# Nutrition and OSTEOPOROSIS

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In recent years, much attention has been directed toward the prevention of osteoporosis, since this disease has become a leading cause of morbidity and mortality in elderly women. Evidence suggests that osteoporosis is easier to prevent than to treat and this may best be achieved by initiating appropriate health behaviours early in life and continuing them throughout life. Healthy early life practices, including the adequate consumption of most nutrients and regular physical activity contribute to greater bone mineral measurements and optimal peak bone mass.

The prevention of osteoporosis through increased physical activity and diet is challenging, especially in technologically advanced societies. Data from epidemiologic and prospective studies are sufficiently convincing that important advances can be made to reduce morbidity and mortality of this condition in future generations.

Nutritional requirements of individuals are not easily determined; however, ranges of reasonable intakes for good bone health can be approximated for the macronutrients and many of the micronutrients. Many nutrients play significant roles in bone development and maintenance. Whereas most investigations of bone have focused primarily on calcium, little is known about the nutritional needs of bone tissue for B vitamins, vitamins C, D and K, zinc, manganese, magnesium and iron, all of which have been established to have essential functions in this tissue. Moreover, emerging quantitative data are available to establish recommendations for a wide variety of phytochemicals found in foods from plant sources, such as phytoestrogens from soybean, that may benefit health in diverse ways.

Achieving optimal intakes of these nutrients and/or phytochemicals should be coupled with other optimal health behaviours including regular physical activity and avoidance of adverse behaviours, such as cigarette smoking and excessive alcohol use.

## Calcium

The best sources of calcium, both qualitatively and quantitatively, are milk and other dairy products. Not all dairy products are good calcium sources — butter and cream are high in fat and low in calcium. There are many non-dairy foods that are also good sources of calcium. These include certain leafy green vegetables (eg collard greens and kale), soybean products and canned fish with bones (eg sardines and salmon).

The high bioavailability of calcium in dairy products is probably related, in part, to the vitamin D and lactose presence in these products, both of which enhance intestinal absorption. However, many nutritional factors, including oxalates, phytates and a large amount of dietary fibre, can interfere with calcium absorption and

## Salient Points

- Prevention of osteoporosis needs to begin during the prepubertal years and should be continued throughout life
- Healthy early life practices contribute to greater bone mineral measurements and optimal peak bone mass
- Maintain regular physical activity and avoid cigarette smoking and excessive alcohol use
- Dairy products are the best sources of calcium; other good sources include leafy green vegetables, soybean products and canned fish with bones
- Vitamins D and K play different but essential roles in bone metabolism

Calcium absorption and bioavailability can be adversely affected by oxalates, phytates and large amounts of dietary fibre

adversely affect its bioavailability. Moreover, factors increasing calcium loss have a disproportionately large effect on calcium balance compared with factors affecting absorption. This is because only a fraction of ingested calcium is absorbed. Dietary factors that increase urinary excretion of calcium include sodium, protein, caffeine and phosphates found in soft drinks.

Skeletal benefits from long-term calcium supplementation have been reported for females at practically every period of the life cycle. The requirement of calcium to maintain the optimal bone mineral content (BMC) or density (BMD) varies at the different stages of the life cycle beyond infancy. The adequate consumption of calcium (in conjunction with vitamin D) in early life will optimise peak bone mass, and adequate intakes of these two nutrients should continue throughout the remainder of life to help maintain bone mass.

### Prepubertal Period

The demand for calcium during the prepubertal period is probably greater than at any other period of the life cycle. A significant amount of bone mass is typically accumulated during this time in females and also in males. The incremental amount of BMC is highly associated with calcium intakes.[1] Low calcium intakes may compromise the accrual of bone mass.[2]

### Adolescent (Postpubertal) Period

The major impact of sufficient calcium intake on bone development in females occurs before menarche. However, accrual of bone mass continues at a very high rate for about four more years.[3,4] The onset of sex hormones related to postmenarche growth apparently dominates the growth pattern as long as nutrients are supplied in amounts sufficient to support growth.[5] Unfortunately, many females avoid milk and other dairy products during the teenage years because of concern about dietary fat consumption.[6] The low calcium intake, coupled with high consumption of soft drinks containing phosphoric acid, may affect the skeletal accumulation of calcium.

### Adult Females

Bone consolidation continues in females after height growth ceases at about 16–18 years of age. It follows therefore, that an adequate supply of dietary calcium is necessary for calcium accumulation in the skeleton. Calcium acts independently on bone to enhance peak bone mass at least up to age 30, particularly in the forearm bones and in the total body BMC, but probably not in the lumbar vertebrae or proximal femur after adolescence ends.[3,4]

Peak bone mass can be maintained by exercising regularly, avoiding cigarette smoking and minimal or no alcohol consumption

Women who exercise regularly are more likely to maintain their bone mass as they proceed toward the menopause. In the case of radial bone, they may even improve their BMC and BMD. Avoidance of cigarette smoking and minimal or no alcohol consumption help the maintenance of peak bone mass.

### Early Postmenopausal Women

Several studies have reported that calcium supplementation during the early menopause has little or no effect on BMC or BMD. It has been demonstrated that an adequate vitamin D status in perimenopausal women is protective against bone loss through reducing the serum concentration of parathyroid hormone (PTH). Calcium supplementation of women 5 years after menopause results in significant gains of BMD compared to placebo-treated subjects.

### Late Postmenopausal Women

A number of studies suggest that calcium alone is not sufficient to slow the rate of bone mass loss late in life. A 5-year prospective study of elderly women living independently showed a bone mass loss rate of 1% per year, despite variations in their calcium intake.[7] Inadequate intakes of other nutrients, such as vitamin D, may have skewed or confounded the results.

## Vitamins D and K

These two fat-soluble vitamins play different but essential roles in bone metabolism. Vitamin D plays a central and lifelong role in bone remodelling. Age-associated changes in several aspects of its synthesis, absorption and metabolism may be deleterious to bone health.

There are a number of reasons why the elderly may have reduced circulating levels of 25(OH)D that may be indicative of a suboptimal vitamin D status. One reason is that the elderly, voluntarily or involuntarily, generally have less exposure to sunlight. Another reason is that there is a marked age-dependent decrease in the epidermal concentrations of the vitamin D precursor, 7-dehydrocholesterol.[8] Furthermore, less-efficient intestinal absorption of vitamin D and lower dietary intakes may also exacerbate the lowered vitamin D status of the elderly.

There is increasing evidence that vitamin D supplementation, with or without calcium, may be effective in preventing fractures in the elderly. In communities with a high prevalence of vitamin D deficiency in the elderly population, routine vitamin D

supplementation should be encouraged in high-risk subjects, for example those who are institutionalised or housebound.

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Compared with the well-established role of vitamin D in bone health, an appreciation that vitamin K also plays a role in skeletal metabolism occurred only comparatively recently. In the mid 1970s it was discovered that mineralised tissue contained a large reservoir of γ-carboxyglutamic acid (Gla), which is known as osteocalcin or bone Gla protein (BGP), and accounts for up to 15% of the non-collagenous bone.[9] The Gla is transformed from glutamic residue in the protein precursor by a carboxylation reaction which is catalysed by a microsomal enzyme called γ-glutamyl or vitamin K-dependent carboxylase.[10] Two other proteins isolated from bone tissue (matrix Gla protein and protein S), neither of which is exclusive to bone tissue and whose roles in bone metabolism are uncertain, are also vitamin K-dependent proteins.

Relatively little is known about the adequacy of vitamin K status in relation to bone health. However, at the nutritional and biochemical level there is good evidence that the dietary intakes of vitamin K needed to sustain maximal carboxylation of BGP are substantially higher than those needed for carboxylation of the coagulation Gla proteins synthesised in the liver. Circulating levels of the under-carboxylated fraction of BGP are found to be responsive to changes in dietary vitamin K (ie phyllo-quinone).[11]

## Other Nutritional Factors

There are numerous nutritional factors that affect the bioavailability of calcium. Sodium intake is indicated to be a significant determinant of calcium requirement and therefore calcium balance.[12,13] Excreted sodium is particularly important as it increases urinary excretion of calcium by means of sodium-calcium exchange in the renal tubules.

A high protein intake is evidently related to a negative calcium balance. High protein diets can increase urinary excretion of calcium, and have inverse associations with bone density in cross-sectional studies.[14,15] This effect is due to the phosphate naturally associated with protein in the diet. The phosphate can increase the synthesis of PTH by depressing serum calcium, and thereby increasing the PTH-dependent reabsorption of calcium by the renal tubules. The dietary protein-phosphorus relationship is critical to the maintenance of calcium homeostasis on a high protein diet.[16]

## The dietary protein-phosphorus relationship is critical to the maintenance of calcium homeostasis on a high protein diet

Concern about the effects of a high phosphorus diet is particularly justified when the calcium intake is low.

Oxalates, which are present in high concentration in spinach, bind calcium in an insoluble form and decrease absorption.[17] Phytates and large amounts of dietary fibre also reduce calcium bioavailability. However, considering the beneficial effects of dietary fibre in the prevention and treatment of coronary heart disease and cancer it is still worthwhile to keep whole grain products in the diet in moderation.[18]

There are a number of compounds in food that are not regarded as nutrients, yet which are of biological relevance in terms of osteoporosis. Boron, at the levels obtainable from fruit and vegetables, changes endogenous oestrogen status.[19] It also reduces urinary calcium excretion, particularly at low magnesium intakes.[20]

Exogenous oestrogenic compounds found principally in plant-derived foods might exert an oestrogenic effect on bone in a similar manner to endogenous oestrogens. In addition, genistein and daidzein reduce bone resorption in vitro.[21] An increase of BMC has been reported in postmenopausal women who were supplemented with a soy diet for 12 weeks.[22]

## Conclusion

The prevention of osteoporosis needs to begin during the prepubertal years and should be continued throughout life. Bone mass can better be maintained later in life through adequate consumption of several nutrients with specific roles in calcium and bone metabolism, regular physical activity and the practice of a healthy lifestyle. CT


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