

Copper, magnesium, zinc and calcium status in osteopenic and osteoporotic post-menopausal women

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Summary

Copper, magnesium, zinc and calcium status were measured in postmenopausal women with osteoporosis ($n = 23$) and osteopenia ($n = 28$) as classified on the basis of the T-score of the femur neck and dual energy X-ray absorptiometry results. Anthropometric indices, dietary intake and serum copper, magnesium, zinc and calcium were assessed.

The results of our study showed that the mean dietary intake of magnesium, zinc and calcium in post-menopausal women with low bone density were significantly lower than recommended dietary allowance. The mean serum levels of zinc ($P = 0.001$) and copper ($P = 0.000$) were significantly lower than normal range and 40.4% of this participants had serum magnesium levels lower than normal range. No statistically significant differences were observed between the osteopenic and osteoporotic groups with respect to serum levels and dietary intakes of copper, calcium, magnesium and zinc.

Due to the mineral deficiency in post-menopausal women with low bone density and the key role of minerals on bone health, supplementation with magnesium, calcium, zinc and perhaps copper recommended.

KEY WORDS: copper; magnesium; zinc; calcium; osteoporosis; osteopenia.

Introduction

Osteoporosis, characterized by decreased bone mass,

seems to be due to an imbalance between bone resorption and bone formation at older ages (1-3), and is widely recognized as a major public health problem, especially for women (4).

Osteopenia, defined as a bone mineral density that is lower than normal but not low enough to be classified as osteoporosis, generally increases in severity with age and is most prevalent in women who are postmenopausal. Osteopenia is often called 'pre-osteoporosis' as it sometimes leads to osteoporosis (5). The etiology of osteoporosis and osteopenia is multi-factorial. Many factors – genetic differences, endocrine factors and lifestyle behaviour, such as physical activity and diet, especially mineral deficiency due to reduced dietary intake and reduced absorption of these nutrients – are thought to play important role in osteopenia or osteoporosis and its prevention (5, 6).

Minerals such as magnesium, zinc, copper and calcium are all essential for health. They help promote strong bones and are involved in the interaction of more than 300 enzyme reactions. These minerals are also necessary for the transmission of nerve impulses, temperature regulation, detoxification and the formation of healthy bones and teeth (7-9).

Studies for at least three decades have shown that magnesium and zinc are essential for organic bone matrix synthesis (5), and magnesium deficiency may affect the quality of bone by decreasing bone formation, preventing the optimal crystal formation and having a negative effect on PTH (10).

Zinc has been demonstrated to have a wide variety of roles in mammalian system and may play a physiological role in mineralization of bone tissue (11). However, zinc nutritional deficiency is a global health problem (12, 13). Hill et al. in their study showed a relationship between zinc nutritive status and bone turnover in elder adults (14). In addition, zinc is required for the complete physiological action of vitamin D on calcium metabolism in rats (15). The physiological role of copper in bone metabolism and homeostasis is unclear. Studies have shown that copper is needed for the enzyme that increases the crosslinking of collagen and elastin molecules (16).

Because nowadays, osteoporosis is a major health concern in the world and with notice the important role of minerals in bone density, and also because there has been little research on the dietary intake and serum levels of magnesium, zinc, copper and calcium in osteoporotic and osteopenic women, especially in Iran, the purpose of this study was to investigate and compare the mineral status between osteopenic and osteoporotic postmenopausal women in Tabriz, Islamic Republic of Iran.

Methods

Fifty-one post-menopausal women that were referred to the rheumatology clinic in Tabriz, Islamic Republic of Iran, based on the result of bone mineral density measurements and T-score were selected randomly and assessed for inclusion in

the study. Women were defined as post-menopausal if they were > 50 years of age and there had been no menstruation for ≥ 6 months prior to entry into the study.

The inclusion criteria were: women >50 years old who had been no menstruation for ≥ 6 months prior to entry into the study, having no history of hormone replacement therapy, other bone disease, kidney stones, endocrine disorders or any medical conditions that could influence on the mineral status.

The exclusion criteria were: use of mineral supplements, having history of hormone replacement therapy, bone disease, kidney stones, endocrine disorders or any medical conditions that could influence on the mineral status.

Using the World Health Organization's classification criteria (17) based on bone mineral density, the post-menopausal women were classified as having osteoporosis and osteopenia on the basis of the femur neck T-score and dual energy X-ray absorptiometry (DEXA) results. Patients with bone loss of at least 1.0 SD from normal, are considered to be osteopenic, whereas those with bone loss of at least 2.5 SD, are considered to be osteoporotic. Approval for the study was obtained from the regional medical research ethics committee in Tabriz University of Medical Sciences and informed consent was obtained from all the participants.

The height and weight of the women were measured while they wore light clothes and without shoes, and body mass index (BMI) was calculated. All subjects completed take home 3-day food recall (two weekdays and one weekend), and these records were verified by a nutritionist.

Venous blood samples for serum preparation were obtained after 12 h of fasting and collected in polystyrene tubes and then centrifuged within 2 h at $3000 \times g$ for 10 min.

The serum was separated and stored at -32°C . Serum calcium level was assessed using kits (Pars Azmoon Inc.). Serum zinc, magnesium and copper were analyzed using atomic absorption spectrophotometer (Chemtech Analytical CTA 2000).

The data was analyzed by SPSS software package version

11.5, and using Pearson correlation coefficients, independent *t*-test and 1-sample *t*-test. *P*-values < 0.05 were considered to indicate statistically significant differences.

Result

A total of 51 post-menopausal women aged between 50 and 80 years were included in the study. From 51 participants, 23 women had osteoporosis and 28 women had osteopenia. The mean age of participants was 57.97 ± 1.2 years old and the mean menopausal age was 48.6 ± 0.36 years old. The mean weight and height of participants were 67.97 ± 1.09 kg and 156.8 ± 0.79 cm, respectively. The mean of body mass index was 27.62 ± 0.39 kg/m². The general characteristics base on two groups (osteopenic and osteoporotic patients) have shown in Table 1.

As shown in Table 1, there isn't significant difference in general characteristics between osteopenic and osteoporotic patients.

The mean dietary intake of zinc, calcium and magnesium were significantly lower than recommended dietary allowance (RDA).

The mean dietary intake (and percent from RDA) of zinc, calcium, magnesium and copper in post-menopausal women with low bone density were 3.82 ± 0.19 mg/day ($48 \pm 2.41\%$ RDA), 740.61 ± 41.8 mg/day ($61.65 \pm 3.5\%$ RDA), 115.76 ± 8.6 mg/day ($35.55 \pm 2.68\%$ RDA) and 1.07 ± 0.08 mg/day ($120 \pm 12.2\%$ RDA), respectively.

The mean serum levels of zinc, calcium, magnesium and copper were 67.4 ± 3.32 $\mu\text{g/dl}$, 9.2 ± 0.19 mg/dl, 0.76 ± 0.01 mmol/L and 27 ± 0.9 $\mu\text{g/dl}$, respectively. The mean serum levels of zinc ($P = 0.001$) and copper ($P = 0.000$) were significantly lower than normal range and serum calcium and magnesium levels were in normal range, but 40.4% of participants have serum magnesium levels lower than normal range.

Dietary intake and serum levels of minerals in osteopenic and osteoporotic patients have shown in Table 2.

Table 1 - General characteristics in osteopenic and osteoporotic patients.

Characteristics	Osteopenia (n=28)	Osteoporosis (n=23)	P value
Age (years)	59 ± 1.76	65.6 ± 1.55	0.31
Age of menopause (years)	48.37 ± 0.57	48.95 ± 0.35	0.39
Weight (kg)	67.81 ± 1.27	68.2 ± 1.94	0.86
Height (cm)	156.77 ± 1.07	156.95 ± 1.20	0.91
Body mass index (kg/m ²)	27.58 ± 0.44	27.68 ± 0.72	0.89

Table 2 - The dietary intake and serum concentration of minerals in osteopenic and osteoporotic patients.

	Osteopenia (n=28)	Osteoporosis (n=23)	P value
Serum Zinc ($\mu\text{g/dl}$)	70.44 ± 4.5	63.3 ± 4.8	0.28
Serum Calcium (mg/dl)	9.2 ± 0.28	9.1 ± 0.26	0.83
Serum Copper ($\mu\text{g/dl}$)	27.29 ± 1.26	26.75 ± 1.35	0.77
Serum Magnesium (mmol/L)	0.77 ± 0.01	0.76 ± 0.02	0.79
Energy intake (Kcal/day)	1893.62 ± 110.6	1945.45 ± 85.51	0.71
Zinc intake (mg/day)	3.87 ± 0.30	3.75 ± 0.22	0.78
Calcium intake (mg/day)	737.4 ± 62.65	744.95 ± 52.19	0.92
Copper intake (mg/day)	1.12 ± 0.13	1.01 ± 0.06	0.39
Magnesium intake (mg/day)	121.94 ± 13.99	107.42 ± 7.27	0.36

As shown in Table 2, no statistically significant differences were observed between the osteopenic and osteoporotic groups with respect to serum levels and dietary intake of zinc, calcium, magnesium and copper.

Discussion

The result of this study demonstrated that the mean dietary intake of zinc, calcium and magnesium in osteopenic and osteoporotic post-menopausal women was significantly lower than recommended dietary allowance. In addition serum levels of zinc and copper were significantly lower than normal range, also 40.5% of patients had serum magnesium level lower than normal range.

According to WHO standards, when BMD falls sufficiently below healthy values (1 standard deviation [SD]), low bone mass or osteopenia exists and osteoporosis occurs when the BMD becomes so low (greater than 2.5 SDs below healthy values) (17). Although diseases such as osteoporosis and osteopenia have complex causes, the development of these diseases can be minimized by providing adequate amounts of nutrients throughout the life cycle (16).

Minerals such as magnesium, zinc, calcium and copper are all essential for health. They help to promote strong bones and are important for bone metabolism. Studies have shown that calcium, magnesium and zinc are essential for organic bone matrix synthesis (5).

Magnesium deficiency through several mechanisms can affect on bone health. Low magnesium alters the structure of apatite crystals. Indeed, osteoporotic women with demonstrated magnesium deficiency have larger organized crystals in trabecular bone than healthy women and larger crystals cause bones do not bear a normal load. Also magnesium deficiency associates with the reduction of the levels of PTH and thus the decrease of vitamin D (18).

Zinc, as a trace element, is essential for function of several critical enzymes in osteoblasts that are essential for collagen synthesis and other products. In addition, alkaline phosphatase requires zinc for its activity in the osteoblasts (19). Until now, the physiological role of copper in bone homeostasis is unclear. It has shown that copper is needed for the enzyme that increases the crosslinking of collagen and elastin molecules, also it may have roles in other enzymes of bone cells. Because of the changes induced in the two matrix proteins by low copper intakes, bone mineralization may also be reduced (16).

Mutlu et al. (5) in their study demonstrated lower levels of magnesium and zinc in serum samples of post-menopausal women with osteoporosis and osteopenia than normal women, in their study in opposite of our finding, serum copper level in these patients was in normal range.

Ryder et al. (20) have suggested that meeting the recommended dietary allowance for magnesium improve bone mass density.

Zinc deficiency in our study is similar to the results that obtained from the second National Health and Nutrition Interview Survey in 1976-80 (21) and an epidemiological survey conducted in Rome (22). One study in Iran showed that the mean of serum zinc level in patients with bone fractures was significantly lower than normal range and supplementation with zinc caused a significant elevation of serum zinc and had positive effect on callus formation (23). Although many studies suggested that low serum zinc concentrations can be

the result of low zinc dietary intake, Relea et al. (24) and Herzberg et al. (25) reported that urinary zinc excretion is higher in osteoporotic women than women with no osteoporosis.

With notice that nutritional monitoring programs in different countries have shown an inadequate dietary intake of some minerals such as magnesium (26), zinc (27, 28) and calcium (29) in human, and significant association between bone density and minerals status in body, on the basis of our results, mineral supplementation especially with calcium, magnesium, zinc and perhaps copper may have beneficial effect on bone density in post-menopausal women with low bone density. Future studies are recommended.

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