

Role of Minerals in Bone Health

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ARTICLE ID:042

Introduction

Minerals are essential for adequate skeletal physiology and bone health. Any exception to the optimum supplementation of certain minerals will lead to various disorders related to the bones. Osteoporosis is a major concern as a health problem in the adults and with that, comes 'Osteopenia', lowered bone mass. Risk factors of these types of disorders are dependent on the intensity of dietary factors supplied to the individuals. As the bones undergo remodelling all the time, it is important to supply nutrient/mineral substrates to support the incident. Calcium, Phosphorus, Magnesium, Fluoride, Copper, Zinc, Boron, Manganese, Iron and Potassium are needed for maintaining the nutriture to maintain the bone-physiology, promotion of bone-strength at different stages of life. The study refers to the importance of the aforesaid minerals in maintenance of proper-bone health according to proper Dietary Supplementation to an individual.

Calcium

Calcium is one of the most important bone-forming minerals. 99% of the calcium present in the body are stored in the skeleton i.e. the bones. Evidences are there that optimum dietary calcium increases and maximises peak bone mass in the embryonic and infantile stages of an individual and also accounts for lesser bone loss in the later stages of life. Also, there were trials conducted showing the increased Calcium intake led to better calcium balance in the body, increased bone gain during the growing stage with the help of STH (Somato-Trophic Hormone) and decreased fracture incidents. Controlled trial studies also showed that the reduction of the chances of hip-fractures and hip-dysplasia by 25-70%, vertebral fractures by 23% and non-vertebral fractures by 14%. Benefits of calcium supplementation in bone are very much apparent in the individuals with lower calcium intake habit and magically the benefits disappear when Calcium supplementation is stopped, suggesting a crucial role in bone-health.

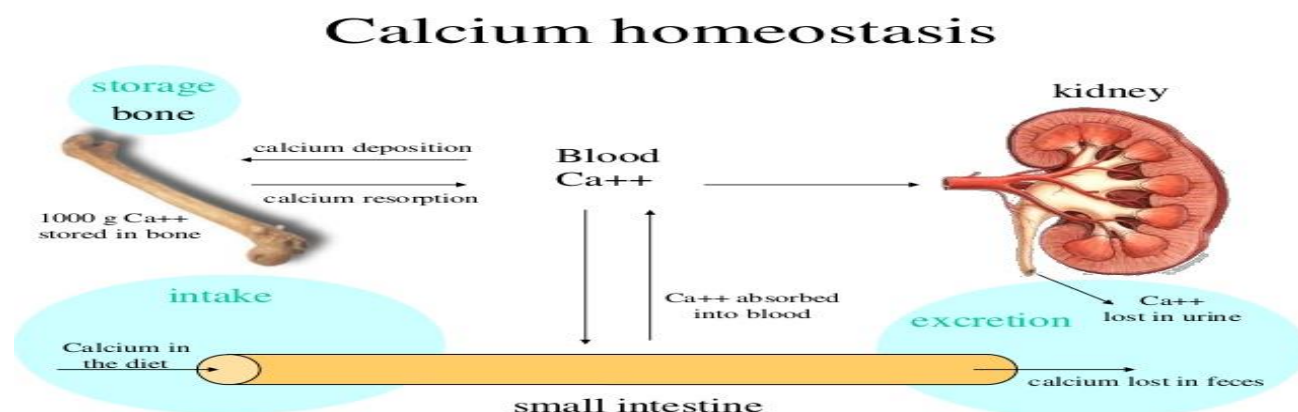


Fig: Calcium homeostasis and its role in bone-health

Phosphorus

Phosphorus helps in appropriate mineralisation of the skeleton of the body. Depletion of phosphorus leads to impaired mineralisation of the bones. But there is more concern on the fact of rich phosphorus diet containing lower levels of calcium in it. Such diet elevates the Parathormone (PTH) actions in young and adults. Another fact of concern is that regarding the phosphorus rich carbonated drinks causing increased incidences of bone fractures and lower bone mass in adults, causing Osteopenia. It is seen that the individuals can withstand a deficiency of much larger ranges of phosphorus but there are limitations of withstanding deficiency of calcium in their diets. It proves the importance of ratio of phosphorus to calcium within the diet rather than the individual concentrations of phosphorus within the food/feed regarding optimum bone physiology of the body.

Magnesium

Magnesium is also an important mineral for proper bone health with the fact that 60% of the mineral in the body is present in the bones. Magnesium influences the body metabolism via its contribution to various enzymes in the body as co-factor and modulates ATP metabolism. Also, it has direct effects on the bone quality as it decreases hydroxyapatite crystal sizes, thus reducing the chances of brittle bones. High deficiency of calcium intensifies magnesium deficiency causing stunted bone growth, lowered osteoblastic activity, elevated osteoclastic activity, fragile bones. This also affects the calcium metabolism of the body hindering the physiological calcium pool and homeostasis.

Fluoride

Fluoride helps to replace hydroxyl groups of hydroxyapatite crystals in the bones to form less soluble fluoro-apatite, thus increasing the crystallisation size. Fluoridation in drinking water not only helps to prevent dental caries but also it affects bone health. Fluoridated water at 1ppm has showed significant lower rates of fracture cases. High fluoride concentrations stimulate osteoblasts which is why fluoride supplements are provided in the cases of fractures and fracture prevention. Also, lower concentrations (11-20mg/dl) help to decrease fracture risks of vertebral column. Clinical studies show that excessive fluoride concentrations may make the bone to be brittle and fragile while the lower concentrations pose beneficial for the bones.

Copper

Copper has an influence over bone formation, skeletal mineralisation and maintenance of connective tissue integrity. A copper containing enzyme, lysyl oxidase, helps to form cross-linking of collagen fibrils and increase the mechanical strength of the protein, leading to strong connective tissue formation. Thus, copper deficiency has exhibited to decrease bone strength in animal models. Copper supplementation showed bone-loss reduction in elderly females.

Boron

Boron may have a significant role in bone health. It helps in formation of steroid hormones which in-turn helps to reduce calcium loss from the body and decreases bone-demineralisation by reducing urinary calcium and magnesium excretion. It also increases serum levels of oestradiol and thus increases calcium absorption. Besides, it was also found that boron increases vitamin D functions.

Manganese

Manganese helps for biosynthesis of bone-matrix mucopolysaccharides. It also helps in several biochemical pathways as it accounts for several enzymes found in bone tissue. Animals, deficient in manganese show IGF metabolism and bone-growth alterations. Manganese supplementation with calcium, copper and zinc in the diet helped in more bone-growth as compared to the individual fed with calcium only diet.

Potassium

Potassium-rich diet promotes alkaline environment in the body, thus, reducing the skeletal salt demand to balance the overall body pH and as a result, bone calcium is preserved. This is the way, potassium prevents osteoporosis, especially in the elderly women/animals. Clinical trials with bicarbonate salts of potassium showed decreased urinary calcium excretion, optimum calcium homeostasis in the body, decreased bone demineralisation and increased osteoblastic activity while low potassium diet showed increased bone resorption.

Iron

Iron works as cofactor in the enzymes (like prolyl hydroxylase, lysyl hydroxylase) involved in the formation of collagen bone-matrix, involved in the steps before the cross-linkage formation by the enzyme lysyl oxidase¹. Besides, iron is also a cofactor of the enzyme 25-hydroxycholecalciferol hydroxylase which helps in Vitamin D transformation to its active form, ultimately helping in calcium absorption. In rat models, iron-deficient ones have lower bone mass and mechanical strength.

Conclusions

Bone health is strongly dependent on the dietary intake of several nutrients. The aforesaid minerals along with several like Vitamin D, Riboflavin, Niacin, Vitamin B₆, B₁₂ etc. are required for optimum bone growth and maintenance. Milk, meat and meat products, fish, nuts, seeds and vegetables are natural sources of these micronutrients which are needed for bone health. Epidemiological studies, animal models and human trials are made to visualise the effects of the aforesaid nutritional factors on skeletal physiology maintenance. Optimum diet with these minerals accounts for lesser bone fracture, lesser bone fragility, making strong bones and elevated bone mass. Further studies are also required to visualise these effects more profusely and precisely.