

Do the other nutrients except calcium and vitamin D prevent the incidence of osteoporosis?

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ABSTRACT

Osteoporosis as a skeletal disorder characterize by compromised bone strength predisposing a person to an increased risk of fracture. All people should be encouraged to take efforts to prevent bone loss and fractures. Nutrition is one of several factors that can be modified to reduce osteoporosis risk. The purpose of this review article is assessment the role of the other nutrients the exception of calcium and vitamin D on bone health and prevention of osteoporosis.

The search was undertaken in three databases (PubMed, google scholar and science direct) for publications from 2005 onwards using key words as follows. Initial searches yielded approximately 2467 results. After considering additional exclusion criteria, 33 clinical trial and meta- analysis papers remained.

According to investigations, high intake of dietary protein increase bone resorption and calcium excretion and low protein intake can prevent calcium absorption and decrease strength and bone mass. Omega-3 supplementation also can decrease bone resorption and α -linleic acid (for men and women) and arashidonic acid (in men) and isoflavones can significantly diminish the risk of hip fracture. Adequate intake of some nutrients like zinc, vitamin A, boron and manganese in bone formation and copper, fluoride and strontium in bone mineralization have positive effects. However, high intake of vitamin A and fluoride result in hip fracture incretion. Vitamin K (in form of K₂) along with calcium and vitamin D induce bone fracture decrease. If intake of phosphate, iron and sodium be more than the recommended values, they may present negative effects on bone mineralization.

In conclusion, risk of osteoporosis incidence may be diminished with an adequate and balanced diet containing variety of foods to meet needs and a healthy lifestyle. Nutrition education and training the other preventive factors should be carrying out in childhood to achieve the peak bone mass in youth and aging.

Key words: Osteoporosis; Nutrition; Diet; Macronutrients; Micronutrients; Dietary patterns

INTRODUCTION

Osteoporosis is defined as a skeletal disorder characterized by compromised bone strength predisposing a person to an increased risk of fracture, bone strength reflecting the integration of bone density and bone quality [1]. Osteoporosis is associated with high morbidity and mortality especially because of its expression in age related fractures. Childhood and adolescence are important for optimal formation of bone and for prevention of osteoporosis in older age. After the age of 30, there is no further increase of bone mass and a

gradual natural reduction ensues [2]. The first fracture incidence in younger age increases the risk of a second fracture [3]. Because of increase in elderly population, osteoporosis appears to become as a major public health issue in developing countries as in Iran, even though osteoporosis is not exclusive to older age [4]. The overall prevalence rate of osteoporosis in elderly people was 32.1% in at least one measurement sites. Osteoporosis prevalence in women was 55.7% and this value in elderly men was 12.4% [5].

With the anticipated increases in world population and life expectancy, hip fractures are predicted to rise to 6.3 million by 2050. Accordingly, the World Health Organization has identified osteoporosis as a priority health issue and called for a global strategy for the prevention and control of the disease [6].

The aim of osteoporosis management is to prevent a first or subsequent fracture by slowing or preventing bone loss, maintaining bone strength and minimizing skeletal trauma. All people should be encouraged to take efforts to prevent bone loss and fractures, such as eating a balanced diet, participating in appropriate weight-bearing exercise, not smoking, avoiding excessive alcohol consumption, and instituting measures to prevent falls. Nutrition is one of the several factors that can be modified to reduce osteoporosis risk. A balanced diet is crucial for bone development and for general health. Calcium and vitamin D have received most of the attention directed to diet and bone health, moreover, many other nutrients and food components can affect bone status [7].

The purpose of this review article was to assess the role of the other nutrients except calcium and vitamin D on bone health and prevention of osteoporosis.

MATERIALS AND METHODS

The search was undertaken in three databases (PubMed, google scholar and science direct) for publications from 2005 onwards. The initial search terms were “osteoporosis” and “nutrition” later refined by searching for particular terms like “macronutrients, micronutrients, trace elements, dietary pattern, physical activity, each of macro and micronutrients separately”.

Initial searches yielded approximately 2467 results. After considering additional exclusion criteria (non-English language, manuscripts not available as full-text), 33 papers remained.

RESULTS

Osteoporosis has multifactorial etiology. Osteoporosis is one of diseases which are influenced by nutrition and life style (see table 1). Nutrition management of osteoporosis are discussed as these categories: macronutrients, micronutrients, trace minerals, other influencing factors (alcohol, caffeine, sodium, isoflavone) and dietary pattern.

Macronutrients

Protein

Half of the volume of bone and about one-third its mass is made of protein, and this bone protein matrix undergoes continuous turnover and remodeling [8]. Protein intake affects bone in several ways: 1) it provides the structural matrix of bone, 2) it optimizes IGF-1 levels, 3) it is reported to increase urinary calcium, and 4) it is reported to increase intestinal calcium absorption [9].

Protein deficiency can contribute to the risk of osteoporotic fractures and result in failure to achieve peak bone mass and in a lack of preservation of bone mass during ageing. The risk of fracture may be increased not only as a consequence of decreased bone mass but also as a result of an increased propensity to fall because of altered muscle strength and impairment of movement coordination [10].

Acid-forming foods such as meat, fish, eggs, and cereal can increase urinary calcium that is likely determined by the acid-base status of the total diet. Bone loss may be attributable, in part, to the mobilization of skeletal salts to balance the endogenous acid generated from acid-forming foods [9].

Fat

In longitudinal observational study, a-linolenic acid (ALA) intake was significantly associated with reduced risk of hip fracture in women and men, and arachidonic acid (AA) intake was significantly associated with reduced risk of hip fracture in men but not women. Fish consumption (3 serving/wk), intakes of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and (EPA+DHA) and the (n-6):(n-3) fatty acid ratio were not associated with hip fracture risk [11].

Higher saturated fatty acid (SFA) consumption was associated with higher hip fracture risk. Lower total fracture risk was associated with a higher monounsaturated fatty acid (MUFA) intake and polyunsaturated fatty acid (PUFA) intake. Higher consumption of marine n-3 FAs was associated with greater total fracture risk, whereas a higher n-6 FA intake was associated with a lower total fracture risk. These results suggest that saturated FA intake may significantly increase hip fracture risk through several mechanisms, including opposing effects

on inflammatory cytokine, modulation of prostaglandin E₂ (PGE₂) production, enhancement of calcium transport, and reducing urinary calcium Excretion, whereas MUFA and PUFA intakes may decrease total fracture risk [11]. In postmenopausal women with a low intake of marine n-3 FAs, a higher intake of n-6 FAs may modestly decrease total fracture risk [12].

To evaluate the impact of n-3 fatty acids on bone biomarkers, twenty-five osteoporotic postmenopausal women were recruited in the study and randomized in treatment and control groups. The patients received 900 mg n-3 fatty acid capsules or placebo per day for 6 months. Supplementation with n-3 fatty acids can decrease bone resorption; however, it could not affect bone formation significantly after 6 months treatment [13].

Conjugated linoleic acid (CLA) as a group of PUFAs, contains two conjugated double bonds, naturally is found in meat and milk products from cattle, lamb, and goat. CLA induces retention of bone mineral density (BMD) in older mice [14]. Supplementation with CLA for 14 weeks 2-month-old mice resulted in increased BMC and BMD of trabecular and cortical bone [15].

CLA modulates bone physiology through a mechanism dependent on changes of peroxisome proliferator-activated receptor (PPAR)- γ -mediated induction (a family of transcription factors) of adipogenesis of mesenchymal cell differentiation to adipocytes in bone [16].

Micronutrients

Phosphate

Phosphate salts are available in all foods either naturally or because of processing. Calcium and phosphate ions in a ratio of approximately 1: 1 are needed for the mineralization of bone. Soft drinks are poor in nutrient value but high in phosphate content. Those at high risk and those who have osteoporosis may want to avoid these beverages because an effect is theoretically possible [17].

According to the acid-ash hypothesis, increased excretion of "acidic" ions such as phosphate, contributes to net acidic ion excretion, urine calcium excretion, demineralization of bone, and osteoporosis. Findings from a meta-analysis were

contrary to the acid ash hypothesis. When dietary phosphate was increased, urine calcium decreased, whether the subjects had low or high calcium intakes and whether the phosphate supplement was neutral/ alkaline or acidic. Three of the four calcium balance analyses revealed that as phosphate supplements are increased, calcium balance increased. However, when the phosphate salt was acidic, there was no important change in calcium balance. The effect of phosphate supplementation on the bone metabolism markers did not provide any clear information. The increased net acid excretion from phosphate supplements in three studies was associated with lowered urinary calcium excretion [18].

Zinc

Zinc is required for the growth, development, and maintenance of healthy bones. In different conditions associated with zinc deficiency the retardation of bone growth is a common. Zinc sulfate caused increases in bone components: Alkaline phosphatase is related to bone mineralization, Collagen is a main bone matrix protein that is produced in osteoblasts, DNA content in the bone tissues that is a marker of bone cells, including osteoblasts, osteoclasts, and osteocytes. Zinc stimulates the production of IGF-I and TGF- β 1 (bone growth factors) and has a stimulatory effect on osteoblastic bone formation and mineralization, and an inhibitory effect on osteoclastic bone resorption [19].

The study was conducted on 224 postmenopausal women provided with adequate vitamin D and Ca to determine whether increased Cu and Zn intakes would reduce the risk for bone loss. Healthy women aged 51-80 years were recruited for a double-blind, placebo-controlled study. Women were randomly assigned to two groups of 112 each that were supplemented daily for 2 years with 600 mg Ca plus maize starch placebo or 600 mg Ca plus 2 mg Cu and 12 mg Zn and 5 d food diaries were obtained annually. Based on 5 d food diaries, the negative effect was caused by Zn and mainly occurred with Zn intakes ≥ 8.0 mg/d. With Zn intakes < 8.0 mg/d, Zn supplementation apparently prevented a significant decrease in whole-body bone densities. The findings indicate that Zn supplementation may be beneficial to bone health in postmenopausal women with usual Zn intakes

< 8.0 mg/d but not in women consuming adequate amounts of Zn [20].

Table 1. Selected publications on nutrients affecting the incidence of osteoporosis.

Publication	Type of Study / Duration	No. of Subjects	Results
Farina EK/2011	Cross-sectional / longitudinal (4 years)	623	Cross-sectionally, both women and men with high fish intakes (3 servings/wk) had a greater mean baseline FN-BMD. longitudinally between fish intakes and change in BMD over 4 y in women and men (ALA) associated with <u>reduced risk of hip fracture in women and men</u> , and (AA) intake was associated with <u>reduced risk of hip fracture in men</u>
Salari Sharif P, et al/ 2010	Case-control	25 osteoporotic postmenopausal women	900 mg n-3 fatty acid capsules or placebo per day for 6 months. Supplementation with n-3 fatty acids can decrease bone resorption; however, it could not affect bone formation significantly after 6 months treatment
Banu J / 2006	Interventional / 14 week	2-month mice	Supplementation with CLA increased BMC, bone area, and BMD of trabecular and cortical bone
Nielsen FH, et al / 2011	Case-control/2 years	224 postmenopausal women aged 51-80	Zn supplementation may be beneficial to bone health in postmenopausal women with usual Zn intakes < 8.0 mg/d but not in women consuming adequate amounts of Zn
Mackinnon ES, et al / 2011	Interventional /one-month	23 healthy postmenopausal women, 50–60 years old	Results showed significantly increased NTx. These findings suggest that the daily consumption of lycopene may be important as it acts as an antioxidant to decrease bone resorption in postmenopausal women and may therefore be beneficial in reducing the risk of osteoporosis.
Gajic-Veljanoski o / 2011	Cohort / 5 years	1,000 healthy 50-year-old postmenopausal women without osteoporosis or previous fractures	Supplementation with vitamin K2 to vitamin D3 with calcium in postmenopausal women reduced the lifetime probability of at least one fracture by 25%, increased discounted survival by 0.7 quality-adjusted life-years (QALYs). vitamin K1, vitamin D and calcium reduced the lifetime probability of fracture by 20%, increased discounted survival by 0.4 QALYs.
Pinheiro MM / 2009	population-based study	2344 individuals aged 40 years or older	Only 20% of the participants reached the DRI. Fractures was reported by 13% of men and 15% of women. Women with fractures presented significantly higher calcium, phosphorus and magnesium intakes. for every 100 mg of phosphorus intake the risk of fractures increases by 9% (adverse effects????).
Odabasi E / 2008	Case-control	77 osteoporotic women & 61 age- and BMI-matched healthy postmenopausal women	Mg levels in RBC was significantly lower in postmenopausal women with osteoporosis. Mg transport mechanism(s) into the cell could be affected in patients with osteoporosis. No significant difference was found between patient and control groups, for zinc, copper, manganese, and selenium
Hooshmand S, et al / 2011	Case-control / 12 month	160 Postmenopausal women	In comparison with corresponding baseline values, only dried plum significantly decreased serum levels of bone turnover markers including bone-specific alkaline phosphatase and tartrate-resistant acid phosphatase-5b.
Tsay J / 2010	Case - control	8 male mice of 2-month-old	Iron-overloaded mice exhibited: Dose-dependent increased tissue iron content, Changes in bone composition, Trabecular and cortical thinning of bone, Increased bone resorption
Pejović-Milić A, et al / 2009	Case - control	40 subjects (30 welders and 10 controls)	The mean bone Mn levels were higher than for welders that showed bone Mn levels do reflect differences in the occupational exposure of Mn
Bae YJ, et al / 2008	Interventional	ovariectomized rats/12 week	Serum C-telopeptide cross-links of type I collagen (CTX), and alkaline phosphatase (ALP), were not significantly different among the four groups. serum osteocalcin was significantly increased by Mn supplementation resulted in Mn supplementation increased BMD and bone formation.

Reginster JY, et al / 2012	Case-control / 10 years	Postmenopausal osteoporotic women	Lumbar BMD increased continuously and significantly, over 10 years.
Hallstrom H, et al / 2010	Cohort study / 2 years	359 men and 358 women (aged 72 years)	A high consumption of coffee (i.e. 4 cups or more per day) could contribute to a reduction in BMD of the proximal femur in elderly men. BMD was lower in high consumers of coffee with rapid metabolism of caffeine.
Haghighian A / 2005	Interventional / 12 week	15 osteopenic women 45–64 years	Soy protein consumption resulted in a significant reduction in the urinary deoxypyridinoline and increasing of total alkaline phosphatase, although the alterations in osteocalcin, c-telopeptide, IGFBP3 and type I collagen telopeptide were not significant.
Wosje KS / 2010	longitudinal study / 4 years	308 children	High intake of dark green and deep-yellow vegetables was related to high bone mass; high processed-meat intake was related to high bone mass; and high fried-food intake was related to high fat mass.
Cole ZA / 2009	longitudinal study / 9 years	198 pregnant women 17–43 yr of age and their offspring at 9 yr of age	Higher prudent diet score in late pregnancy was associated with greater whole body and lumbar spine BMC and areal BMD in the offspring at 9 yr of age. Associations with prudent diet score in early pregnancy were weaker and non significant.

Vitamin A

Vitamin A consumption has beneficial effects on bone growth and maintenance. Lycopene may be protective against oxidative stress and bone resorption. 23 healthy postmenopausal women, 50–60 years old, provided blood samples at baseline and following a one-month lycopene-depletion period. Serum samples were analyzed for carotenoids and the bone turnover markers bone alkaline phosphatase and crosslinked N-telopeptide of type I collagen (NTx). Results showed significantly increased NTx that suggested the daily consumption of lycopene may be important as it acts as an antioxidant to decrease bone resorption in postmenopausal women and may therefore be beneficial in reducing the risk of osteoporosis [21]. Excessive retinol intake (but not carotenoids) may contribute to risk for hip fractures. The inconsistencies may be due, in part, to difficulties in obtaining an accurate assessment of vitamin A intake or status. Serum retinol is a poor measure of vitamin A status because it is subject to homeostatic control. Stable-isotope-dilution methodology gives a validated assessment of the total-body and liver vitamin A stores and is recommended in future studies on vitamin A status and osteoporosis. The potential for exacerbating an already serious public health problem with intakes of vitamin A currently considered safe indicates further research into this matter is warranted [22].

Vitamin K

Vitamin K has role in posttranslational modification of several matrix proteins, including osteocalcin. Following bone resorption, osteocalcin is released and enters the blood (osteocalcin serves as a serum bone marker for predicting the risk of a fracture). Vitamin K intakes in older persons who may also be taking vitamin K antagonists are low [23]. Supplementation with vitamin K2 to vitamin D3 with calcium in postmenopausal women reduced the lifetime probability of at least one fracture by 25%, increased discounted survival by 0.7 quality-adjusted life-years (QALYs). Vitamin K1, vitamin D and calcium reduced the lifetime probability of fracture by 20%, increased discounted survival by 0.4 QALYs. The efficacy of vitamin K was the most important parameter in sensitivity analyses. Conclusions Lifetime supplementation with vitamin K, vitamin D3, and calcium is likely to reduce fractures and increase survival in postmenopausal women. [24].

Magnesium

Magnesium deficiency may affect the quality of bone by decreasing bone formation, preventing the optimal crystal formation, having a negative effect on PTH [25]. In a transversal population-based study, a total of 2420 individuals over 40 years old were evaluated for nutrient intakes. Fractures were reported by 13% of men and 15% of women. In all regions and socio-economical levels mean intakes of bone related nutrients were below the recommended levels. It was demonstrated that for every 100 mg/phosphorus increase the risk of fractures by 9% [26].

Seventy-seven postmenopausal women with osteoporosis aged 61 years and 61 age- and BMI-matched healthy postmenopausal women aged 60 years were included in the study to evaluate element concentrations in plasma and red blood cells. Only statistically significant difference between the osteoporotic and healthy subjects was observed in red blood cell (RBC) magnesium concentration. Mg levels in red blood cells are significantly lower in postmenopausal women with osteoporosis. It is concluded that Mg transport mechanism(s) into the cell could be affected in patients with osteoporosis [27].

Trace minerals

Boron

Prunes are a rich source of boron and raisins, dried apricots, or avocados are the other source. Boron is used by osteoblasts for bone formation [28]. It is required to convert estrogen to its most active form, 17-betaestradiol, and estrogen is involved in bone metabolism. Boron stabilizes and extends the half-life of vitamin D and estrogen [29].

Bone marrow stromal cells (BMSCs) proliferation and cell osteogenic differentiation was evaluated [through alkaline phosphatase (ALP) activity] by Ying and his colleagues. The results indicated that the proliferation of BMSCs was no different from the control group when added with boron at the concentration of 1, 10, and 100 ng/ml respectively [30].

To examine the extent to which dried plum reverses bone loss in osteopenic postmenopausal women, the study was carried out on 236 women, 1-10 years postmenopausal, not on hormone replacement therapy or any other prescribed medication known to influence bone metabolism. Qualified participants (n 160) were randomly assigned to one of the two treatment groups: dried plum (100 g/d) or dried apple (comparative control). Dried plum significantly increased BMD of ulna and spine in comparison with dried apple. In comparison with corresponding baseline values, only dried plum significantly decreased serum levels of bone turnover markers including bone-specific alkaline phosphatase and tartrate-resistant acid phosphatase-5b after 12 months [31].

Copper

Copper is needed for enzyme that increases the crosslinking of collagen and elastin molecules.

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. There is no significant difference between the postmenopausal women with and without osteoporosis in terms of Cu levels in plasma and in RBC [27].

In Nielsen's study, findings also indicated that the greatest decreases in bone loss occurred with Cu and Zn supplementation. Food diaries also indicated that Mg intakes < 237 mg/d, Cu intakes < 0.9 mg/d and Zn intakes < 8.0 mg/d are associated with poorer bone health [20].

Fluoride

Fluoride ions enter the hydroxyapatite crystals of bone. Fluoride ions have little effect on increasing the hardness of bone mineral. At intakes of 2 ppm or greater, fluoride may produce bone that is subject to increased micro fractures because of the change in the properties of the hydroxyapatite crystals [28].

Meta-analysis indicates that beneficial anabolic effects may dominate at lower doses of fluoride (≤ 20 mg/day fluoride equivalents). The used doses of fluoride equivalents there is a marked and clinically significant increase in BMD especially in the spine but also in the hip without any reduction in vertebral or non-vertebral fracture risk with increasing treatment duration

($5.04 \pm 2.16\%$ /year of treatment). Spine BMD increased 7.9% and hip BMD 2.1%. Low dose fluoride reduced vertebral fractures by 72% and non-vertebral fractures by 48% [32].

Iron

Iron serves as a catalytic cofactor for the vitamin C-dependent hydroxylations of proline and lysine in collagen maturation. Iron also has other roles in osteoblasts and osteoclasts in mitochondrial oxidative-phosphorylation, as well as in other heme- and non heme-containing enzymes [28]. Tsay & colleagues generated an iron-overloaded mouse by injecting iron dextran at 2 doses into mice for 2 months to define the effect of iron excess in bone. Compared with the placebo group, iron-overloaded mice exhibited dose-dependent increased tissue iron content, changes in bone composition, and trabecular and cortical thinning of bone accompanied by increased bone resorption. Liver and spleen iron content were markedly

increased. Although bone iron content was also increased in iron-treated mice compared with placebo, the increase was not as pronounced as in liver and spleen. Analysis of cortical bone (mid-diaphysis femur) in the iron-overloaded animals showed thinner cortices and decreased cortical area compared with controls [33].

Manganese

Manganese is required for the biosynthesis of mucopolysaccharides in bone matrix formation, and it also acts as a cofactor in energy-generating reactions. There is a need for a diagnostic tool with the ability to measure cumulative exposure to manganese (Mn) in the workplace. Bone Mn levels of welders were measured and compared to the levels found in subjects without exposure to the element in a study. Forty subjects (30 welders and 10 controls) were recruited. An occupational history was obtained and subjects underwent *in vivo* neutron activation analysis (IVNAA) bone Mn measurements. The mean bone Mn levels were higher than for welders. It appears that bone Mn levels do reflect differences in the occupational exposure of Mn [34].

The effect of manganese (Mn) supplementation on bone mineral density (BMD) and bone metabolism parameters was determined in ovariectomized rats. Rats were divided into four groups and fed with different intake levels of manganese for 12 weeks. BMD of the lumbar vertebrae, femur, and tibia were significantly lowered in ovariectomized rats compared to the sham group. In addition, BMD of the lumbar vertebrae was significantly increased by Mn supplementation in the sham groups. Serum C-telopeptide cross-links of type I collagen (CTX), bone resorption biomarker; alkaline phosphatase (ALP), and bone formation biomarkers were not significantly different among the four groups. However, serum osteocalcin, a more sensitive bone formation biomarker, was significantly increased by Mn supplementation. To summarize, Mn supplementation resulted in increased BMD and bone formation [35].

Strontium

Strontium has gained attention for bone mineralization because it increases bone density as measured by DXA Scan. Strontium is considered an alkaline earth metal, that makes it much heavier than calcium and it replaces natural calcium in bone. Strontium ranelate in

doses of 2 gram/day have been used for the treatment of osteoporosis in several countries. Strontium ranelate has proven efficacy against vertebral and nonvertebral fractures, including hip, over 5 years in postmenopausal osteoporosis. Long term efficacy and safety of strontium ranelate was explored over 10 years. Postmenopausal osteoporotic women participating in the double-blind, placebo-controlled studies, Spinal Osteoporosis Therapeutic Intervention (SOTI) and Treatment of Peripheral Osteoporosis (TROPOS) trials, were invited to enter a 5- year open-label extension, during which they received strontium ranelate 2 g/day (n=237, 10-year population). Lumbar BMD increased continuously and significantly, over 10 years. Long-term treatment with strontium ranelate is associated with sustained increases in BMD over 10 years, with a good safety profile. Our results also support the maintenance of antifracture efficacy over 10 years with strontium ranelate [36].

Overall, the clinical data available suggest that strontium ranelate is an effective and generally well tolerated option for the first-line treatment of postmenopausal osteoporosis [37].

Other influencing factors

Alcohol

Moderate consumption of wine and beer may be beneficial to bone in men and postmenopausal women. In men, high liquor intakes (>2 drinks/d) are associated with significantly lower BMD. Heavy alcohol consumption also may be accompanied by poor dietary intake, cigarette smoking, body imbalance, and an increased risk of falls [17].

Caffeine and Soft Drinks

Excessive caffeine intake has a deleterious effect on BMD. Intake of colas is also associated with lower BMD. Although the primary issue may be displacement of dairy beverages, there is also potential direct effect [38]. Dietary intakes of 359 men and 358 women (aged 72 years) were assessed by a 7-day food diary. Two years later, BMD for total proximal femur, femoral neck and trochanteric regions of the proximal femur were measured by Dual-energy X-ray absorptiometry (DXA). In this cohort the consumption of coffee was high and they observed a decrease in BMD of the proximal femur in men consuming 4 cups of

coffee or more daily. In high consumers of coffee, rapid metabolizers had lower BMD values than slow metabolizers of caffeine. A potential risk group more prone to develop osteoporosis might, thus, have been identified. The observed decrease in BMD in male high consumers of coffee could be estimated to correspond to an approximately 30% increased risk of hip fracture. A high consumption of coffee (i.e. 4 cups or more per day) could contribute to a reduction in BMD of the proximal femur in elderly men. BMD was lower in high consumers of coffee with rapid metabolism of caffeine, suggesting that this group of coffee consumers might be at special risk of bone loss [39].

Sodium

It's not demonstrated that bone sodium has a critical role in bone mineral properties or in calcium homeostasis. While investigations was suggested that bone sodium plays a role in total body sodium homeostasis, the major view is that bone is at most a passive participant in ECF sodium homeostasis. A high sodium intake may contribute to osteoporosis because of increased calcium excretion. Excesses intake of sodium, in the form of sodium chloride, elevates urinary calcium excretion and, at prevailing calcium intakes, evokes compensatory responses that may lead to increased bone remodeling and bone loss. The calciuria is partly due to salt-induced volume expansion, with an increase in Glomerular Filtrating Rate (GFR), and partly to competition between sodium and calcium ions in the renal tubule. Potassium intakes in the range of current recommendations actually reduce or prevent sodium chloride-induced calciuria. At calcium intakes at or above recommended levels, there appear to be no harmful effects of excessive salt intakes on bone or the calcium, mainly because adaptive increases in calcium absorption offset the increased urinary loss. It would seem that the optimal strategy to protect the skeleton is to ensure adequate calcium and potassium intakes [40].

Isoflavones

Soy isoflavones as natural phytoestrogens have weak estrogen agonistic effect on estrogen receptor β , which make them similar to selective estrogen receptor modulators (SERMs). Isoflavones (including daidzin, daidzein,

genistin, and genistein) are present in soybeans at relatively high concentrations. Genistein or daidzein has been demonstrated to have a direct anabolic effect on bone metabolism in vitro, suggesting their role in the prevention of osteoporosis. Genistein as a food factor is useful in the prevention and therapy of osteoporosis [19].

In clinical trial of before-after type was carried out on 15 women 45–64 years of age, subjects were given 35 g soy protein provided 98 mg of isoflavones per day for 12 weeks. Soy protein consumption in postmenopausal women after 12 weeks resulted in a significant reduction in the urinary dpy (resorption marker) and increasing of total alkaline phosphatase, although the alterations in osteocalcin, c-telopeptide, IGFBP3 and type I collagen telopeptide were not significant. Therefore, in view of beneficial effect of soy protein on bone metabolism indicators, inclusion of this relatively inexpensive food in the daily diet of menopausal women, will probably delay bone resorption, thereby preventing osteoporosis [41].

Results of Meta-analysis indicate that phytoestrogens prevent bone resorption, but its benefits on bone formation are not significant in low doses and in at least 3 weeks of intake. Therefore,

phytoestrogens seems beneficial in decreasing bone resorption in postmenopausal women, and to date, no advantage on bone formation has been determined [42].

Dietary patterns

Health and growth are affected by dietary intake through single nutrients and interactions among nutrients. Finding of the study to identify dietary patterns related to fat and bone mass in children during the age period of 3.8–7.8 y showed that increasing intakes of dark-green and deep yellow vegetables and limiting fried-food intake may promote healthy fat and bone mass accrual [43]. The biological process by which dark-green and deep-yellow vegetables (eg, spinach, romaine lettuce, broccoli, carrots, and sweet potatoes) affect bone mass, remains unclear, but may be related to their high content of alkalizing minerals such as potassium. Higher dietary potassium intake is related to lower net endogenous acid production and to a higher bone mass in adults [44]. Training at

preschool age, diets rich in dark-green and deep-yellow vegetables and low in fried foods may lead to healthy fat and bone mass in young children.

A high prudent diet score was characterized by elevated intakes of fruit, vegetables, and wholemeal bread, rice, and pasta and low

CONCLUSIONS

Nutritional management for prevention of osteoporosis can be implemented by suitable food choice and healthy dietary pattern. Because of the vital role of nutrition in preventing or delaying the incidence of osteoporosis, it is necessary to include variety of foods in usual diet. When nutritional needs are met through diet, may be supplementation is generally unnecessary. However, nutrient supplementation might be needed for some high risk groups like children or aged people.

According to investigations, high intake of dietary protein increase bone resorption and calcium excretion and low protein intake can prevent calcium absorption and decrease strength and bone mass. Omega-3 supplementation also can decrease bone resorption and α -linoleic acid (for men and women) and AA (in men) and isoflavones can significantly diminish the risk of hip fracture.

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intakes of processed foods. Higher prudent diet score in late pregnancy was associated with greater whole body and lumbar spine BMC and areal BMD in the offspring at 9 yr of age. Associations with prudent diet score in early pregnancy were weaker and non- significant [45].

Adequate intake of some nutrients like zinc, vitamin A, boron and manganese in bone formation and copper, fluoride and strontium in bone mineralization have positive effects. However, high intake of vitamin A and fluoride result in hip fracture increment. Vitamin K (in form of K₂) along with calcium and vitamin D induce bone fracture decrease. If intake of phosphate, iron and sodium be more than the recommended values, they may present negative effects on bone mineralization.

In conclusion, risk of osteoporosis incidence may be diminished with an adequate and balanced diet containing variety of foods to meet needs and a healthy lifestyle. Nutrition education and training the other preventive factors should be carrying out in childhood to achieve the peak bone mass in youth and aging.

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