DIFFERENT TRENDS OF CR, FE AND ZN CONTENTS IN HAIR BETWEEN OBESE, OVERWEIGHT AND NORMAL-WEIGHT MEN

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SUMMARY

Objectives: Overweight and obesity are risk factors for many diseases, nutrition leading to these phenomena is not only a question of disbalance between energy intake and expenditure, but also the presence of micronutrients. In our study, we focused on measuring residues of chromium, zinc and iron in the hair of men with different BMI.

Methods: Hair samples and anthropometric questionnaires were collected from 45 males. Numbers of subjects and age structure were comparable between the three BMI groups. The determination of metal levels was performed by inductively coupled plasma mass spectrometry after mineralization of the hair.

Results: The hair of obese men contained significantly higher chromium (0.096 μg/g vs. 0.045 μg/g, p = 0.0039) and iron (9.42 μg/g vs. 5.84 μg/g, p = 0.0009) concentrations than that of overweight men, but no significant difference between the normal-weight group and the obese group were found. The concentration of zinc was lower in obese subjects compared to overweight subjects (183.5 μg/g vs. 206.2 μg/g, p = 0.038). Also, statistically significant correlations between chromium and iron concentrations in hair and BMI were found (r = 0.307, p = 0.040, r = 0.360, p = 0.015, respectively). According to our results, age did not significantly affect chromium, iron and zinc concentrations in hair.

Conclusion: Consistent with some published studies, we have found that obese men have higher chromium and iron concentrations and lower zinc concentrations in hair.

Key words: hair, chromium, iron, zinc, obesity

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INTRODUCTION

Hair analysis has proven to be a useful tool for human biomonitoring in terms of both essential and toxic elements (1, 2). The contents of elements in hair may, on one hand, reflect the exposure to environmental pollutants, and on the other hand, be linked to metabolic parameters (2, 3). It has been shown that metabolic disorders (such as obesity-induced hyperinsulinemia) are manifested by mineral disbalance of e.g., chromium (Cr), iron (Fe) and zinc (Zn) (4–6).

The aim of the study was to assess the hair content of the three above-mentioned elements and examine differences between three groups of men classified according to their BMI: normal weight, overweight, and obese.

Chromium in trivalent state is an essential trace element that plays a key role in the regulation of glucose (as a mediator of the insulin signal in insulin-dependent tissues) and its possible effect on weight reduction is also explored. An insufficient amount of this element can lead to many physiological disorders such as elevated blood levels of glucose, insulin, cholesterol, and triacylglycerols, and reduced HDL cholesterol levels, which increase the risk of type 2 diabetes mellitus and cardiovascular disease (5, 7–9).

Zinc is an essential micronutrient that plays a key role in adipose tissue metabolism (zinc stimulates lipogenesis and glucose uptake in isolated adipocytes) and in the synthesis and action of insulin (7, 9, 10). Zinc deficiency might affect glucose metabolism, leading to development of metabolic disorders including insulin resistance and impaired glucose tolerance (11).

The most common deficiency with respect to essential micro-nutrients is iron deficiency, which is very common among overweight and obese children and adolescents (7). Iron is involved in electron transfer in the mitochondria and oxygen transport through bonds with myoglobin and haemoglobin (12). Iron deficiency and anaemia may lead to fatigue and a consequent decrease in physical activity associated with further weight gain. In addition, deficiency of iron might disrupt the mitochondrial activity of the respiratory chain, thereby reducing exercise capacity and increasing insulin resistance (13).

Recent studies suggest that obese people have more frequent occurrences of iron (13, 14), zinc (15, 16) and chromium deficiency (7, 17, 18), and therefore it may be beneficial to provide these individuals with these essential trace elements in the form of supplements (17–19). In obesity, the potentially beneficial roles of essential minerals and trace elements might be related to their...
samples spiked with known amounts of Cr, Fe, and Zn before and after mineralization. Spiking recoveries were found to be 105 ± 3% and 105 ± 2%, respectively.

Statistical Analysis
The obtained data were statistically analysed by means of STATISTICA 12. Using the Shapiro-Wilk test, it was found that the distribution of the data differed significantly from the normal one. Therefore, nonparametric tests were used for further analysis. The Mann-Whitney U test and the Kruskal-Wallis test were used to compare the contents of selected elements within individual groups. The nonparametric Spearman’s correlation coefficient was used to determine the relationship between the observed continuous parameters. All tests were evaluated at a significance level of p<0.05.

RESULTS
The concentration of chromium, iron and zinc in male hair are shown in Table 1. In this study population, the median concentrations of chromium in the hair of men in the normal-weight, overweight, and obese groups were 0.047 μg/g, 0.045 μg/g, and 0.096 μg/g, respectively, with an overall median concentration of 0.053 μg/g. The median concentrations of iron in the hair of men in the normal-weight, overweight, and obese groups were 6.16 μg/g, 5.84 μg/g, and 9.42 μg/g, respectively, with an overall median concentration of 6.26 μg/g. The Kruskal-Wallis test revealed significant differences between medians of chromium and iron contents between the groups (p=0.011, p=0.007, respectively). Since the spread of chromium and iron contents was relatively wide in the normal-weight group, no statistically significant difference was observed in the other groups. However, the shift in the content of both elements was significant from the overweight group towards the obese group (Table 1).

The median zinc concentration in the hair of all tested men was 201.8 μg/g. The difference in zinc concentrations between groups was statistically significant (Kruskal-Wallis test, p=0.042). The obese group exhibited significantly lower concentrations of zinc than the overweight group (Table 1). The median zinc concentration for the normal-weight group reached 201.1 μg/g and was insignificantly higher than the median for the obese group.

Correlations between the variables were also analysed. The Spearman’s correlation coefficient showed statistically significant correlations between BMI and chromium and iron concentrations in hair (r=0.307, p=0.040, r=0.360, p=0.015, respectively). In contrast, no statistically significant correlation was found between BMI and zinc concentration in hair. A strong positive correlation was found between chromium and iron concentration in hair (r=0.683, p<0.001). No age dependency was found for chromium, iron or zinc levels.

DISCUSSION
Numerous studies aimed to resolve the relationship between obesity and chromium, zinc and iron disbalance have led to conflicting results. Positive correlation between hair chromium content and BMI observed in the present study was evidenced by...
former research conducted on pubic hair (5) and scalp hair (22). In contrast, other authors observed no such dependence (4, 27). Higher chromium concentrations in hair of obese individuals may be associated with the fact that metabolic disorders which accompany obesity may lead to increased chromium excretion from the body via excretory pathways (28, 29).

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Content of iron in the hair samples follows similar pattern as that observed for chromium, i.e., that hair of obese subjects contained more iron than that of normal-weight and significantly more than that of overweight subjects. Król et al. (30) reported that obese patients with type 2 diabetes mellitus had significantly higher concentrations of iron in hair as well as a higher dietary iron intake than the control group. Such elevated iron concentrations in hair in diabetic and obese subjects were assumed to be caused by increased inflammatory changes typical for type 2 diabetes mellitus or differences in dietary iron intake. Nevertheless, other attempts to reveal a relationship between BMI and hair iron resulted in observation of negative (24) or no correlation (3, 27).

In contrast to trends observed for chromium and iron, no correlation between hair zinc content and BMI was detected. In some studies, lower zinc content in hair of subjects with excessive weight was observed (3, 5, 33) and this phenomenon was attributed to the fact that both zinc deficiency and imbalance play a role in the pathogenesis of obesity and type 2 diabetes. Kruskal-Wallis showed a lower concentration of zinc in the obese group in this study, the trend of the whole group’s dependence of zinc concentration on BMI was not statistically significant. Similar findings were made by Hong et al. (22) and Lee et al. (27), who failed to find a significant correlation between zinc concentration and BMI.

Although the hair concentration of some metals (especially those accumulative and toxic ones such as cadmium or lead) has been often associated with age (17, 22, 29, 32, 33), no such dependence was observed in this study.

CONCLUSION

The findings of this pilot study confirm some of the trends reported by previous research focused on the relationship between BMI and the content of chromium, iron and zinc in hair. Concentrations of chromium and iron in the hair of obese subjects were significantly higher compared to overweight men. Conversely, concentrations of zinc in the hair of obese subjects were lower than those in overweight subjects. However, no dependence was confirmed between chromium, iron or zinc concentration and age. Further research on the topic is required to help clarify the exact causes of this understudied phenomenon.

Table 1. Metal concentrations in hair of men in normal-weight, overweight and obese groups (in micrograms per gram)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal weight (n=14)</th>
<th>Overweight (n=16)</th>
<th>Obese (n=15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) – mean (SD)</td>
<td>42.1 (20.9)</td>
<td>46.9 (16.9)</td>
<td>51.1 (11.2)</td>
<td>–</td>
</tr>
<tr>
<td>BMI (kg/m²) – mean (SD)</td>
<td>22.8 (1.4)</td>
<td>27.4 (1.3)</td>
<td>34.1 (3.7)</td>
<td>–</td>
</tr>
<tr>
<td>Chromium (percentiles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>0.028</td>
<td>0.028</td>
<td>0.036</td>
<td>–</td>
</tr>
<tr>
<td>25th</td>
<td>0.032</td>
<td>0.034</td>
<td>0.067</td>
<td>–</td>
</tr>
<tr>
<td>50th (median)</td>
<td>0.047</td>
<td>0.045</td>
<td>0.096*</td>
<td>0.0039*</td>
</tr>
<tr>
<td>75th</td>
<td>0.076</td>
<td>0.053</td>
<td>0.175</td>
<td>–</td>
</tr>
<tr>
<td>95th</td>
<td>0.209</td>
<td>0.140</td>
<td>0.239</td>
<td>–</td>
</tr>
<tr>
<td>Iron (percentiles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>4.75</td>
<td>4.90</td>
<td>5.72</td>
<td>–</td>
</tr>
<tr>
<td>25th</td>
<td>5.52</td>
<td>5.40</td>
<td>8.12</td>
<td>–</td>
</tr>
<tr>
<td>50th (median)</td>
<td>6.16</td>
<td>5.84*</td>
<td>9.42*</td>
<td>0.0009*</td>
</tr>
<tr>
<td>75th</td>
<td>9.22</td>
<td>6.42</td>
<td>12.34</td>
<td>–</td>
</tr>
<tr>
<td>95th</td>
<td>17.05</td>
<td>11.45</td>
<td>40.16</td>
<td>–</td>
</tr>
<tr>
<td>Zinc (percentiles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>161</td>
<td>176</td>
<td>137</td>
<td>–</td>
</tr>
<tr>
<td>25th</td>
<td>174</td>
<td>198</td>
<td>165</td>
<td>–</td>
</tr>
<tr>
<td>50th (median)</td>
<td>201</td>
<td>206*</td>
<td>183*</td>
<td>0.038*</td>
</tr>
<tr>
<td>75th</td>
<td>229</td>
<td>238</td>
<td>202</td>
<td>–</td>
</tr>
<tr>
<td>95th</td>
<td>245</td>
<td>399</td>
<td>237*</td>
<td>–</td>
</tr>
</tbody>
</table>

*Median test (overweight vs. obese); *statistically significant, p < 0.05

Acknowledgements

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REFERENCES


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