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TRACE ELEMENTS AND IMMUNOBIOLOGICAL RESISTIBILITY OF CHILD'S ORGANISM

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ABSTRACT: The comparative analysis of 24 major and trace elements in preschoolers hair was carried out. Dependence of hair elemental composition on functional condition of child's organism was determined. Essential trace elements imbalance is characteristic for children of all health groups. The highest concentration of toxic chemical elements in hair is characteristic for children of the health group IV. The health group II is marked out appreciably from the others. There is the maximum number of credibly reduced absolute values of chemical elements hair concentration in children of this group.

Introduction

Absolute majority of diseases of adult people forms in childhood. It is admitted that children are a special part of the population, which especial peculiarity is vulnerability and sensitivity. During intensive growth, organism is characterized by increased rate of accumulation of different substances including environmental pollutants. Age related differences in sensitivity to influence of industrial contaminants may be connected with lower intensity of detoxication processes in growing organism. High sensitivity of child's organism not only determine health condition at the moment, but also influence on further development of the organism and its future health.

Stability of chemical composition is one of the most important and essential conditions of organism's normal functioning. Respectively, deviations in chemical elements concentration, caused by ecological, climatogeographical factors, or diseases, lead to different disturbances of children's health (Skalny, Skalnaya, 1999). It should be also pointed out that many metals, abundant in the environment, belong to trace elements, necessary for normal functioning of human organism. Trace elements play a great role in formation of many important adaptive mechanisms including functioning of all vital systems of the organism. That is why sufficient content of essential elements in the organism and minimal concentration of toxic and relatively toxic elements, not threatening frustration of adaptive mechanisms, is one of the most important requirement of modern human (Skalny, Skalnaya, 2000).

Last time one give particular attention to correlations between concentration of toxic substances, including metal compounds, in blood, urine, hair and other human tissues on the one hand and rate of their negative influence on human organism on the other hand. At that, concentration of a substance in human tissues or excretions is used as indicator of both its influence on the organism and its concentration in the environment. Hair is a biosubstance, which adequately reflects elemental balance in the organism (Serebryansky et al., 2002). Multielement hair analysis allows to determine reliably enough the risk groups of hyper- and hypoelementoses for their further investigation and forehanded prophylaxis.

Materials and methods

During the years 2000–2002 observation of 1312 children up to 7 years old, living in Russia, was made. The investigation included questioning, medical examination and determination of 24 chemical elements concentration in hair (Al, As, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Na, Ni, P, Pb, Se, Si, Sn, Ti, V, Zn).

All investigated children were divided into four health groups depending on functional condition of the organism. Data of children's diseases were taken from physician's examination and case records present in medical cards of Center for Biotic Medicine. The group I consisted in healthy children with normal rate of physical and mental development, having no malformations, injuries or functional deviations. The group II contained children having no chronic diseases, but being characterized by some functional and morphological deviations. The group III included children having chronic diseases in state of compensation with undisturbed functional capabilities. The group IV consisted of children having chronic diseases in state of subcompensation or decompensation with disturbed functional capabilities.

Table 1. Mean concentrations of chemical elements in hair of preschool children depending on health group, mg/kg (M±m).

Chemical element	Group I (n=222)	Group II (n=518)	Group III (n=455)	Group IV (n=117)
Al	21.39±1.28	19.67±0.63	22.79±1.13	30.07±4.55
As	0.36±0.06	0.3±0.02	0.37±0.03	0.25±0.04
Be	0±0	0±0	0±0	0.01±0.01
Ca	409.79±23.83	**351.63±9.13**	389.39±14.89	425.37±32.1
Cd	0.23±0.04	**0.17±0.01**	0.2±0.01	0.21±0.03
Co	0.08±0.01	**0.1±0**	**0.11±0.01**	0.08±0.01
Cr	0.85±0.05	0.78±0.03	0.77±0.03	0.88±0.09
Cu	11.85±0.41	11.06±0.24	11.17±0.39	11.66±0.65
Fe	27.43±1.66	**22.88±0.7**	25.61±1.37	27.97±3.26
Hg	0.25±0.03	0.25±0.02	0.28±0.03	0.35±0.07
K	1019.88±87.91	924.62±50.66	995.95±60.51	960.62±107.66
Li	0.04±0	0.04±0	0.04±0	0.04±0.01
Mg	39.1±3.65	**30.91±1.91**	36.65±2.83	34.39±3.38
Mn	0.77±0.07	0.73±0.07	0.91±0.16	0.75±0.09
Na	767.04±71.15	699.47±47.89	782.88±49.16	747.27±104.71
Ni	0.51±0.05	0.43±0.03	0.43±0.03	0.5±0.07
P	151.14±5	142.23±1.91	151.15±3.14	153.59±5.88
Pb	2.77±0.21	2.19±0.12	2.55±0.15	3.35±0.79
Se	1.01±0.08	1.19±0.05	**1.27±0.07**	1.11±0.01
Si	23.43±1.34	20.36±0.7	23.91±1.09	22.22±2.25
Sn	0.64±0.06	**1.02±0.05**	**0.84±0.04**	0.86±0.1
Ti	0.82±0.07	**0.58±0.03**	**0.69±0.03**	0.83±0.07
V	0.12±0.01	0.12±0.01	0.12±0.01	0.11±0.01
Zn	117.31±6.49	118.67±4.8	**104.77±3.76**	107.59±5.5

Note: Bold font indicates statistically significant difference from the group I ($p < 0.05$).

Hair samples were taken from 3–5 places of scalp occipital zone. Proximal parts of hair strands 3–4 cm long were used for analysis. Hair (0.2–0.5 g) thus cut was immediately placed in special bags, which were then accurately sealed and labeled with a group number, the subject name, and the date. All specimens were stored in dry, cool and ventilated environment until delivery to the laboratory and then kept in desiccators until analysis. Hair samples were cut in pieces no longer than 1 cm, processed by acetone (ex.p.) in 10–15 minutes, and then washed thrice by double distilled water. After that they were dried at 600°C till air-dry condition. Then 0.1 g of the dried hair was used for analysis. Hair digestion has been carried out in plastic test-tubes by wet ashing with nitric acid on a balneum within 1 hour. Analytical determination has been carried out by atomic emission spectrometry with inductively coupled argon plasma (ICP-AES) method using ICAP-9000 (Thermo Jarrell Ash, USA) and Optima 2000 DV (Perkin Elmer, USA) spectrometers.

Hair analyses were carried out in accordance with IAEA recommendations and methodical guidelines of Ministry of Health of Russian Federation. For the check-up our laboratory data the certified reference material of human hair GBW09101, obtained from Shanghai Institute of Nuclear Research, was used.

Results and discussion

Statistical calculations of the obtained results revealed considerable differences in concentration of chemical elements in hair of preschool children depending on their health condition. Generally, the highest concentration of toxic chemical elements such as Al, Hg, Pb, Ni were found in hair of children of the health group IV, As and Cd — in children of the health group I. The group II was found to be the most peculiar among the others. It is characterized by significantly lower concentration of 30 % of determined elements

though without signs of Zn deficiency formation, which is characteristic of the groups III and IV.

Comparison of analytical data obtained from different health groups showed statistically significant difference in concentration of some chemical elements in hair of preschool children. Generally, hair of somatically weak children (groups II, III, IV) differs from that of healthy preschoolers (group I) by higher level of Se, Co ($p<0.01$), Sn ($p<0.05$) and lower level of Fe, Ca, Pb, Ti ($p<0.01$), Cd, Mg, and Zn ($p<0.05$) (Table 1).

For better understanding of elemental profile of preschoolers belonging to different health groups we used relative values, which reflect frequency of deviations in chemical element concentrations from normal (biologically allowable) level.

According to the data obtained, children of the group I were characterized by high occurrence of the decreased hair level of Ca (42% of children), Co (84%), Mg (64%), Se (43%), Zn (68%) and the increased one of Si (20%) and K (22%). Absence of manifested deviations in health condition does not exclude presence of hidden pathogenic agents or functional deviations, having intermediate character in children during intensive development and growth.

Children of the group II were featured by high occurrence of decreased Ca (46%), Fe (23%), Mg (67,5%), Mn (54%), P (32%), Se (37%), Zn (67%) levels and increased concentration of K (23% of children). This data evidence significant disturbances in mineral metabolism and high risk of pathologic deviations in children's health condition.

The group III was characterized by high occurrence of low concentrations of Fe, P (26% and 29%, respectively), Se (36%), Ca (44%), Mn (55%), Mg (66%), Zn (73%) and Co (79% of cases).

Children of the group II were featured by high occurrence of decreased concentrations of Co (84%), Zn (71%), Mn (56%), Mg (59%), Se and Ca (40% each) in hair; risk of Al, Cd, Cr, Pb, Ti excess was relatively abundant (from 10% till 15% of children).

Correlation analysis of children's hair elemental content in different health groups detected interrelations between levels of many elements, which generally coincides with current knowledge about interactions of chemical elements in human organism. Thus, in virtually all investigated groups of children, despite sharp distinctions in organism functional condition, close correlation in levels of Ca and Mg, K and Na, Ca and P was found, as well as similarity of proportions of these elements (Ca/Mg, K/Na, Ca/P, Zn/Cu), which are claimed to be biochemical constants of human organism.

It is notable that number of the detected interelemental correlations were found to be dependent on health condition. Generally, the worse the health condition, the less the number of correlations. Thus, 63 pairwise correlations were detected in the group I, just 24 — in the group II, 55 — in the group III, and 38 — in the group IV. In the group I the closest positive correlation was observed for hair levels of the following combinations of chemical elements: Al/Fe ($r = 0.51$), Ca/Mn-Mg ($r = 0.66$), Ca/Fe ($r = 0.5$), K/Na ($r = 0.69$), Fe/Mn ($r = 0.69$), Fe/P-Ti ($r = 0.57$), Mn/Ti ($r = 0.57$), P/Ti ($r = 0.68$), Cr/Ni ($r = 0.56$). Significant, though moderate enough, negative correlation was detected in the pair Be/Sn ($r = -0.32$). In the group II significant positive correlations were found only for two pairs: K/Na ($r = 0.63$) and Ca/Mg ($r = 0.53$). Significant negative correlation was observed only between Sn and Ti ($r = -0.29$). In the group III correlations Al/Cr ($r = 0.56$), Al/Fe ($r = 0.64$), Ca/Fe-Mg ($r = 0.54$), Ca/P ($r = 0.59$), Cr/Fe-P ($r = 0.53$) were found. In the group IV – Ca/Mn ($r = 0.85$), Ca/Mn ($r = 0.58$), Fe/Ni ($r = 0.5$), Mg/P ($r = 0.56$), Ni/P ($r = 0.68$), and negative correlation between K and Zn ($r = -0.3$). Thus, in organisms of somatically weak children the interelemental metabolic relations typical for healthy organism with normal physiological functions are partly disrupted or impaired. At the same time, in some cases another new "pathologic" relations can be formed, that may cause further negative effect. It results in disturbance of various physiological processes in human organism (regulation of water-salt exchange, neuromuscular conduction, muscles traction etc.), which needs coordinated action of different chemical elements for their regulation.

In general, it may be pointed out that, according to our data, the characteristic of all observed children was imbalance of essential major and trace elements, which was conditioned by inadequate intake of biologically wholesome nutrients on the one hand and antagonistic relations between some toxic and essential elements on the other hand, that leads to various disturbances of health condition.

Conclusions

1. Decline in immunobiological resistibility is accompanied by increase of Al, Cd, Cr, Pb, Ti concentration in the organism and decrease of that of Co, Mn, Mn, Se, Ca, Fe, P and Zn, the latter being an essential element playing a key role in regulation of growth and development of the organism, immune system formation, sexual maturation of boys.

2. Correlation analysis shows that, unlike healthy children, somatically weak children is characterized by disturbance of elements' interactions. Such disturbance of interelemental coordination in child's organism leads to complex physiological and biochemical disorders, because homeostatic mechanisms in children are not reliable enough.

3. Results of multielement hair analysis can be used to arrange adjusted correction of elements imbalance by means of biologically active supplements, that may have a benefit effect in case of some diseases.

4. Multielement hair analysis may be included in complex of mass health examination as an additional test for estimation of children's immunobiological resistance, especially in cases when combined influence of negative environmental factors takes place.

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