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# Copper Concentration in a Healthy Urban Adult Population of Southern Iran

**Mohammad Hossein Dabbaghmanesh · Narges Mohammad Salehi · Javad Siadatan · Gholamhossein Ranjbar Omrani**

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**Abstract** Nutritional deficiencies are important and widespread problems in most developing countries. Preventing and correcting micronutrient deficiencies are important because of the multiple negative consequences of these deficiencies. This study was designed to determine the prevalence of copper deficiency in an adult population in Shiraz, southern Iran. We also determined the association between copper status and other factors such as age, sex, and body mass index (BMI).In this cross-sectional study, 416 adults residing in Shiraz were selected by two-stage sampling. Serum copper was measured by flame-atomic absorption spectrometry. The data were analyzed with SPSS software. Mean age in our sample was 39.33±15.06 years, and mean BMI was 26.17±4.81 kg/m$^2$. Mean serum copper concentration was 118.15±54.33 μg/dL in the whole sample, 109.74±56.22 μg/dL in men, and 122.15±53.04 μg/dL in women. The overall prevalence of copper deficiency was 24%. The prevalence of copper deficiency differed significantly between men and women but not between different age groups. Serum copper concentration correlated significantly with BMI ($p<0.05$). This study is the first to evaluate serum copper status in a healthy population in southern Iran. We show that the mean copper concentrations were higher than those reported for Iranian populations in northern cities and were also higher compared with studies in most other countries. We suggested more detailed studies to identify the etiological determinants of this nutritional deficiency in Iran and elsewhere.

**Keywords** Serum copper · Deficiency · Prevalence

## Introduction

Micronutrient-related malnutrition is one of the most important nutritional problems worldwide, especially in most developing countries, and represents a serious health threat

M. H. Dabbaghmanesh (✉) · J. Siadatan · G. R. Omrani
Endocrine and Metabolism Research Center, Nemazee Hospital,
Shiraz University of Medical Sciences, Shiraz, Iran
e-mail: dabbaghm@sums.ac.ir

N. M. Salehi
Vice-Chancellory of Research, Shiraz University of Medical Sciences, Shiraz, Iran

for more than two billion people worldwide [1, 2]. One threat is the result of insufficient or unbalanced nutritional intake, and another is due to secondary complications from other diseases. Both problems can be evaluated by analyzing element concentrations in serum or other tissues [3].

Minerals, hormones, and different enzymes are known to have beneficial effects on growth. More than 25% of the body's enzymes depend on mineral ions for their proper functioning and metabolic activities [1]. Minerals such as copper are essential because they play a key role in various activities such as regulatory functions, as well as immunological and enzyme functions [4–7]. The most common clinical manifestations of copper deficiency are anemia, bone abnormalities [8], and sensorineural disorders [5]. Because copper plays an important role in the biological transfer of electrons, it is vital for the synthesis of red blood cells and the maintenance of nervous system structure and function [4]. Copper deficiency in adults can therefore result in blood and nervous system disorders [6, 9]. Moreover, copper plays an important role in the body's immune system and immune response [1].

Various studies have assessed copper deficiencies in various diseases, and the prevalence of copper deficiencies has been reported in other healthy populations [1, 4, 5, 9–12]. However, few community-based studies have investigated the prevalence of copper deficiency in the healthy Iranian population, and information about copper status among the people of southern Iran is lacking. Therefore, this study was conducted to determine the prevalence of this nutritional problem in this region.

## Materials and Methods

This analytical cross-sectional study was done at the Endocrine Research Center of Shiraz University of Medical Sciences in 2010 in Shiraz, Iran. The study protocol was approved by the Review Board of Shiraz Endocrine Research Center and the Shiraz University of Medical Sciences Ethics Committee.

Sample size for the estimation of mean serum copper concentration was calculated as 440 subjects, for an alpha level of 0.05.The subjects were selected by random sampling from each of the eight districts of Shiraz. First, postal codes that ended in even digits were chosen. Then, from each district, 55 individuals were selected (55 families from each district and one adult person from each family) with a table of random numbers. Each participant signed a written informed consent form after the nature of the study was explained to them.

The exclusion criteria were the presence of gastrointestinal disease including malabsorption or hepatic disorders, renal and cardiovascular disease, cancer, smoking, infection, use of oral contraceptives, chronic inflammatory disease, pregnancy, and a vegetarian diet. After excluding participants with any of these conditions, the total number of participants was 416 (134 men, aged 18–95 years and 282 women, aged 18–96 years).

A trained research assistant recorded anthropometric measurements in each participant, with the participants wearing light clothing and no footwear. Each participant was weighed to the nearest 0.1 kg with a portable digital balance. The height in all participants was measured to the nearest 1 cm with a portable stadiometer. Body mass index (BMI) was calculated as weight (kg)/height$^2$ (m), and was classified into four groups: BMI<20, 20≤BMI<25, 25≤BMI<30, and BMI≥30.

Serum concentrations of copper were measured by atomic absorption spectrometry (Chemtech Analytical CTA 2000, AAS, Kempston, UK). A copper concentration lower than 80 μg/dL was considered to indicate a low serum copper level [13].

Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS version 16.0.1, SPSS Inc, Chicago, IL). The data are presented as the mean ± standard deviation. One-way ANOVA and Student's two-tailed *t* test were used to compare the mean values obtained in different groups. Frequencies were compared with the chi-squared test. Pearson's correlation coefficient was used to study the correlation of copper concentration with age and BMI. In all analyses, the level of significance was considered $p<0.05$.

## Results

Two thirds (67.8%) of the 416 participants in study were women. Mean age of the participants was 39.33±15.06 years, and mean BMI was 26.17±4.81 kg/m². One third (30.3%) was less than 30 years old; 26.2% were in the 30–39-year-old group, 20.2% in the 40–49-year-old group, and 23.3% in the over-50-year-old group. Table 1 shows some of the demographic variables of the participants. Mean height and weight differed significantly between men and women ($p<0.05$). Except for BMI, the mean value for all other variables was higher in men.

Table 2 shows the serum copper levels in different subgroups based on gender, age, and BMI. The overall mean serum copper level was 118.15±54.33 μg/dL (18.6±8.5 μmol/L). Mean serum copper level did not differ significantly between men and women ($p>0.05$). The frequency distribution of copper concentrations in men and women is shown in Fig. 1. Most individuals (60.8% overall, 64.2% women, 53.7% men) had a serum concentration of over 100 μg/dL.

The correlation between serum copper concentration and BMI was statistically significant ($p=0.015$, $r=0.12$), but we did not find any significant correlation between serum copper concentration and age ($p=0.393$, $r=-0.04$).

There were no significant differences in mean copper concentration among different age or BMI subgroups ($p>0.05$), but when we used the post hoc test, it detected a statistically significant difference in copper concentration between subgroups with a BMI of 20–25 or 25–30 and individuals with a BMI≥30 ($p<0.05$).

Table 3 shows the frequency distribution of copper deficiency in our study population based on gender, age, and BMI. The overall incidence of copper deficiency was 24%. The incidence of copper deficiency was significantly higher in men (31.3%) than in women (20.6%).

There was no significant difference in the incidence of copper deficiency among age subgroups or BMI subgroups ($p>0.05$). However, we found the highest percentage of copper deficiency in the under-40 age groups and the BMI under-30 subgroups.

**Table 1** Anthropometric measures in the participants

| | Men (Mean ± SD) | Women (Mean ± SD) | Total (Mean ± SD) | *p* Value |
|---|---|---|---|---|
| Age (years) | 39.90±14.89 | 39.07±15.16 | 39.33±15.06 | 0.601 |
| Weight (kg) | 76.39±13.07 | 65.20±12.03 | 68.82±13.43 | <0.001 |
| Height (cm) | 172.08±7.84 | 157.52±6.53 | 162.24±9.75 | <0.001 |
| BMI (kg/m²) | 25.81±4.09 | 26.35±5.12 | 26.17±4.81 | 0.287 |

**Table 2** Serum copper concentration in an Iranian population according to sex, age and BMI

| Variable | Copper, μg/dL[a] | | Confidence interval | *p* Value |
|---|---|---|---|---|
| | *N* | Mean ± SD | | |
| Overall | 416 | 118.15±54.33 | 112.91–123.39 | NA |
| Sex distribution | | | | |
| Men | 32.2% | 109.74±56.21 | 100.13–119.34 | 0.029 |
| Women | 67.8% | 122.15±53.04 | 115.93–128.36 | |
| Age group (years)[b] | | | | |
| <30 | 30.3% | 119.33±56.24 | 109.42–129.25 | 0.349 |
| 30–39 | 26.2% | 124.28±57.85 | 113.29–135.26 | |
| 40–49 | 20.2% | 110.20±48.74 | 99.62–120.78 | |
| >50 | 23.3% | 116.61±52.14 | 106.1–127.12 | |
| BMI (kg/m$^2$)[b] | | | | |
| <20 | 9.4% | 115.90±55.27 | 97.98–133.81 | 0.082 |
| 20–24.9 | 33.4% | 114.45±54.03 | 104.84–124.06 | |
| 25–29.9 | 38.9% | 114.17±53.77 | 105.83–122.52 | |
| ≥30 | 18.3% | 132.45±55.99 | 119.65–145.24 | |

*NA* not applicable

[a] To compare mean serum copper concentration between sexes, *t* tests for independent samples were used

[b] To compare mean serum copper concentration between different age and BMI groups, one-way analysis of variance was used

## Discussion

Mean copper concentration in our study population was 118.15±54.33 μg/dL. Other studies in northern cities of Iran such as Mashhad and Tehran showed the mean copper concentrations of 14.7±3.3 μmol/L (93.39±20.96 μg/dL) and 95±20 μg/dL, respectively

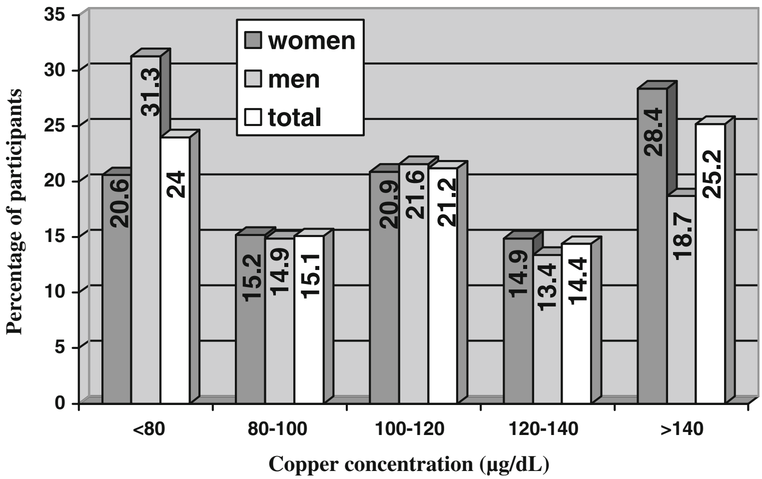


**Fig. 1** Distribution of serum copper concentrations in the whole sample an in men and women. Each *bar* represents the percentage frequency distribution of individuals with each concentration of copper

**Table 3** Frequency distribution of copper deficiency prevalence for the population classified by age group and BMI

| Variable | % Women | % Men | % Total | *p* Value |
|---|---|---|---|---|
| Overall | 20.6 | 31.3 | 24 | 0.01 |
| Age group (years)* | | | | |
| <30 | 16.1 | 35.9 | 22.2 | 0.48 |
| 30–39 | 16.4 | 27.8 | 20.2 | |
| 40–49 | 27.6 | 30.8 | 28.6 | |
| >50 | 25 | 30.3 | 26.8 | |
| BMI ($kg/m^2$)* | | | | |
| <20 | 30 | 11.1 | 25.6 | 0.16 |
| 20–24.9 | 20.3 | 40 | 27.4 | |
| 25–29.9 | 23.3 | 32.2 | 26.5 | |
| ≥30 | 12.1 | 22.2 | 14.5 | |

**P* value; for comparison of frequencies, chi-square test was used

[6, 14]. Thus, serum copper concentration in this study was higher than in northern parts of Iran. Table 4 compares the mean serum concentrations of copper in the present study and several other studies. The mean concentration for copper in this study was similar to figures for Greece and Northern Ireland and but higher than in Germany, Norway, continental Spain, the Canary Islands (Spain), Oman, China, and India. However, compared with the high value reported for Kuwait, mean serum copper in all adult Iranian populations was lower [15–24]. This difference could be due to local or regional differences in nutritional habits.

Our study found that mean serum copper concentration was higher in women than men, although this difference was not statistically significant. Other studies also found higher copper concentrations in women, which is consistent with the present study [6, 16, 18, 21]. The differences among age subgroups were not statistically significant. In a study of Greek

**Table 4** Mean serum copper concentrations in healthy individuals published for various countries

| Country | Age (years) | copper (μg/dL ) | Reference |
|---|---|---|---|
| Iran (Shiraz) | 18-96 | 118.1 | This study |
| Iran (Mashhad) | 15-65 | 93.6 | 6 |
| Iran (Tehran) | 6–62 | 95 | 14 |
| Kuwait | 15-80 | 147.7 | 17 |
| Oman | 18-62 | 101.1 | 23 |
| N. Ireland | 25-64 | 114.9 | 18 |
| Spain (Canary Islands) | 6-75 | 110 | 21 |
| Norway | 20-54 | 111.1 | 24 |
| Greece | 18-60 | 115.4 | 16 |
| Spain | 20-70 | 109.2 | 22 |
| Germany | 75 - 22 | 104.7 | 20 |
| India | 18-75 | 91.1 | 15 |
| China | 16-60 | 99 | 19 |

schoolchildren and their parents [25], there was also no significant difference between the age groups; however, a significant trend was seen toward higher concentrations in younger members of the population. In a Northern Ireland study, the opposite trend was seen: Serum copper concentration was higher in older age groups [18].

The total prevalence of copper deficiency among our participants was 24% (20.6% in women, 31. 3% in men). Another study of persons 18 to 75 years old in India reported a prevalence of copper deficiency of 34%, a higher figure compared with our study [15]. However, in a study of people older than 60 years of age in Chile, the prevalence of copper deficiency was 5.1% in women and 6.5% in men, which was lower than in the participants of our study [26]. The different results reported in different studies may reflect personal differences among participants. Although all studies compared groups of adults, the genetic, nutritional, demographic, and racial factors considered were different, and different criteria were used to diagnose copper deficiency. For example, in some studies, the cut-off point for copper deficiency was below 80 μg/dL, whereas other studies used a cut-off value of 75 μg/dL.

One of most noteworthy finding in this study was the statistically significant difference between sexes in the prevalence of copper deficiency, which was higher in men than in women. A study in India reported the same finding [15]: a higher mean copper concentration in females and a lower prevalence of copper deficiency.

In our study population, serum copper status correlated significantly with BMI: As BMI increased, so did serum copper concentration. A similar finding was reported in studies done in Kuwait and Iran [6, 17].

As previous studies have shown, many factors influence the etiology of micronutrient deficiencies, such as genetic factors, insufficient absorption, and some infectious diseases. In developing countries, low dietary quality plays a significant role in the insufficient intake of micronutrients. In addition, environmental factors play a prominent role in the amounts of elements available in the soil [1, 27, 28].

## Conclusion

This study shows that mean serum copper concentrations in Shiraz (southern Iran) were higher than those reported for Iranian populations in the northern part of the country and were also higher compared with other countries. We suggest more comprehensive studies are needed to determine the etiology of this micronutrient deficiency in different Iranian populations (as well as other populations) and to explain the differences between populations in different parts of Iran as well as different regions worldwide.

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