Zinc in the body and somatic health of industrial workers

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Abstract 30% of industrial workers have a chronic (at least 3-4 months) zinc deficiency as a vital trace element necessary for the functioning of a significant amount of metalloproteins. The cause of zinc deficiency may be copper intoxication noted earlier, which together is important for the development of structural pathology of internal organs.

1. Introduction
Dysmicroelementoses are common in the Russian Federation as a whole and in the Siberian region, which is also characterized by a low level of population health [1]. For industrial workers, the amount of metals in the body can be increased 20-50 times according to the methodological recommendation of the USSR Ministry of Health for professional activities (1988). However, it is not known in which concentration range in the body the vital elements become toxic. Analysis of human hair and nails is considered an adequate method for mass non-invasive assessment of elemental status [1] within 3-4 months prior to the examination. However, the official boundaries of the “norm” for the content of chemical elements in human hair have not been established [2], in particular, due to their dependence on the region of residence [3]. Due to the wide range of values, poorly regulated definitions of “recommended levels” and “biologically acceptable levels” are proposed [2-4].

In certain quantities, zinc is an essential element in the absence of fluctuations in its concentration in the environment. The paper presents the results of a study of the zinc content in the body of workers of an industrial enterprise in Tomsk and some indicators of their somatic health.

2. Materials and methods
A survey of employees of the enterprise producing methanol was carried out as part of a preventive medical examination. The examination of healthy volunteers was carried out with the permission of the Ethics Committee (opinion No. 583 of March 19, 2007) Siberian State Medical University (Tomsk). The subjects were informed about the features of the diagnostic procedures performed in accordance with ethical requirements. In the occipital region, closer to the neck, for men and women employed in the production of the Metanol OJSC enterprise (Tomsk), hair was cut at 3-5 points in strands 2-3 mm2 thick. The total sample volume was about 100 mg. Quantitative chemical analysis of hair samples for zinc and copper is based on the inversion volumetric method for determining the mass concentrations of elements in the solution of the prepared sample [5]. Semi-quantitative assessment of the state of parenchymal organs was carried out in points according to ultrasound data (ultrasound). The absence of structural changes in the parenchyma was taken for 1 point. In the case of detected organic changes in each organ (liver, kidney, pancreas, thyroid, prostate), an additional score was added.
The results were expressed as mean value (X) and standard deviation (SD), median (Me), 1st (Q1) and 3rd (Q3) percentiles. Statistical processing of the results was carried out by methods of variation statistics using the Mann-Whitney test and the Spearman rank correlation coefficient.

3. Results

An analysis of the type of distribution (universal criteria of Lilliefors and Shapiro-Wilk) of the quantitative contents of zinc in the hair of men and women showed a distribution close to normal (Fig. 1a, b).

![Figure 1. A histogram of the distribution of zinc in the hair of employees: a) in women; b) in men](image)

Given the nature of the distribution, the values of zinc in the hair of the employees of the enterprise were described both as an average value (X ± SD) and were presented as values of centile intervals of concentrations (Me (Q1-Q3)).

A physical examination of the enterprise employees did not show a statistically significant change in the average zinc content in comparison with both the recommended levels (Table 1) and with the regional indicator in Tomsk [6]. Gender differences in zinc accumulation were not detected (Table 1); therefore, the groups were combined. Only in 5 workers (2% of the examined) did the zinc concentration in the hair exceed the extreme limit of 280 kg / kg, which removes the question of possible mass zinc intoxication in methanol production using metal catalysts. More common was reduced (less than 100 mg / kg) zinc levels in 73 people (30%). According to ultrasound data, only 11% of the examined employees of the enterprise, mainly young people (less than 33 years), did not reveal structural changes in internal organs. In other cases, polyorgan (in 2-3 internal organs) structural changes were found (Table 2), primarily of the gall bladder, kidneys, liver, and pancreas.

Table 1. The level of trace elements in the hair of the examined employees of the enterprise, X ± SD, Me (Q1-Q3)

| Group                              | Age (years) | Zinc (mg / kg) |
|------------------------------------|-------------|----------------|
| Recommended levels for men and women [1,3,4] | ~           | 140-280        |
|                                    |             | 100-250        |
| Male workers, n=180                | 43.7±11.4   | 124.5 (97.4-151.0) |
| Female workers, n=64              | 42.0±8.5    | 121.0 (91.8-147.0) |
Employees of the enterprise (men and women), n=244

| Group          | Spearman correlation | Significance of the coefficient, t(N-2) |
|----------------|----------------------|----------------------------------------|
| Female workers, n=63 | 0.039                | 0.302                                  |
| Male workers, n=168 | 0.026                | 0.342                                  |

Table 2. Results of correlation analysis of the dependence of emerging pathologies on the content of zinc in the hair, at P=0.95 (according to Spearman)

Table 3. Data of ultrasound investigation of internal organs in employees, X±SD.

| Organ pathology, points | % of examined employees |
|-------------------------|-------------------------|
| Renal system            | Liver                   | Thyroid gland | Pancreas gland | Prostate |
| 41          | 36          | 14            | 6               | 3        | 2.81±1.15* n=237 |

However, correlation analysis did not reveal statistically significant correlations between the Zn content in the hair, passport age (Fig. 2a, b) and somatic pathology (Table 2, 3).

Figure 2. Dependence of the distribution of zinc in the hair of employees on the age: a) in women; b) in men.

Table 3. Data of ultrasound investigation of internal organs in employees, X±SD.

4. Discussion
The reduced level of zinc in the hair of the company’s employees testifies, first of all, in favor of the chronic pathology of the liver, pancreas and kidneys. Nevertheless, the nature of organ pathology among the employees of the enterprise as a whole did not differ from that among the population of the Tomsk region of comparable age. Apparently, the main reason was occupational hazards associated with the constant use of copper (Cu) catalyst in the methanol production process, which is accompanied by excessive intake of heavy metal in the body of workers of this enterprise [6]. Cu and Zn are biological competitors [4].

5. Conclusion
30% of industrial workers have a chronic (at least 3-4 month) zinc deficiency as a vital trace element necessary for the functioning of metalloproteins that regulate metabolism, cell function and antioxidant defense of the body [7]. The cause of zinc deficiency may be copper intoxication noted earlier, which together is important for the development of structural pathology of internal organs.

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