

Nutrition in Osteoporosis - A Mini Review

Akash Shaw^{1*}, Sudhanshu Mishra², Priyanka Sarkar³ and Mumtahena Khatun¹

¹Department of Pharmacy, Dr. B.C. Roy College of Pharmacy & AHS, West Bengal, India

²School of Pharmaceutical Science, Rajiv Gandhi Technical University, Bhopal, Madhya Pradesh, India

³Department of Pharmacy, Bengal School of Technology, Hooghly, West Bengal, India

Correspondence should be addressed to Akash Shaw, shawakash153@gmail.com

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ABSTRACT

Osteoporosis leads to a decrease in bone mineral density (BMD), reduces bone strength, and increases the risk of fractures. Fractures lead to high morbidity, mortality, increase health problems, and high medical expenses. Calcium and Vitamin D intake are good for bone metabolism homeostasis. Vitamin C has also a potential role in osteoporosis and the prevention of fracture. Intake of proteins, minerals, vitamin K is recommended by the experts to prevent the risk of fractures. It is important to know the influence of nutrients not only in isolation but also within the context of a dietary pattern, which may be a complex mixture of nutrients. In this review, we evaluate by reviewing the various scientific evidence for the consequences of the most dietary patterns on both health. Although some dietary patterns seem to possess beneficial effects, more studies are needed to completely elucidate the truth influence of diet on bone fragility.

KEYWORDS

Osteoporosis; Bone mineral density (BMD); Calcium; Vitamin D; Dairy products; Vitamin C; Dietary pattern; Nutrition

INTRODUCTION

Osteoporosis is an asymptomatic bone disease characterized by low bone mass density (BMD) and deterioration of the bone tissues. Bone fragility and susceptibility to fractures, especially hip fractures also increase in the case of osteoporosis [1]. The word osteoporosis is derived from the "osteon" which means bone and "porous" which mean little hole. Bone is a very vital organ of the body that not only provides structural support and mobility but it also works as a storehouse of the minerals such as calcium and phosphorous. Bones are made up of minerals and proteins. These proteins and minerals add up various properties to the bones [2].

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Mineral makes the bones to brittle and proteins make the bones too soft and flexible. There are many diet and lifestyle-associated variables that constitute the risk factors for osteoporosis occurrences. Therefore, the encouragement of healthy food habits plays a crucial role in reducing the risk of osteoporosis [3,4]. Maintaining an adequate dietary intake of calcium, vitamin D, and protein as well as performing regular exercise and resisting harmful habits, such as alcohol intake and smoking will definitely improve bone quality. It is recommended daily intake of at least 1000 mg/day of calcium, 800 IU/day of vitamin D to maintain serum 25-hydroxyvitamin D levels >50 nmol/L and 1g/kg body

weight of protein for all women aged over 50 years for the prevention of the age-related deterioration of musculoskeletal health [5-7]. There are several drug therapy which appears to be the first-line option for reducing the risk of fractures in the old aged people. Certain dietary modification specifically increasing calcium, vitamin D, protein, and other minerals intake may also be a promising option to improve bone health [8]. Various risk factors for the occurrence of osteoporosis have been identified, indicating the role of genetics and biological factors, as well as environmental conditions, including dietary habits [5].

The Risk factor that cannot be modified includes [2]:

- **Age:** Usually, in every 10 years, the risk of fracture is multiplied by 1.4-1.8.
- **Sex:** Women have a three times higher tendency to have fractures than men.
- **Ethnicity:** Caucasians are prone to have a higher risk of fracture.
- Family history of fracture.
- Early menopause.

The risk factor that can be modified includes [2]:

- Body Mass Index (BMI).
- Toxic habits: Tobacco and Alcohol consumption.
- Diet.
- Inactive lifestyle and/or low mobility.
- Diseases and medicines.
- Environment (obstacles/barrier/hurdles/stumbling blocks at home, in the person's environment).

In this article, we have performed a review of the various publications associating with bone health and nutritional habits. In this review, we aim to outline the present data on osteoporosis and the diet to be followed.

Bone Diseases in the Elderly [4]

While normal human body development, the skeletal system grows in three different stages. These three stages are:

- ✓ Attainment of maximum bone mass.
- ✓ Maintenance of bone mass through adulthood.
- ✓ Diminishing of bone mass with age.

Osteomalacia and osteoporosis are the two major diseases affecting the bone of adults. Osteomalacia is rickets generally seen in adults that result from a deficiency in vitamin D, calcium, or phosphorous [8]. It leads to the softening of bones. It occurs in adults that do not get sufficient exposure to sunlight and adults with very less absorption of calcium and other minerals. Osteoporosis is also a very common disease, especially in adults. Osteoporosis leads to porous bones and results in higher bone loss [5]. It is often asymptomatic and generally resulting in a fracture. It is caused due to deficiency of sex steroids, calcium, and vitamin D, genetics, lack of exercise, high dose of corticosteroids, smoking, alcohol, low body mass, and rheumatoid arthritis [4].

Nutrition in Osteoporosis

Calcium, vitamin D and dairy products

Calcium and Vitamin D are required for bone strength and form calcium phosphate (hydroxyapatite crystals) which is a bone mineral matrix. A healthy diet is the best way to achieve adequate calcium intake. Sometimes diet could not achieve the requirements of calcium at that time pharmacological calcium supplements are required [9,10]. Very good source of calcium is coming from fish (sardines with bones), dairy products (yogurt, milk & cheese), pulses, and vegetables, fruits (nuts & seeds). Vitamin D predominantly regulates calcium homeostasis. 80%-90% of vitamin D is synthesized by sunlight exposure and the rest 10%-20% came from foods like oily fish, mushrooms, fortified dairy products. Highly efficacious vitamin D is obtained from Vitamin D fortified foods (reduced-fat cheese) & Vitamin D biofortified eggs [11]. For bone health management as well as bone structure, for maintaining muscle mass Vitamin D has an extremely important role. Vitamin D deficiency causes osteoporosis in elderly or menopausal women. Calcium, phosphorus, and magnesium which are a good source for bone health & some protein, vitamin B-12, zinc, potassium, and riboflavin are also obtained from

dairy products. Dairy products could be a good source of Vitamin D if it is fortified as such. Yogurt and cheese contain a higher concentration of vitamin D than milk but milk intake is more than yogurt and cheese. So, the total body bone mineral content (BMC) can increase on regular consumption of dairy products or calcium/vitamin D fortified products [12].

Other minerals

Other minerals like potassium, magnesium have an important role in bone health management. Acid loads and calcium depletion from bones is reduced by dietary potassium. It maintains the alkaline state in the body but it also accumulates calcium in the kidney. There is reduced renal calcium excretion and acid excretion caused by alkaline potassium salt. Magnesium is found in green leafy vegetables, nuts. The daily intake allowance of magnesium is 310 mg - 360 mg for women and 400 mg - 420 mg for men. 50%-60% of body magnesium content accumulates in the bone [13,14] (Figure 1).

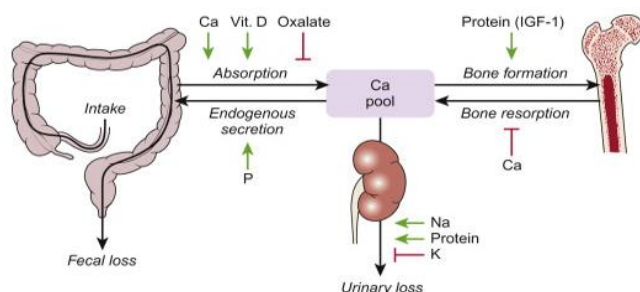


Figure 1: Nutrients and their bone effect.

Protein intake

For bone health protein intake is essential. 50% of the bone volume contains proteins. The secretion and action of insulin-like growth factor 1(IGF-1), is an orthotropic hormone that is important for bone formation and is affected by dietary proteins. A dietary protein intake of 1.0 g/kg - 1.2 g/kg body weight/day, with at least 20 g - 25 g of high-quality protein at each main meal recommends by Society for Clinical and Economic

Aspects of Osteoporosis and Osteoarthritis (ESCEO) [15-17].

Vitamins K and C

In bone matrix formation during mineralization Vitamin K is involved. Vitamin K is the cofactor for microsomal γ -carboxylase which facilitates the conversion of glutamyl to γ -carboxyglutamyl residues in osteocalcin and influences other Vitamin K proteins. Osteocalcin is a calcium-binding protein in bone. Bone health can improve because of the antioxidant property of Vitamin C. It suppresses osteoclast activity. It presents in fruits and vegetables [18-20].

Omega-3 polyunsaturated fatty acids and other nutrients

Omega-3 polyunsaturated fatty acids (PUFA) helps on bone metabolism. Bone growth and remodeling in humans by the inhibition of bone resorption and stimulating bone formation are influenced by the intake of eicosapentaenoic acid (EPA) and docosahexaenoic acid. PUFAs are present in fish and seafood, especially n-3 FAs, which have an anti-inflammatory effect which improves bone quality [21,22].

Dietary Patterns

Dietary patterns are more useful than single-nutrient and food studies for elucidating the effects of different nutrients alone on bone health. Usually, a dietary pattern with a high intake of fruit, vegetables, low-fat dairy products, whole grains, poultry, fish, and nuts has been proved to have an excellent effect on bone health and directly linked with a better BMD and lower the risk of fracture.

Mediterranean diet

Various studies have demonstrated that adherence to the Mediterranean diet is protective against osteoporosis. Antioxidant-rich fruits show a prominent effect by increasing trabecular bone volume, number, and thickness, and decreasing trabecular separation through

the initiating bone formation and suppression of bone resorption. Studies including postmenopausal women demonstrate that those with higher adherence to Med-Diet have better BMD at the lumbar spine and improved muscle mass, which is also important for the prevention of osteoporosis and fractures. Olive oil is reported as beneficial for bone status. Previous studies suggest that olive oil, with a high proportion of phenols, may be beneficial by preventing the loss of bone mass. It has been shown that the phenolic compounds can alter the growing capacity and cell maturation of osteoblasts by increasing alkaline phosphatase activity and contributing to the formation of the extracellular matrix [8,23,24].

Western diet

Individuals having diet like processed protein foods (with a high percentage of protein intake from cheese, processed meat, pastries, pizza, French fries, and snacks) have shown a lower BMD compared to other individuals. A diet with high fat intake, derived mostly from carbohydrates and fatty foods, can interfere with intestinal calcium absorption and also increase fat accumulation and obesity, which results in a decrease in osteoblast differentiation and bone formation. Sodium consumption induces higher calciuria, which is presumed to increase bone loss and bone remodeling. High intake of inorganic phosphorus, found in processed food items, leads to a disruption of the calcium-phosphorus ratio, affecting the endocrine regulation of calcium homeostasis. This is disastrous for bone health [23].

Asian diet

Asians have dietary habits in which soy and fish consumptions are high as compared to that in Western populations. They have comparatively lower chances of osteoporotic fractures. Studies have proved that the supplementation of soy isoflavones with omega-3 fatty acids improved bone health status in women. Consumption of white rice and vegetables, may also decrease the risk of osteoporosis. Higher intake of meat

or processed meat or a higher intake of fish and seafood did not alter BMD or the risk of fractures. Few studies also indicate that protein consumption from fish or meat is not harmful to bone [25].

Vegetarian diets

Vegetarian diets usually contain a lesser amount of calcium, vitamin D, vitamin B-12, protein, and fatty acids, all of these have crucial roles in improving bone health. Healthy vegetarian food generally contains larger quantities of various protective bone-related nutrients such as magnesium, potassium, vitamin K, and antioxidant and anti-inflammatory phytonutrients. Vegetarians are at higher risk of low BMD and fractures. Vegetarians should consume calcium from other sources - such as tofu, fortified soy products, or fortified orange juice. This dietary habit was compared to "Healthy" habit, characterized by high consumption of fruit and vegetables, and the "Milk/Dairy" pattern, and these two patterns were associated with a decreased risk of low BMD. The "Healthy" habit has been shown to have a significant preventive effect on fracture risk, on the other hand, "Meat/Western" pattern significantly increased the fracture risk [26].

Different Drug Formulations For Osteoporosis

Nanoliposomes

Malekar et al., 2015 had designed, characterized, and evaluated stable liposomes containing hydrophobic drug raloxifene HCl (RAL) and hydrophilic doxycycline HCl (DOX), for the treatment of osteoporosis and other bone disorders, in conjunction with a radio frequency-induced, hydrophobic magnetic nanoparticle-dependent triggering mechanism for drug release. Both drugs were successfully incorporated into liposomes by lipid film hydration method [27].

Nanostructured lipid carriers

Murthy et al., developed nanostructured lipid carriers (NLCs) for raloxifene (RLX) to enhance its

bioavailability. Glyceryl tribehenate and oleic acid was used for the preparation of NLC formulation. The produced nanoparticle was with positive zeta potential; % EE was over 90% with the drug loading of 5%. The RLX was present in an amorphous form in the lipid matrix. The produced RLX-NLC formulation showed sustained release in-vitro. The RLX-NLC showed significantly enhanced oral bioavailability as compared to RLX-free suspension. The RLX-NLC can potentially enhance the oral bioavailability of RLX. It can also improve the storage stability [28].

Oral jelly

Okimoto et al., concluded that once-weekly alendronate oral jelly 35 mg may be a suitable alternative therapeutic agent for primary osteoporosis. Alendronate oral jelly was developed to prevent gastrointestinal irritations and decrease the choking hazard that is associated with the tablet formulation and they also demonstrated it to be bioequivalent to the alendronate 35 mg tablet. The results also indicated that there was no apparent difference in terms of efficacy between the formulations [29,30].

Mucoadhesive film

Mukherjee et al., developed thiolated chitosan based risedronate mucoadhesive film for osteoporosis treatment. Risedronate sodium is bisphosphonate derivative which increase the bone mineral density for osteoporosis treatment. Solvent evaporation method was done for preparation of mucoadhesive film and then it was incorporated with thiolated chitosan (chitosan with thioglycolic acid) to increase the mucoadhesive property, improved swelling behavior [31].

Micelles

Xie et al., developed Simvastatin (SIM) loaded Tetracycline mediated PEG-PLGA (TC-PEG-PLGA) micelles. SIM has beneficial effect for osteoporosis management. Solvent diffusion method was used to prepare TC-PEG-PLGA/SIM micelles which in release

of SIM for prolong period of time from micelles. TC-PEG-PLGA micelles improve therapeutic index of SIM [32]. Wang et al., developed poly (ethylene glycol)-block-poly(e-caprolactone) (NOB-PEG-PCL) loaded with Nobiletin (NOB) by dialysis method. NOB is a polymethoxy flavonoids obtained from dried peel of Tangerine. NOB inhibit bone resorption and helps in improving lower bone density which in the treatment of osteoporosis. NOB-PEG-PCL micelles decrease the fast release of MOB from micelles and also increase the drug circulation time [33].

Nanoparticles

Narayanan et al., developed Chitosan nanoparticles loaded with Human Parathyroid hormone 1-34 (PTH 1-34). In bone forming cells anabolic response is improved by PTH 1-34 which helps in the improvement of osteoporosis. Ionic gelation method is done to prepare PTH 1-34 loaded Chitosan Nanoparticles. When PTH 1-34 is loaded with Chitosan it improve bioavailability and peptide is protected for long time so it can decrease the frequency of drug intake and increase the patient compliance [34].

Intranasal nanoparticles

Fazil et al., developed polymeric nanoparticles (NPs) of risedronate sodium (RIS) for the treatment of osteoporosis using intranasal (IN) route in order to reduce peripheral toxic effects. Polymeric NPs of RIS were prepared by nanoprecipitation methods. They found that the intranasal delivery demonstrated a good result in in-vivo study. Therefore, they concluded that PLGA-NPs have great potential for delivering the RIS for the treatment and prevention of osteoporosis after clinical evaluation in near future [35].

Phosphate-based glasses

Patel et al., developed phosphate-based glasses (PBGs) that are perfect materials for regenerative medicine strategies because their composition, degradation rates,

and ion release profiles can easily be controlled. Their study revealed that discs and microspheres formulated from the near invert glass system are cytocompatible and promoted adhesion and growth of human MG63 and hMSCs, respectively, up to 14 days. Their observations developed in study suggested that these materials are appropriate for the culture, expansion, and cellular activity of human cells constituting as excellent candidates for bone regeneration [36].

CONCLUSION

To reduce the risk of osteoporosis awareness program encouraging a proper healthy lifestyle having a balanced diet of rich nutrients should be developed. Everyone, individually has a high risk of osteoporosis, specifically the aged ones, and thus recommended to take a sufficient

amount of calcium & vitamin D. As through different in-vitro and animal model studies it is seen that there is a vital influence of vitamin C on the skeletal system. A proper amount of vitamin C must be in the diet, as it has a beneficial effect on bone metabolism. Therefore, sticking to a healthy dietary habit including fruit, vegetables, whole grains, poultry, fish, nuts and legumes, and low-fat dairy products and ignoring processed food products will be extremely beneficial for bone health, minimizing the risks of osteoporosis and fractures. It is necessary to take care of the health from child to the aged persons by the social workers, physiotherapist, proper occupational therapist, whether they take a proper healthy diet and it helps in the bone mass formation and help to prevent the osteoporosis.

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