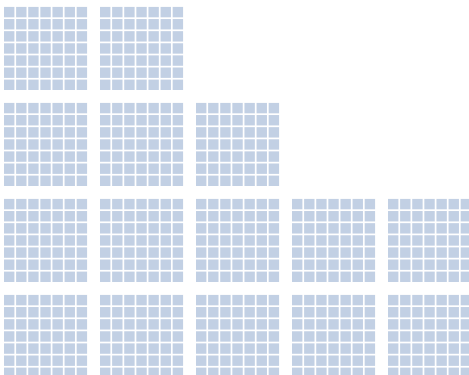




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DIGESTION
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Bone Health

-Alan Gaby, M.D.

Approximately 44 million American women and men aged 50 and older have osteoporosis (severe bone loss) or osteopenia (mild bone loss), with women being affected about twice as often as men.¹ At least 1.5 million fractures of the hip, vertebra (back or neck), or wrist occur each year in the United States as a result of osteoporosis, and the annual cost of treating this disorder is nearly \$14 billion and rising. And the toll in human suffering and loss of independence is even greater.

Q. What are the risk factors for osteoporosis?

A. Small body frame, underweight, Caucasian or Asian race, a sedentary lifestyle, cigarette smoking, excessive alcohol or caffeine intake, high intake of carbonated beverages (especially colas), and having other family members with osteoporosis all increase personal risk of developing the disease. Certain medical conditions, including diabetes, celiac disease, hyperthyroidism, rheumatoid arthritis, chronic obstructive lung disease, hyperadrenalism, and hyperparathyroidism, are all associated with an increased risk of osteoporosis. Some medications increase the rate at which bone is lost; these include drugs prescribed for the treatment of seizures, drugs used for blood thinning, steroids such as prednisone, aluminum-containing antacids, and loop diuretics (furosemide [Lasix]).

Q. Isn't bone loss just a normal consequence of aging?

A. Although bone mass normally declines after the age of 35, bone loss severe enough to cause fractures after just minor trauma (such as a bump or fall) seems to be a relatively new phenomenon. Osteoporosis was rare in the late 19th century, and it was not until around 1920 that the condition began to attract attention among doctors. Since that time, the percentage of people who develop osteoporosis has continued to increase. For example, the age-adjusted prevalence of osteoporosis in England and Sweden doubled between 1950 and 1980.²⁻⁴ In addition, the percent of elderly people with osteoporosis in some developing countries is lower than that of elderly Americans, despite lower calcium intakes in the developing countries, further suggesting that osteoporosis is a disease of modern civilization.⁵

Q. Can osteoporosis be prevented?

A. Engaging in regular weight bearing exercise, avoiding excessive consumption of alcohol and caffeine, and quitting smoking will slow the rate of bone loss. Eating adequate, but not excessive, amounts of protein also enhances bone health. In addition, a growing body of research has shown that supplementing with various vitamins and minerals may not only help prevent, but in some cases actually *reverse*, bone loss. At least 15 different nutrients have been found to play a role in bone health.

Q. What type of calcium is best?

A. For most people, the different types of calcium salts are absorbed about the same, between 30% and 40% of the administered dose. People who have low stomach acid (hypochlorhydria) should not use calcium carbonate, because that form of calcium is absorbed poorly in the absence of stomach acid. Calcium phosphate may be preferable for many older people, because phosphorus is necessary for normal bone formation, the phosphorus intake of older people is often low, and calcium supplements inhibit the absorption of phosphorus.⁶

Also, calcium bound to phosphorus is the form in which calcium in the bone is stored, and it has a much greater bone activity than other forms.⁷

Q. How much vitamin D is needed to promote strong bones?

A. Because vitamin D is produced when ultraviolet rays from the sun come in contact with skin, people who stay out of the sun, who wear sunscreen, or who live in a northern latitude (such as Boston or Seattle) where less ultraviolet light reaches the skin are at increased risk of vitamin D deficiency. In addition, aging decreases a person's ability to synthesize vitamin D in the skin. Results from five research trials on vitamin D found that supplementation with 700-800 IU of vitamin D per day decreased the number of hip fractures by 26%, but 400 IU per day was ineffective.⁸ In addition to enhancing bone health, vitamin D improves nerve and muscle function in older people, thereby reducing their chances of falling down. Supplementation of elderly women with 800 IU of vitamin D per day has been shown to decrease the number of falls by about 50%.^{9,10}

Q. Is that much vitamin D safe?

A. The Food and Nutrition Board of the Institute of Medicine established a "safe upper limit" of 2,000 IU per day in 1997. More recent research suggests that up to 4,000 IU of vitamin D per day is safe for the average person.¹¹ However, this amount is more than generally regarded necessary to address most bone issues.

Q. Why would nutrients besides calcium and vitamin D be important?

A. Bone is living tissue, constantly remodeling itself and engaging in numerous biological functions. Like other tissues in the body, bone has a wide range of nutritional needs. The typical refined and processed American diet has been depleted of many different vitamins and minerals, some of which play a key role in promoting bone health.¹² Not getting enough of one or more of these micronutrients may be an important contributing factor to the modern epidemic of osteoporosis. In addition, supplementing with calcium may cause a loss of magnesium, zinc, silicon, manganese, and phosphorus, unless these nutrients are also provided.¹³⁻²⁰

Q. What nutrients besides calcium and vitamin D promote healthy bones?

A. Magnesium, zinc, copper, manganese, vitamin K, boron, strontium, silicon, folic acid, vitamin B6, vitamin B12, phosphorus, and vitamin C have all been shown to play a role in bone health. Following is a brief description of the role that each of these 15 nutrients play in building healthy bones.

Calcium: A component of the mineral crystals that make up bone

Vitamin D: Enhances calcium absorption, prevents falls by improving nerve and muscle function.

Magnesium: Important for bone mineralization (accumulation of minerals which form bones). Magnesium deficiency is associated with abnormal bone mineral crystals in humans.²¹ In an open clinical trial in postmenopausal women, magnesium supplementation increased bone mineral density up to 8% in some participants after 1-2 years.²²

Copper: Laboratory research has found that copper promotes bone mineralization and decreases bone loss, and that osteoporosis can develop if the diet is deficient in copper.^{23,24} Western diets often contain less copper than the amount recommended by the National Academy of Sciences.²⁵ In a 2-year double-blind trial, copper supplementation reduced bone loss by 90% in middle-aged women, compared with a placebo.²⁶

Zinc: Like magnesium, zinc is important for bone mineralization, and also has been shown to decrease bone loss.²⁷⁻²⁸ Low dietary zinc intake was associated with increased fracture risk in a study of middle-aged and elderly men.²⁹ The zinc content of the diet is frequently low; a study of elderly low-income people found they were consuming only half the Recommended Dietary Allowance for this mineral.³⁰

Manganese: Plays a role in the synthesis of the connective-tissue components of bone. Manganese deficiency in laboratory tests resulted in low bone mineral density and weak bones.^{31,32} Manganese deficiency may be associated with the development of osteoporosis.^{33,34}

Boron: Supports creation of bone-protecting hormones such as estrogen, testosterone, and DHEA. Boron supplementation prevented bone loss in experimental studies.³⁵ In human volunteers consuming a low-boron diet, boron supplementation decreased urinary calcium excretion by 25-33%, a change that may indicate reduced bone loss.³⁶

Silicon: Plays a role in the synthesis of the connective-tissue components of bone. Silicon deficiency has been associated with bone abnormalities. In an observational study, higher dietary silicon intake correlated with higher bone mineral density.³⁷ In a clinical trial, administration of an organic silicon compound increased bone mineral density of the femur (thigh bone) in postmenopausal women.³⁸

B vitamins (folic acid, vitamin B6, and vitamin B12): These three B vitamins have been shown to lower blood levels of homocysteine, a breakdown product of the amino acid methionine. An elevated homocysteine concentration is a strong and independent risk factor for fractures in older men and women.^{39,40} Homocysteine levels increase around the time of menopause, which may explain in part why bone loss accelerates at that time.⁴¹ In a 2-year double-blind trial, supplementation of elderly stroke patients with folic acid and vitamin B12 reduced the number of hip fractures by 78%, compared with a placebo.⁴²

Strontium: This trace mineral is incorporated into bone and appears to increase bone strength. It also stimulates bone formation and inhibits bone breakdown. Controlled trials have demonstrated that strontium supplementation of postmenopausal women increases bone mineral density and decreases fracture risk.^{43,44}

Vitamin K: Best known for its effect on blood clotting, vitamin K is also required for the creation of osteocalcin, a unique protein found in bone that participates in the mineralization process. The amount of vitamin K needed for optimal bone health appears to be greater than the amount needed to prevent bleeding.^{45,46} Vitamin K levels tend to be low in people with osteoporosis.⁴⁷ In randomized clinical trials, supplementation of postmenopausal women with vitamin K prevented bone loss and reduced the incidence of fractures.^{48,49}

Q. Which form of vitamin K is best?

A. Two forms of vitamin k compounds are present in food: vitamin K1 and vitamin K2. Vitamin K1 (also called phylloquinone) is present in leafy green vegetables and some vegetable oils, and vitamin K2 is found in much smaller amounts in meat, cheese, eggs, and natto (fermented soybeans).

To make things a little more complicated, Vitamin K2 itself can occur in more than one form. The two most important to this discussion are menaquinone-4 (MK-4, also called menatetrenone), which is licensed as a prescription drug in Japan, and menaquinone-7 (MK-7), which is extracted from natto.

Research suggests that MK-7 from natto may be an ideal form of vitamin K. The biological activity of MK-7 in laboratory studies was *17 times higher* than that of vitamin K1 and *130 times higher* than that of MK-4.⁵⁰ After oral administration, MK-7 was better absorbed and persisted in the body longer, compared with MK-4 and vitamin K1.^{51,52} Although both have shown ability to prevent osteoporosis in laboratory research, a much lower dosage (600 times lower) of MK-7 is required, compared with MK-4, to obtain beneficial effects.^{53,54}

Thus, MK-7 has greater biological activity, greater bioavailability, and possibly more potent effects on bone, compared with other forms of vitamin K. The potential value of MK-7 for bone health is supported by an observational study from Japan, in which increasing natto consumption was associated with a lower risk of hip fracture.⁵⁵ While additional research needs to be done, the available evidence suggests that the best forms of vitamin K for long-term use at physiological doses are MK-7 and vitamin K1.

Q. What is the optimal dose of strontium for bone health?

A. The safest and most effective dose may turn out to be substantially less than what researchers are currently investigating. Strontium doses in recent clinical trials ranged from 170 to 680 mg per day, or up to 300 times as much as the 2-3 mg present in a typical daily diet. Interestingly, the lowest strontium dose (170 mg per day) produced the greatest reduction in fracture risk, which raises the possibility that further lowering the dose might produce even better results.⁵⁶

In fact, high-dose strontium causes rickets in animals under certain conditions, and in an observational study in Turkey, high soil-strontium concentrations were associated with an increased prevalence of rickets in children.^{57,58} Thus, adverse effects counterbalance the beneficial effects of strontium on bone tissue, if the dose is too high. Strontium supplementation also increased thyroid-gland weight and decreased pituitary weight in rats, with a "no-observed-adverse-effect-level" roughly equivalent to 41 mg per day for humans.⁵⁹

In one of the clinical trials, bone biopsies performed after 3 years of strontium supplementation did not reveal any mineralization defects.⁶⁰ However, only mature bone was biopsied, whereas the earliest evidence of a mineralization defect would likely be found in newly formed bone. Of note, the degree of protection against fractures decreased as the study progressed, even though bone mineral density continued to increase. That finding raises the possibility that the new bone formed under the influence of high-dose strontium therapy may not have been of high quality. Additional studies are therefore needed before long-term supplementation with high-dose strontium can be considered safe.

Q. So, physiological doses of strontium may be safer, but are they effective?

A. Even in the small amounts present in a normal diet, strontium accumulates in bone and persists there for decades. Consequently, strontium supplementation at physiological (as opposed to pharmacological) doses would be expected to have effects on bone. While low-dose strontium has not been studied as a treatment for osteoporosis, clues are provided from the effect of strontium on teeth, the other major calcified tissue in the body. In observational studies, the prevalence of dental caries (cavities) was lowest in geographical regions where the strontium content of drinking water was 5-6 mg per liter. Caries prevalence was higher when water contained substantially more or substantially less than 5-6 mg of strontium per liter.⁶¹ Thus, the optimal dose of supplemental strontium may turn out to be fairly low, perhaps in the range of 6 mg per day or less.

Q. Can people taking osteoporosis medications also take bone-building nutrients?

A. Because nutrients work by a different mechanism than osteoporosis drugs, nutritional supplements are likely to enhance the beneficial effect of these medications. Calcium or other minerals may interfere with the absorption of bisphosphonates such as alendronate (Fosamax) or etidronate (Didronel). For that reason, calcium and other minerals should be taken at least two hours before or two hours after these medications. Also, it is always best to discuss the supplements you are using with your healthcare practitioner to create an integrated health plan.

Conclusion

Osteoporosis is a common and potentially serious condition. Fortunately, a great deal can be done to help prevent, and in many cases reverse, bone loss. Important components of a bone loss prevention program include diet, lifestyle changes, regular exercise, and taking a broad-spectrum nutritional supplement that contains all of the nutrients that play a role in bone health.

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