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# AGE AND GENDER CHARACTERISTICS OF THE CHEMICAL ELEMENTS IN THE HAIR OF RESIDENTS OF UFA CITY

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The formation of the elemental status of the human body living in a certain region de-pends on the biogeochemical, ecological and geographical factors of the area, nutrition, and pro-fession. The content of chemical elements in the body and their ratio are an indicator of human health. For residents of the city of Ufa, a large industrial center of the Republic of Bashkortostan, References intervals for the concentration of macro- and microelements in hair have been developed. However, to identify deficiencies, excesses or imbalances of chemical elements in the body, it is necessary to take into account gender and age differences. In this regard, the purpose of this work was to study the age and gender characteristics of the content of macro- and microelements in the hair of residents of a large industrial city. The content of 12 chemical elements in the hair of residents of the city of Ufa of the age groups - 18-29 years, 30-44 years, 45-65 years and over 65 years old was determined by atomic absorption spectrometry using devices with flame and electrothermal atomization.

In all age groups, a deficiency of zinc and copper was detected in the hair of both men and women against the background of excess chromium, lead and manganese. Median concen-trations of iron, magnesium, cadmium, mercury and arsenic are within the 25-75 centile range. A deficiency of calcium in the hair of men under 65 years of age was revealed; in women it was found in the range of References values. An excess of 4-11% of the upper limit of permissible Ni content in men was esTableished. There is a tendency towards higher accumulation of cadmium, lead and arsenic in the hair of the male population. In women over 65 years of age, the minimum levels of essential elements are determined - calcium, magnesium, zinc and copper, in men of this age - copper, iron and manganese. Toxic elements cadmium, lead and arsenic accumulate to their maximum at 65 years of age and older.

The results of the study can be used as an additional method for determining the charac-teristics and time of onset of various diseases, as well as for the medical correction of diselementoses and enriching diets with essential micronutrients.

**Keywords:** macroelements, microelements, hair, age, residents of Ufa.

**Introduction.** The study of the elemental status of the population is a very promising scientific direction in connection with the growing pollution of the environment with metals and their importance for the functioning of the body. The role of elements for the human body is beyond doubt, for example, calcium is involved in all types of metabolism (protein, mineral, fat, carbohydrate, en-ergy). With its deficiency, metabolic processes are disrupted, bones, muscles, nervous and cardi-ovascular systems suffer, and the immune system weakens [2]. A lack of magnesium can lead to diseases of the nervous system, heart, gallbladder, kidneys, pancreas, cause diabetes mellitus, and atherosclerosis [11]. Iron is a vital element for the growth, division, differentiation and vital activity of body cells, but if consumed in excess, it can cause irreversible damage to cellular structures [7]. A lack of zinc in the body is manifested by the development of skin diseases, de-creased immunity, mental disorders, delayed growth and sexual development [16]. Due to the absence of clinical symptoms in adults, zinc deficiency is a serious problem worldwide. Copper and manganese are part of many enzymes that participate in the redox reactions of the body [8]. With a lack of copper, brittle bones, neutropenia, and arterial aneurysms can develop. Manganese affects growth, reproduction, hematopoiesis, immunity, metabolism, and plays a significant role in protecting the body from the harmful effects of peroxide radicals.

Residents of different regions are characterized by the formation of elemental status, which depends both on the state of the environment and occupational exposure, as well as on the quality of nutrition, lifestyle and other factors.

The city of Ufa, a large industrial center of the Republic of Bashkortostan, is character-ized by a high risk of pollution of atmospheric air, water bodies, and soil with toxic metals asso-ciated with the activities of oil refining enterprises, mechanical engineering, and the intensity of traffic flow [1, 3, 5, 10]. This largely determines the load of metals on the body of residents of the capital of the republic.

Based on previously conducted studies, a database of References values for the elemental composition of biological media (blood, hair) was formed [4]. Among biological media, hair is the most informative and accessible material for analyzing the content of chemical elements in the human body [18, 20]. However, to diagnose diselementosis, it is necessary to take into ac-count the gender and age characteristics of a person, since with age the body becomes more sus-ceptible to the effects of macro- and microelements [6]. In addition, age-related differences in the content of chemical elements in biological media in women and men may explain different susceptibility to certain diseases [15]. An analysis of the literature data showed multidirectional changes in the age-related changes in the content of macro- and microelements in the hair, lead-ing with age not only to a deficiency, but also to an excess of certain elements [6, 15, 19].

**Aim of the work**: to study the age and gender characteristics of the content of mac-ro- and microelements in the hair of residents of a large industrial city.

**Materials and methods.** The study involved residents of the city of Ufa who had lived in the area for at least five years and had no professional contact with salts of heavy metals. The examinations were approved by the bioethical commission of the Ufa Research Institute of Oc-cupational Medicine and Human Ecology, protocol No. 01-11 dated November 15, 2022. Hair samples were collected from 296 clinically healthy individuals (125 men and 171 women) with their written informed consent. Samples were

**Table 1**

**The content of chemical elements in men's hair, median (25th and 75th percentile), µg/g**

| Chemi-cal ele-ment | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 18-29 years old n=34 | 30-44 years old n=39 | 45-65 years old n=31 | References values (25 and 75 percentile) | Over 65 years old n=21 | References values (25 and 75 percentile) |
| Ca | 429 (347; 623) | 489 (398; 658) | 475 (376; 611) | **494; 1619** | 539 (473; 721) | **354; 1122** |
| Mg | 34 (29; 46) | 42 (34; 51) | 43 (35; 59) | **39; 137** | 38 (29; 42) | **32; 113** |
| Fe | 19.7 (14.0; 27.1) | 21.3 (13.2; 28.0) | 24.5 (15.9; 29.9) | **11; 24** | 15.9 (11.5; 19.5) | **12; 25** |
| Zn | 108 (105; 127) | 117 (114; 126) | 120 (112; 150) | **155; 206** | 120 (113; 141) | **145; 196** |
| Cu | 8.6 (7.4; 10.0) | 11.0 (9.1; 12.1) | 9.0 (7.0; 11.0) | **9; 14** | 6.9 (6.8; 10.0) | **9; 12** |
| Mn | 1.00 (0.72; 1.81) | 0.85 (0.66; 1.06) | 1.40 (1.10; 1.67) | **0.32; 1.13** | 0.80 (0.65; 0.93) | **0.31; 1.29** |
| Cr | 0.74 (0.42; 1.06) | 0.99 (0.87; 1.32) | 1.63 (1.49; 1.78) | **0.32; 0.96** | 1.97 (1.42; 2.01) | **0.20; 0.60** |
| Ni | 0.57 (0.50; 0.62) | 0.59 (0.48; 0.66) | 0.55 (0.48; 0.60) | **0.14; 0.53** | 0.53 (0.39; 0.58) | **0.14; 0.51** |
| Cd | 0.084 (0.076; 0.147) | 0.078 (0.052; 0.123) | 0.090 (0.078; 0.090) | **0.02; 0.12** | 0.066 (0.041; 0.093) | **0.02; 0.13** |
| Pb | 2.63 (2.41; 3.42) | 3.32 (2.80; 3.83) | 2.44 (2.25; 2.99) | **0.38; 1.40** | 3.78 (2.73; 4.20) | **0.50; 1.67** |
| Hg | 0.252 (0.202; 0.307) | 0.168 (0.136; 0.204) | 0.176 (0.156; 0.187) | - | 0.181 (0.176; 0.188) | - |
| As | 0.023 (0.015; 0.034) | 0.026 (0.020; 0.032) | 0.042 (0.040; 0.054) | **0.00; 0.56** | 0.077 (0.062; 0.086) | **0.00; 0.98** |

collected in paper bags, hair was cut from the back of the head, and stored in a dry place at room temperature until analysis. The content of the chemical elements calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), chromium (Cr), nickel (Ni), cadmium (Cd), lead ( Pb), mercury (Hg) and arsenic (As) after sample preparation were determined by atomic absorption spectrometry using devices with flame and electrothermal atomization in accordance with current regulatory documents.

Statistical processing of the results was carried out using the IBM SPSS Statistics 21.0 software package. The normality of distribution was checked using the Kolmogorov-Smirnov test. Multiple comparisons of the content of chemical elements in the hair of the studied study groups were performed using the Kruskal-Wallis test. To esTableish differences between two in-dependent samples (women and men) in terms of element content, the Mann-Whitney test was used. Differences were accepted as statistically significant at p<0.05.

When processing the data, four age groups of the surveyed were identified: 18-29 years, 30-44 years, 45-65 years and over 65 years. The research results, presented as a median with an interquartile range of 25-75 percentiles, were compared with the References values of concentra-tions of chemical elements given in the work of A.V. Skalny (2003) [12].

**Results and discussion. T**he results of a study of the content of chemical elements in the hair of the male and female population of the city of Ufa, divided by age groups, are presented in Tables 1 and 2.

When considering the results of studies on chemical elements, it was esTableished that women's hair contains more calcium than men's in all age groups, except for people over 65 years of age (p<0,0001). The calcium content in the hair of the female population decreases with age (H=19,03; p<0.0001). The median value of calcium concentration in the hair of men in age groups up to 65 years is beyond the lower limit of the physiological norm (494 μg/g). In persons over 65 years of age – within normal limits.

The concentration of magnesium in the hair of city residents, both men and women, is at the lower limit of the physiological norm and no significant changes are observed with age (H=3,69; p=0,297 – men; H=1,39; p=0,708 – women).

The iron content in hair in all age groups is within the References values. The minimum values were observed in those examined aged 18-29 years and over 65 years.

There is a deficiency of zinc in the hair of those examined relative to physiological stand-ards; with age, the median values do not undergo significant differences (H=2,53; p=0,470). In women's hair under 65 years of age, the level of zinc is higher than in men's, but the differences are statistically insignificant (p=0,185).

Copper deficiency was identified in all age groups of those examined, with the exception of men 30-44 years old.

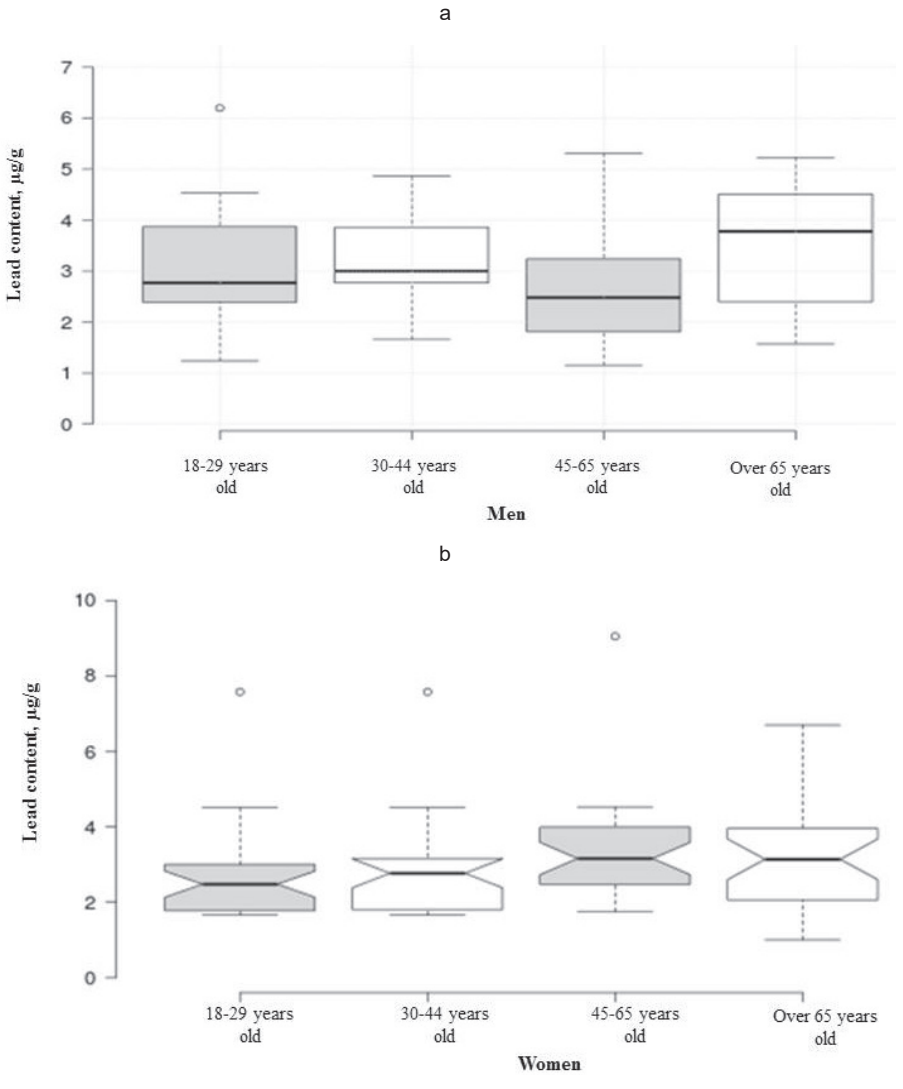
The manganese content in the female population up to 65 years of age decreases from 1.41 to 0.90 μg/g; after 65 years, an increase is observed to 1.08 μg/g. In men, maximum concen-trations were detected at the age of 45-65 years (1.40 μg/g). It should be noted that the median concentrations of manganese in the hair of city residents are quite high, and in women aged 18 to 29 years and men 45-65 years old, they are 25% higher than the upper limit of the physiological level.

An increased content of chromium was found in the hair of those examined. In men under the age of 30, the metal level is within the physiological norm - 0.74 μg/g; with age, its concentration increases to 1.97 μg/g. In women, the highest chromium content in hair (2.85 μg/g) was

**Table 2**

**The content of chemical elements in women's hair, median (25th and 75th percentile), μg/g**

| Chemi-cal ele-ment | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 18-29 лет n=47 | 30-44 лет n=57 | 45-65 лет n=37 | References values (25 and 75 percentile) | Over 65 years old n=30 | References values (25 and 75 percentile) |
| Ca | 1049 (875; 1493) | 636 (317; 897) | 875 (364; 1027) | **494; 1619** | 387 (286; 692) | **354; 1122** |
| Mg | 44 (34; 68) | 39 (34; 63) | 42 (31; 54) | **39; 137** | 34 (27; 49) | **32; 113** |
| Fe | 14.6 (12.6; 18.6) | 17.1 (14.4; 19.0) | 16.8 (14.4; 19.0) | **11; 24** | 15.2 (11.3; 19.1) | **12; 25** |
| Zn | 126 (115; 145) | 123 (113; 137) | 128 (117; 138) | **155; 206** | 116 (109; 125) | **145; 196** |
| Cu | 8.1 (6.4; 10.9) | 8.7 (7.4; 10.6) | 8.6 (7.4; 10.6) | **9; 14** | 7.4 (6.6; 10.2) | **9; 12** |
| Mn | 1.41 (0.71; 1.64) | 1.14 (0.70; 1.64) | 0.90 (0.69; 1.62) | **0.32 1.13** | 1.08 (0.83; 1.11) | **0.31; 1.29** |
| Cr | 0.99 (0.80; 1.31) | 2.85 (1.04; 3.32) | 1.25 (1.07; 1.54) | **0.32; 0.96** | 1.23 (1.11; 1.49) | **0.20; 0.60** |
| Ni | 0.44 (0.36; 0.52) | 0.52 (0.42; 0.59) | 0.45 (0.35; 0.55) | **0.14; 0.53** | 0.40 (0.14; 0.48) | **0.14; 0.51** |
| Cd | 0.069 (0.064; 0.074) | 0.075 (0.063; 0.125) | 0.075 (0.035; 0.109) | **0.02; 0.12** | 0.075 (0.067; 0.087) | **0.02; 0.13** |
| Pb | 2.48 (1.78; 3.01) | 2.77 (1.81; 3.16) | 3.16 (2.48; 4.00) | **0.38; 1.40** | 3.27 (2.61; 3.58) | **0.50; 1.67** |
| Hg | 0.142 (0.109; 0.266) | 0.198 (0.128; 0.342) | 0.204 (0.171; 0.336) | - | 0.199 (0.196; 0.211) | - |
| As | 0.023 (0.014; 0.030) | 0.023 (0.017; 0.032) | 0.030 (0.026; 0.033) | **0.00; 0.56** | 0.047 (0.036; 0.054) | **0.00; 0.98** |




Lead content in hair of residents of Ufa depending on age: a – for men, b – for women

found in the age category of 30-44 years.

The maximum concentrations of nickel were found in those examined aged 30-44 years, regardless of gender. In all age groups, both men and women, the nickel content is within the upper limit of the permissible level of the element.

Increased concentrations of chromium and nickel in hair are probably due to the geo-ecological characteristics of the region and the spectrum of emissions from industrial enterprises in the city.

The concentration of cadmium in the hair of the male population increases maximally at the age of 45-65, and after 65 years it decreases slightly. In women, no significant differences were found with age (H=1,65; p=0,648). For all respondents, cadmium levels were below the upper physiologically accepTable level.

The lead content in the hair of the city population exceeds the permissible values, but is below the "level of concern" equal to 5 µg/g, which indicates excessive intake of the element into the body [13]. High concentrations of lead in the human body may be associated with industrial pollution and vehicle emissions [17]. In Ufa residents, the maximum accumulation of lead was found in the hair of men and women over 65 years of age. Concentrations of more than 6 µg/g were also recorded in the hair of some men aged 18-29 years (Fig. a)

Research has revealed an increase in lead content in women's hair with increasing age (Fig. b). The maximum values (9.05 µg/g) were determined in the age group 45-65 years.

According to the literature, the background level of mercury in hair varies from 0.5 to 1 µg/g [14]. In the hair of Ufa residents, the concentration of mercury is in the range of 0.1 - 0.33 µg/g. The maximum content of mercury in the hair of men was determined at the age of 18-29 years, in women it accumulates at the age of 45-65.

The arsenic content in the hair of city residents is within the physiological norm; it in-creases with age in both men and women from 0.023 to 0.077 µg/g (H=12,25; p=0,007) and from 0.023 to 0.047 µg/g (H=8,79; p=0,032), respectively. Arsenic is a carcinogen of the first hazard class, and therefore an increase in its concentration in older age groups can lead to an increase in cancer [6].

Studies conducted to study the content of chemical elements in the hair of different age groups of the population of the city of Ufa showed reduced levels of zinc and copper in all age groups. Against the background of copper deficiency, increased levels of manganese were found, a microelement that is its antagonist. Probably, the esTableished low concentrations of zinc and copper in the hair of Ufa residents were formed due to insufficient intake of these elements from food products, but they may also be a consequence of the accumulation of lead, cadmium, mer-cury, manganese and iron in the body.

Iron and nickel were significantly higher (p=0,001 и p=0,011, respectively) in the hair of men compared to the hair of women over the entire age period. Women's hair contains more cal-cium, and the average content of the element decreases with age, which is consistent with litera-ture data [9]. The magnesium content is within the References values. Regarding toxic elements, the maximum concentrations of lead and arsenic were found in respondents over 65 years of age. There is a tendency towards higher accumulation of cadmium, lead and arsenic in the hair of the male population. The mercury content is higher in the hair of women, with the exception of those aged 18-29 years.

**Conclusion.** Thus, significant differences have been esTableished in the content of micro- and macro-elements in the hair of residents of the large industrial city of Ufa, depending on gen-der and age. The results of the study are quite informative and can be used as an additional method to determine the characteristics and time of onset of various diseases, as well as for med-ical correction of diselementoses and enrichment of diets with essential micronutrients.

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