Structure of Macro- and Trace Elements Status Observed in Residents of Magadan Town

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Received: September 09, 2014 / Accepted: September 30, 2014 / Published: September 30, 2014.

Abstract: The authors aimed the study at examining macro- and trace elements content in elderly people of the 1 period of middle age (21-35) residing in Magadan town to assess the content of 25 trace elements in hair samples on individual and population levels by atom-emission spectrometry with inductively-bonded argon plasma. It turned out that the majority of surveyed subjects were characterized by deformation of element status demonstrated by excess and deficit of the basic essential elements of different degrees of manifestation. Deficit of Co (68% of surveyed people), Mg (67%), Ca (64%), Cu (47%), K (46%), Zn (44%), I (41%), Na (33%), P (27%) and Se (24%) was typical for female subjects as well as excess of Si (28%), Zn (22%) and P (20%). Male residents were characterized by deficit of Co (81%), Ca (66%), Mg (65%), I (50%), Cu (37%), K and Na (27%) and excess of Zn (41%). In individual cases it was noted excess concentration of nominally essential and toxic elements in both examined groups. They were: Al, As, Cd, Li, Ni, Pb, Sn, V and B. While analyzing of medians of chemical concentration it was stated reliable sex-related differences ($P < 0.05$): content of Ca, Mg and Mn was higher in hair samples of women, and content of As, B, Cd, Cr, K, Li, Na, P, Pb and V, on the contrary, was higher in male samples.

Key words: Macro- and trace elements, misbalance, the North, men, women.

1. Introduction

For the last decade it has been noted the worsening of health state of Russia's population that was explained by influence of socio-economic and ecological factors. This process is characterized by chronization of disease, mortality growth in employable population and in children, birth-rate failing and average-expectancy life of Russians [1].

Anyway most diseases are connected with and often caused by the environment factors, which are well known regarding Russia's north. Low environmental temperatures, photoperiodicity, high level of the air ionization, sharp non-periodical tension fluctuations occurred in geomagnetic and static electric field, atmospheric pressure over-falls and lowered partial density of oxygen in the air are among them. The

exposure of the body to these unfavourable factors can cause disorders in the main physiological systems and lead to pathologies. In addition, it is known that the most significant disorders usually occur in respiratory, hematogenic and blood circulatory systems, as well as in immune, endocrine, reproductive and nervous systems. As regards the term of the "polar" metabolic type, it has been already formulated, while the "circumpolar" metabolic type is on the point of being ascertained soon [2-4].

Moreover, according to some authors [5-7] life conditions in high latitude lead to changes of mineral metabolism that can be associated with chemical content of the local food and their consumption patterns, and, as well, with the biogeochemical provinces with poor concentration of minerals in soil and water.

Stable element composition is one of the main and obligatory conditions for normal functioning of human body. Accordingly, trace elements content deviation caused by ecological, professional, climatic-geographical

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factors or diseases leads to wide range of health state disorders [8].

Since revelation and correction of mineral metabolism deviations among elderly people can delay development of pathological processes, which become nonreversible and increase life span and decrease premature mortality, the authors aimed the study at examining macro- and trace elements content in elderly people of Magadan town to assess the structure of element status of examined subjects on individual and population levels.

2. Materials and Methods

The method of AES-IBP (atom-emission spectrometry with inductively bonded argon plasma) was used and applied with the Optima 2000 DV unit (Perkin, Elmer, USA) in the “Micronutrients” (Moscow) where we examined the content of 25 elements in the hair samples of men ($n = 63$, average age is 28.10 ± 0.48) and women ($n = 114$, average age is 28.76 ± 0.35) who are natives of Magadan town of the 1 period of middle age (Al, As, B, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, I, K, Li, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, V, Zn).

Average indices across Russia were regarded as reference values of elements concentration [9, 10].

Disorders in the bioelement concentration are presented in the form of the element misbalance formulas, based on the frequency of the elemental excess or deficiency revealed in more than 25% of the total number of the examined people in each group.

Adaptation level of element system to environmental factors was examined according to the power and quantity of correlations between the trace elements (A):

$$A = \frac{n \cdot \sum K_k}{N}$$

where

A—adaptation level, n —number of correlations between elements with coefficient of correlation 0.5 and more, $\sum K_k$ —coefficient sum without sign, N —number of elements, united into pleiads [11].

IBM SPSS Statics 21 was used for statistical processing of the obtained data. To reveal the differences between the two independent samples according to quantitative indices, which displacement differ from the normal one, Manna-Whitney criteria was used, where Z corresponds to parametric Student t -test for the independent samples. Parameters of descriptive statistics for quantitative indices are shown as median (Me) and interquartile range (25, 75 percentile). When checking null hypotheses statistical significance level possesses critical value at $P < 0.05$.

3. Results and Discussions

In Table 1, medians of concentration of chemicals that reflect men and women's general element status in the 1 period of middle age are presented.

It turned out that majority of the examined subjects were characterized by deformation of element status demonstrated by excess and deficit in essential elements of different degrees of manifestation. Deficit of Co (68% of surveyed people), Mg (67%), Ca (64%), Cu (47%), K (46%), Zn (44%), I (41%), Na (33%), P (27%) and Se (24%) was typical for female subjects as well as excess of Si (28%), Zn (22%) and P (20%). Male residents were characterized by deficit of Co (81%), Ca (66%), Mg (65%), I (50%), Cu (37%), K and Na (27%) and excess of Zn (41%). In individual cases it was noted excess concentration of nominally essential and toxic elements in both examined groups. They were: Al, As, Cd, Li, Ni, Pb, Sn, V and B.

In general view element status of surveyed groups can be presented as “formula” of element misbalance, where in the numerator we can find elements characterized by the deficit concentration and in the dominator- by the excess one:

Female element status =

$$\frac{Si}{Co, Mg, Ca, Cu, K, Zn, I, Na, P}$$

$$\text{Male element status} = \frac{Zn}{Co, Ca, Mg, I, Cu, K, Na}$$

Table 1 Trace element content observed in hair samples of elderly people of the 1 period mg/kg (Me (25, 75 percentile)).

Examined element	Examined groups		Statistical criteria and importance level of differences between compared groups (U; Z; p)
	Female (n = 114)	Male (n = 63)	
Al	8.21 (4.88; 14.26)	10.00 (6.37; 15.02)	3121.5; -1.44; 0.15
As	0.04 (0.04; 0.07)	0.08 (0.05; 0.12)	1823.5; -5.52; 0.00
B	0.50 (0.34; 0.99)	0.81 (0.59; 1.65)	1408; -2.89; 0.00
Be	0.003 (0.003; 0.003)	0.003 (0.003; 0.004)	2985.5; -0.82; 0.41
Ca	410.30 (252.04; 779.87)	265.42 (191.90; 339.98)	2095; -4.58; 0.00
Cd	0.01 (0.00; 0.02)	0.02 (0.01; 0.05)	1881.5; -5.41; 0.00
Co	0.01 (0.01; 0.02)	0.01 (0.01; 0.02)	3007; -1.79; 0.07
Cr	0.39 (0.30; 0.59)	0.73 (0.48; 1.01)	1826; -5.41; 0.00
Cu	10.48 (8.67; 12.05)	10.90 (9.85; 12.19)	3135.5; -1.40; 0.16
Fe	20.85 (14.85; 30.67)	18.91 (13.83; 27.99)	3231.5; -1.1; 0.27
Hg	0.44 (0.29; 0.66)	0.53 (0.21; 0.87)	2373.5; -1.46; 0.14
I	0.68 (0.35; 1.55)	0.63 (0.31; 1.12)	2154; -0.79; 0.43
K	32.90 (15.29; 77.25)	101.01 (43.88; 155.11)	2119.5; -4.51; 0.00
Li	0.01 (0.01; 0.02)	0.02 (0.10; 0.30)	2903.5; -2.16; 0.03
Mg	31.65 (20.51; 68.27)	27.13 (20.56; 36.22)	2807; -2.40; 0.02
Mn	0.84 (0.47; 1.69)	0.43 (0.29; 0.68)	2170; -4.35; 0.00
Na	85.27 (40.05; 204.58)	198.54 (63.25; 413.47)	2482; -3.40; 0.00
Ni	0.18 (0.12; 0.31)	0.22 (0.15; 0.35)	3106; -1.49; 0.14
P	148.18 (135.89; 163.74)	162.73 (143.89; 174.08)	2549; -3.19; 0.00
Pb	0.16 (0.09; 0.32)	0.48 (0.30; 0.78)	1622; -6.03; 0.00
Se	0.39 (0.27; 0.53)	0.38 (0.31; 0.51)	3507.5; -2.56; 0.80
Si	31.48 (21.11; 53.22)	32.98 (20.01; 48.63)	3470; -0.37; 0.74
Sn	0.08 (0.04; 0.20)	0.09 (0.06; 0.17)	2723; -0.61; 0.54
V	0.05 (0.03; 0.09)	0.13 (0.04; 0.20)	1810.5; -3.92; 0.00
Zn	176.75 (156.16; 227.49)	194.50 (167.59; 217.37)	2979; -1.88; 0.06

Note: U—Mann-Whitney test; Z—corresponds to Student t-test for independent samples; p—importance level; TE—significant differences at $P < 0.05$.

While analyzing of medians of chemical concentration it was stated reliable sex-related differences ($P < 0.05$): content of Ca, Mg, Mn was higher in hair samples of women, and content of As, B, Cd, Cr, K, Li, Na, P, Pb, V, on the contrary, was higher in male samples. Moreover, comparison of the obtained data concerning the trace elements content in hair samples of the examined groups with reference indices of chemical concentrations in hair of healthy people aged 18-65 received by the method of AES-IBP [10] showed that average concentrations of some essentials observed in residents of Magadan town (Ca, Co, Mg, Se) were lower than the minimal limit of reference values. Such shifts, presented in human body in most cases by deficit concentrations of elements are the main feature of element system

peculiar for residents of the north regions and in our mind they are connected with specific feature of mineralization of drinking water in the region. According to chemical composition natural drinking water on the territory of the region is low mineralized and characterized by low content of biogenic elements (fluorine, selenium, iodine, calcium and magnesium etc.). Low calcium and magnesium in water leads to severe state of cardiovascular diseases and the same content of selenium decreases resistance to development of these diseases [12]. It is also well known that age-related decrease of calcium in residents of Magadan town is caused by prolonged influence of north-specific factors and well-known role of calcium ions in the process of support of temperature homeostasis [13]. It was proved that

adaptation to cold caused decrease of calcium ion concentration in blood [14].

When assessing the correlations between chemical elements observed in residents of Magadan town sex differences were found. So numbers of medium and strong correlations in male subjects exceed the same ones in female groups and form 29 vs. 9. In correlation pleyads of women only two strong relations were found. They were Ca/Mg ($r = 0.85$), K/Na ($r = 0.73$), in group of men—only one correlation: As/V ($r = 0.75$) at $P < 0.01$.

On the ground of number of correlations, sum of their coefficients and number of elements, joined in pleyads it was calculated index of adaptation (balance) degree of element system to the environmental conditions. It turned out that this index in males was 10.44 conv. un. and in females—2.17 conv. un. that testifies more stable state of element system in men even at the background of constant expressed chemical deficit.

4. Conclusions

Carried study of structure of macro—and trace element status observed in residents of the 1 period of middle age residing in Magadan town confirms the fact of formation of typical element “portrait”, so called “northern” type with expressed element shifts, substantially, to decrease of concentration of the main essential trace elements in human body.

Timely and rational correction of element status made individually and under the care of physician, maximally possible maintaining of physically necessary concentration of essential chemicals is the main aspect of normal functioning of basic regulatory systems. It is very important for the residents of northern regions, where we can face such reasons of insufficient consumption of micronutrients as monotonization of ration, loss of its variety, increase of refined and high-calories food which is poor of minerals, products which are preserved, under long keeping and intensive technological treatment. These

reasons lead to loss of macro- and trace elements.

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