the hair of all students, regardless of the BMI value, reflects the geochemical features of the territory of the Orenburg region [28, 29]

5. Conclusion

BMI is correlated with the content of most of the studied elements. The levels of the following macro–and microelements had the greatest relationship with obesity: Ca, I, Mg, Mn. The identified imbalance in the diets of students indicates the need to adjust diets, as well as the need to improve the literacy of students in matters of balanced and complete nutrition, such as the prevention of obesity and MS.

Conflict of Interest

The authors have no conflict of interest to declare.

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