Special Health Report

HARVARD MEDICAL SCHOOL

Osteoporosis

A guide to prevention and treatment

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OSTEOPOROSIS
SPECIAL HEALTH REPORT

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Dear Reader,

"Hard as bone"—that's an expression we've all heard. But what does it really mean? Healthy bones are indeed hard. Your skeleton supports your body and facilitates movement. But when you have osteoporosis (literally "porous bone"), you can no longer count on your skeleton to withstand all the stresses placed on it. A twist, a bend, or an unexpected jolt can snap a weakened bone. Sadly, many people do not find out they have low bone mass until a bone breaks in the wrist, spine, or hip.

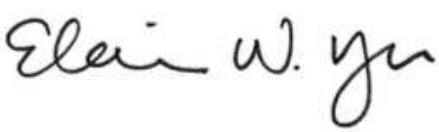
An estimated 10 million Americans have osteoporosis, while another 44 million have low bone density (osteopenia), placing them at increased risk for osteoporosis—and those numbers are likely to grow as baby boomers age. For an individual, the consequences of an osteoporosis-related fracture can be devastating. Many older adults never regain their former health and quality of life. Physical complications range from chronic pain and stooped posture to problems with breathing and digestion. Hip fractures can significantly impair mobility, making it impossible to drive, cook, or even walk without assistance.

But you don't have to wait until the damage is done to fight this disease. At any age, you can start making lifestyle changes that will promote good bone health and prevent or delay severe bone loss. This report tells you how.

Furthermore, on the medical front, there have never been more options for treating osteopenia and osteoporosis. Doctors have sophisticated tools to detect bone loss in the earliest stages and identify which people should begin treatment and when. For those at risk of fractures (i.e., broken bones), a number of highly effective drugs to boost bone strength are available. Unfortunately, only a minority of people who could benefit from this type of medication are getting it. Even after a hip fracture, the proportion of people receiving proper treatment after a year hovers at only 20%. This treatment gap largely reflects a misplaced fear of osteoporosis drugs.

I hope this report will inform and reassure you about osteoporosis diagnosis and treatment. Regardless of your age, it's never too late—or too early—to begin boning up on bone health.

Sincerely,



Elaine W. Yu, M.D.
Medical Editor

The editors would like to thank Dr. David Slovik, who served as medical editor for the previous version of this report.

The basics of bone

Your bones are surprisingly strong. Ounce for ounce, they bear as much weight as reinforced concrete. But unlike concrete, bone isn't inert. It is a living tissue that can grow stronger in response to stresses and heal itself if injured.

Bones serve many roles in the body. They support your weight. They join forces with muscles, ligaments, and tendons to enable complex, highly articulated movements. Less obviously, they also serve as a repository of minerals that are used by the body. Like a savings bank, they allow both withdrawals and deposits of their mineral assets—a process that requires breaking down and rebuilding part of the bone matrix in order to release or absorb the minerals. Thus, even though bones seem solid and unchanging, they are in a constant state of flux, like other tissues in the body.

As you age, that process of flux inevitably includes losing some of your youthful bone density (also called bone mineral density), a measure of how strong your bones are. Yet osteoporosis is not inevitable. You can lose a certain amount of bone density and still be in the normal range. At a certain point, however, if the losses continue, you will be at an intermediate stage of bone loss called osteopenia, or simply low bone density. If you do not manage to halt or slow the loss at this point, you may eventually cross the line into osteoporosis, in which porous bones become weaker and more susceptible to fractures. But even in people with osteopenia, various factors—like older age, frailty, or use of certain medications associated with bone loss—may point to a greater risk for fractures. Thus, it is important to discuss with your doctor whether you would benefit from treatments to improve your bone health.

This report will examine both osteopenia and osteoporosis and explain the various measures you can take to help your bones, no matter which stage you're in. But first, to understand how and why osteoporosis occurs and what can be done to prevent and treat this potentially devastating ailment, it helps to know some basics about the living tissue that makes up the more than 200 individual bones of the body.

"Hard as bone" is an expression we've all heard, and in fact bones are surprisingly strong. But they aren't inert. They're composed of living tissue that renews itself, but also loses density over time.

Two types of bone tissue

The bones in your body contain two essential types of bone tissue.

Compact bone. As the name implies, compact bone tissue is densely packed. It is composed of units called osteons, which consist of tight plates wound into tubular forms that resemble rolled-up magazines (see Figure 1, page 3). A tiny blood vessel, or capillary, runs through the center of each osteon, supplying nutrients and oxygen. Osteons are arranged in stacks to form a bone's hard outer casing. In fact, compact bone is sometimes referred to as cortical bone, derived from the Latin word "cortex," meaning "bark" or "shell."

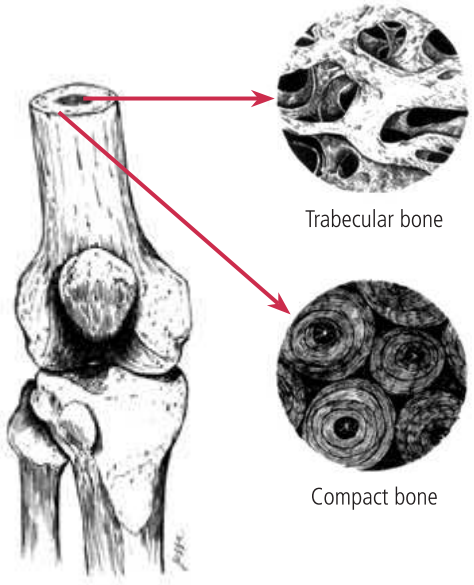
Trabecular bone. The second major type of material in your skeleton is called trabecular bone, meaning "like a little beam." Trabecular bone is composed of millions of tiny beams and plates that form a lattice-like matrix (see Figure 1, page 3). It is less dense and

spongier in consistency than compact bone and, for this reason, is sometimes known as spongy bone or cancellous bone (meaning "lattice-like").

Bones contain a combination of compact and trabecular tissue, with compact bone forming the dense outer casing and trabecular bone filling the interior. Over all, the ratio of compact to trabecular bone in adults is about four to one, although the proportion varies greatly from bone to bone. Long, regular bones, like those of the arms, legs, and ribs, consist primarily of compact bone. Irregularly shaped bones—such as the spinal vertebrae, the pelvis, and the ends of the arm and leg bones—consist mostly of trabecular bone.

Why is this relevant? It helps explain, for example, why the spine is particularly vulnerable to osteoporosis. Not only is trabecular bone—the main constituent of vertebrae—less dense than compact bone by its very nature, it is also metabolically more active. As a result, when bones begin to lose density, trabecular bone in the spine tends to weaken faster than most other bones, starting earlier in the progression toward osteoporosis. For this reason, it's important to see your doctor for a bone density test of the spine no later than age 65 in women and age 70 in men, or sooner if you have risk factors for fracture.

Figure 1: Compact and trabecular bone



The bones in your body are composed of two types of tissue: compact bone (also known as cortical bone) and trabecular bone. Often, the compact bone—tightly packed tubes of bone tissue whose cross-sections resemble the rings of a tree trunk—forms the outer casing, while the trabecular bone, which is more porous, is found at the center.

Bone remodeling

Although compact and trabecular bone differ in structure, they are made of the same basic material: a meshwork of protein fibers, called collagen. The collagen matrix is inlaid with calcium and phosphate minerals, which are mixed with water to form a hard, cement-like substance called hydroxyapatite. Smaller amounts of sodium, magnesium, and potassium are also present in the bone matrix.

Calcium, however, is the main ingredient of bone. The dynamic process by which bones take in or release this vital mineral is known as remodeling, or bone metabolism. Osteoporosis is the eventual result when bone remodeling gets out of balance, causing more calcium to leave the bones than is added.

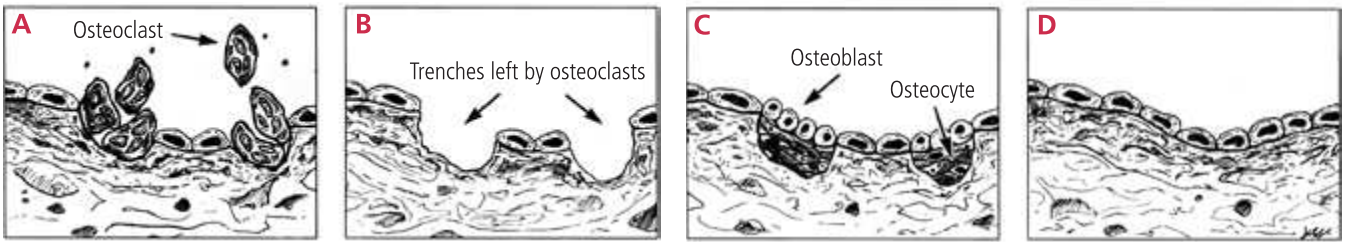
Calcium carries a lot of weight in the body, both literally and figuratively. It's the major component of hydroxyapatite, the material that lends bones their strength. But it also plays a crucial role in other parts of the body. Buoyed along in the blood, circulating calcium enters and exits cells, transmitting signals to nerves and muscles. In this capacity, it is vital for maintaining heart rate and blood pressure, as well as regulating internal organs.

Calcium is so important that when blood levels of this mineral drop below a certain threshold, the body taps some of the calcium in the bones to compensate. However, the amount of calcium required to maintain all these other functions is slight—only about 1% of your body's total calcium stores. The rest—weighing about 2.25 to 4.5 pounds—is sequestered in your bones.

Tapping and replenishing calcium stores

The process by which the body removes calcium from bone is known as resorption, and it is performed by special cells called osteoclasts. The sawtooth membranes of these cells enable them to attach to the surface of bone. Once attached, they use acids and

Figure 2: The cycle of bone construction and demolition



Bone is constantly being constructed and demolished. During resorption (**A**), cells known as osteoclasts break down bone, releasing calcium into the bloodstream.

The trenches that are left behind (**B**) are then filled in by construction cells known as osteoblasts.

The osteoblasts release collagen into these troughs and eventually evolve into structural bone cells, or osteocytes (**C**).

Once these osteocytes mix together with calcium, phosphate, and other minerals to form a cement-like substance known as hydroxyapatite, the process of replacing the lost bone is complete (**D**).

enzymes to break down the bone's matrix of collagen and minerals, releasing these materials into the bloodstream for reuse in other parts of the body. This recycling effort leaves tiny trenches in the bone (see Figure 2, above).

A bone-building process known as formation—carried out by cells called osteoblasts—counterbalances resorption. Osteoblasts move into the trenches left by the osteoclasts and release strands of collagen into the void. Eventually, they become trapped in the web they have woven. Held by these moorings, they evolve into structural bone cells, or osteocytes. Calcium, phosphate, and other minerals carried in the bloodstream also accumulate in the web woven by osteoblasts. The minerals coalesce into crystalline hydroxyapatite, and the formation process is complete: the bone that was removed has been fully replaced.

To maintain bone density, the body needs to keep a constant balance between bone production and breakdown. The main players in this process are the osteocytes—mature osteoblasts that have become trapped within the bone matrix they helped construct. Osteocytes send out signals that regulate bone remodeling. They direct osteoclasts to break down bone and osteoblasts to form new bone, thereby maintaining a kind of equilibrium within the bones.

Other key players

The remodeling process releases stored calcium for vital functions elsewhere in the body, and it also keeps your skeleton fresh and healthy by replacing old bone with new. This important task in the body's housekeeping scheme requires more than just osteoclasts, osteoblasts, and osteocytes. It also takes a sizable array of hormones and other substances to carry out bone formation. For example, vitamin D (which is actually a hormone) plays a pivotal role, limiting withdrawals of calcium from bone by enhancing calcium absorption from food in the intestines into the bloodstream.

Another key player in bone health is parathyroid hormone (PTH), which is secreted by small glands behind the thyroid. The glands release PTH when the level of calcium in the blood falls below the amount needed by the body's cells. In response, the digestive system absorbs more calcium from food and the kidneys excrete less calcium in urine, both of which help to raise blood levels of calcium. PTH also stimulates the osteoclasts to break down bone, releasing calcium into the bloodstream. When the blood levels are adequate, the production of PTH falls.

PTH can be harmful or helpful to bone health, depending on a couple of factors. Sustained high levels of the hormone, as seen in the disorder primary hyperparathyroidism, can lead to bone loss. In contrast, small amounts of synthetic PTH taken intermittently—one type of medical treatment for osteoporosis—can bring about a net increase in bone mass and strength.

The life cycle of bone

Bone remodeling is a lifelong process. At first, building outpaces demolition (resorption). Later in life the ratio is reversed, and overall bone mass starts to decline. In the middle—earlier than most people realize—you reach peak bone mass, the maximum bone density you will achieve.

The early years

During the first 20 years of life, the body builds new bone more quickly than it removes old bone. By the late teens, most bone formation has already occurred. In fact, by age 20, most women have built 98% of their skeletal mass. Over the next decade, building slows, but still outpaces resorption. By age 30, most men and women reach their peak bone mass (see Figure 3, below). In an ideal world, you will have built strong bones early in life. But even if you haven't, it's never too late to adopt bone-preserving habits.

The density of bones at their peak varies from person to person. Heredity, lifestyle, and medical conditions all influence how much bone you'll have in the bank when heavy withdrawals begin. Following are some of the factors that influence peak bone mass.

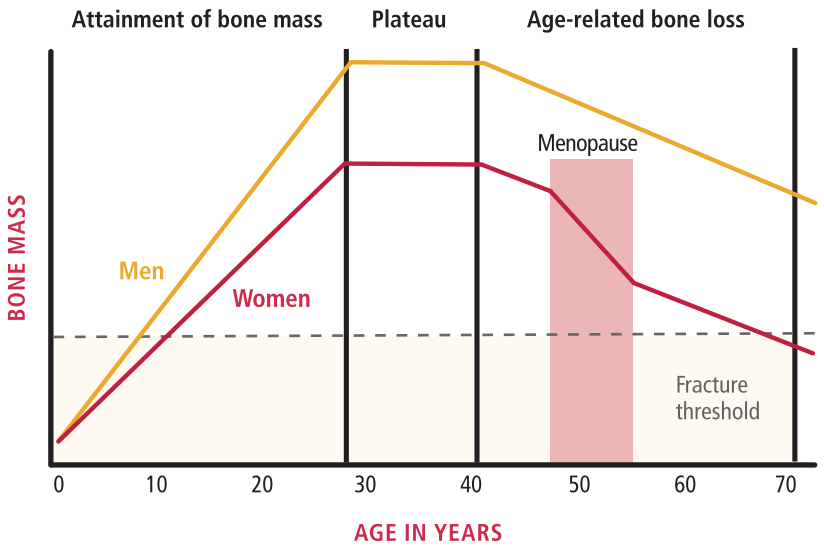
Sex, race, and genes. In general, bone density is 30% higher in men than in women. Rates of osteoporosis and fractures also vary among different racial and ethnic groups. Even so, there is wide variation within these groups, which may trace back to various social, cultural, and genetic influences that affect bone mass, bone turnover, and bone loss.

Diet. Nutrition early in life strongly influences bone health in adulthood. Research indicates that women whose diets contain the greatest amounts of calcium and vitamin D during childhood and adolescence have denser and stronger bones during adulthood. Consuming enough calories is also vital: when girls and women have too little body fat to support menstruation because of anorexia or bulimia, their bones suffer and they are in greater jeopardy of developing osteoporosis.

Exercise. Regular exercise contributes to peak bone density. Particularly important are weight lifting and other forms of resistance training, as well as a larger group of weight-bearing activities—that is, those in which you support your body's weight against gravity—such as running, walking, aerobics, soccer, basketball, gymnastics, tennis, and golf. Exercise puts stress on bone, and bones respond by bulking up. However, for women, exercising to an extreme can result in declining estrogen levels, amenorrhea (abnormal absence of menstrual periods), and eventually bone loss. This unhealthy situation is particularly common among young dancers, elite athletes, long-distance runners, and gymnasts.

Medications. The use of certain medications may be accompanied by bone loss (see "Medical conditions and medications associated with bone loss," page 9). Some drugs, such as oral glucocorticoids (which are taken to control conditions like

Figure 3: How bone density changes with age



Bone formation outpaces resorption up to age 30, when both men and women reach their peak bone mass. Then the process reverses, leading to a plateau and finally a loss of bone mass that occurs gradually in men but much faster in menopausal women.

Source: Clinical Endocrinology, *Nov. 1990, 653–82.*

lung disease and autoimmune disorders), can substantially diminish bone strength, as can medications used to treat breast and prostate cancers. Also, because several drugs that speed bone loss are commonly taken after organ transplants, people who have had these operations are at considerable risk of developing osteoporosis.

Middle age and beyond

Among women, bone mass begins to decline after age 40. The loss is gradual at first, as estrogen levels start to dip during perimenopause (the years preceding menopause, which is the point at which a woman has not had a period for 12 consecutive months). As it accelerates, bone is lost rapidly. But even after menopause, women continue to lose bone. In fact, during the five to seven years after menopause, women lose on average about 10% of their bone density.

Levels of androgens (sex hormones) in men fall off more gradually, so osteoporosis tends to develop later and progress more slowly in them. As noted earlier, men also tend to start with higher bone density than women. These factors combine to make men less susceptible to osteoporosis compared with women of the same age. The main contributors to their bone loss are medical conditions that affect bone and the general effects of aging.

By ages 65 to 70, men and women lose bone at the same rate, although more women than men are diagnosed with osteoporosis at all ages. And the process can be hastened by a variety of medical conditions and medications that are covered in the next chapter.

What causes osteoporosis?

While a certain amount of bone loss is normal, osteoporosis is not. Many things can cause osteoporosis. Some are factors you can change. Others are beyond your control. Doctors sometimes classify osteoporosis as primary or secondary, depending on the cause.

Primary osteoporosis

The term primary osteoporosis is used to describe the most common form of the disease, which is the consequence of a normal physiological process, such as menopause or aging.

Menopause

Postmenopausal osteoporosis occurs when declining estrogen levels in women lead to rapid bone loss. Typically, the process accelerates in the first few years of menopause and then begins to level off. The effects are most prominent in trabecular bone, which isn't as dense as compact bone.

Several factors may contribute to this process. A number of researchers are examining the roles of chemical regulators, such as interleukin-1, interleukin-6, prostaglandin E2, and tumor necrosis factor, which appear to speed up bone resorption by spurring on osteoclasts as estrogen levels decline. Such research could someday lead to better drugs to prevent postmenopausal bone loss.

Aging

Gradual bone loss with aging may also lead to osteoporosis. In this case, the bone loss develops more slowly than postmenopausal osteoporosis and is usually not apparent until age 75 or later. As with all age-related changes, it probably reflects several factors.

Increased breakdown of bone tissue. As described earlier, bone in older people is broken down more quickly than it is formed.

You can't halt aging, but you can take steps to fight certain age-related problems that contribute to osteoporosis, such as reduced calcium absorption and reduced vitamin D production.

Reduced levels of calcium in the bloodstream. With age, the intestines gradually absorb less calcium from food, and the kidneys seem to be less efficient at conserving calcium. Thus, less calcium reaches the bloodstream, and more calcium leaves the body in feces and urine, making it increasingly likely that the body will need to tap the calcium stored in bones. To make matters worse, most people consume less calcium in their diets as they age, further straining their calcium reserves. Some older adults may avoid dairy products if they have lactose intolerance (impaired ability to digest milk sugar), which can produce gas and abdominal discomfort. Others may shun calcium-containing foods and supplements because of their constipating effects.

Reduced vitamin D production. The body's production of vitamin D frequently drops with age as well. Your skin cells use sunlight to produce the chemical raw material that the body needs to make vitamin D. The liver and kidneys then convert this precursor into active vitamin D. However, people often spend less time in the sunlight as they grow older, so there is less of the raw material available—and in addition,

the body becomes less efficient at turning this precursor into active vitamin D. Compounding the problem, many older adults consume fewer dairy products, which are fortified with vitamin D, so they take in less through their diets. Vitamin D plays a central role in the body's absorption of calcium and in the process of turning calcium into bone. If you don't have enough vitamin D to signal your intestines to absorb calcium, your body will break down bone to get the calcium it needs—no matter how much calcium you're getting from food or supplements.

Secondary osteoporosis

The term secondary osteoporosis is used to describe osteoporosis resulting from a medical condition or the use of certain medications. If you have one of these conditions or if you're taking any of these drugs, talk to your doctor about what you can do to keep your bones healthy.

Medical conditions that cause bone loss

Certain medical problems can affect bone health—some severely. One example is premature (early) menopause, in which a woman experiences the end of menstruation at a younger age than usual. Disorders that increase bone metabolism, such as hyperthyroidism, can also lead to accelerated bone loss. Certain rare congenital disorders that affect bone mass over a lifetime can increase the risk for osteoporosis. Examples include Marfan's syndrome, Ehlers-Danlos syndrome, osteogenesis imperfecta, and hypophosphatasia. Some chronic conditions, including anorexia, certain cancers, kidney disease, liver disease, and disorders that affect mineral absorption may also have an impact (see "Medical conditions and medications associated with bone loss," page 9).

Another secondary cause of osteoporosis is primary hyperparathyroidism, a condition in which people have abnormally high levels of parathyroid hormone. This hormone helps regulate the amount of calcium in the blood. Excessive levels spur the removal of calcium from bones and increase the amount of calcium in the blood. In turn, the kidneys often try to compensate for the extraordinarily high blood levels of calcium by excreting large amounts of it in the urine. Every year, approximately 100,000 new cases are detected, with women accounting for three to four times more cases than men. Often, this condition has no symptoms and is found only when a routine blood test shows high calcium levels. However, as primary hyperparathyroidism advances, it can cause kidney stones, muscle weakness, fatigue, and eventually osteoporosis.

Medications that cause bone loss

A variety of medications, both prescription drugs and products available over the counter, can affect bone strength and possibly increase fracture risk. In an otherwise healthy person, such medications might have a small effect. But if you have already begun to lose bone or you've been diagnosed with osteoporosis, the effects of these drugs may be enough of a concern to warrant discussing them with your doctor. Together, you can decide whether it's best to stay on these drugs or switch off them, depending on your bones and your overall health.

Researchers have found definitive links between the following drugs and bone loss:

Anticonvulsants. Numerous studies have found an increased risk of bone loss and fractures among people who take drugs called anticonvulsants, which prevent epileptic seizures. These antiseizure drugs can cause the body to use up vitamin D more quickly, which in turn reduces an individual's absorption of calcium. The risk has been linked most strongly to older anticonvulsant drugs known as enzyme inducers: carbamazepine (Tegretol), phenobarbital, phenytoin (Dilantin), and primidone (Mysoline). Valproate (Depakote), a different type of older drug, may also lead to bone loss. Some newer anticonvulsants—such as lamotrigine (Lamictal) and levetiracetam (Keppra)—may have less impact on bones.

Aromatase inhibitors (for women). Many postmenopausal women with breast cancer have benefited from a class of drugs called aromatase inhibitors, which block estrogen production. These drugs include anastrozole (Arimidex), exemestane (Aromasin), and letrozole (Femara). These drugs reduce the chance of cancer coming back in postmenopausal women with

estrogen-positive tumors, meaning the cancer tends to grow in response to estrogen. But because estrogen slows bone loss, lowering levels of this hormone with an aromatase inhibitor can harm bone health. As a result, women taking these drugs have a greater risk for fractures of the spine and other bones.

Glucocorticoids. The drugs most often linked to drug-related osteoporosis are glucocorticoids, also known as corticosteroids (see "5 ways glucocorticoids hinder bone formation," page 10). These drugs include dexamethasone, hydrocortisone, and prednisone, among many others. They are often used to treat conditions such as asthma, rheumatoid arthritis, cystic fibrosis, and chronic obstructive pulmonary disease. Glucocorticoids are also used to prevent rejection after organ transplantation. Inhaled corticosteroids, which are an integral part of asthma treatment, are less likely to cause bone loss than oral corticosteroids, but they can still weaken bones, especially at high doses.

Gonadotropin-releasing hormone (GnRH) agonists. GnRH agonists are drugs that block production of sex hormones, including testosterone in men and estrogen in women. They are commonly used to treat prostate cancer in men and endometriosis and uterine fibroids in women. These powerful medications are also associated with increased bone breakdown and decreased bone formation, which in turn raises the risk of fractures.

Thyroid hormones. Thyroid hormones affect the rate at which your body replaces old bone. At normal levels in the body, thyroid hormones do not influence bone density or fracture risk. But if levels of thyroid hormones remain too high for an extended time, it can lead to bone loss. This can happen naturally, if you

Medical conditions and medications associated with bone loss

MEDICAL CONDITIONS

- Celiac disease
- Chronic metabolic acidosis
- Cushing's syndrome
- Diabetes (types 1 and 2)
- Eating disorders, such as anorexia and bulimia
- Ehlers-Danlos syndrome
- End-stage renal disease
- Gastrointestinal surgery, such as gastric bypass
- Gaucher's disease
- Heart failure
- Hemochromatosis
- Hypercalciuria
- Hyperprolactinemia
- Hypothalamic amenorrhea
- Hyperthyroidism
- Hypogonadism
- Hypophosphatasia
- Inflammatory bowel disease
- Klinefelter's syndrome
- Liver disease
- Lupus
- Malabsorptive disorders
- Marfan's syndrome
- Multiple myeloma
- Multiple sclerosis
- Muscular dystrophy
- Osteogenesis imperfecta
- Panhypopituitarism
- Post-transplant bone disease
- Premature menopause
- Primary biliary cirrhosis
- Primary hyperparathyroidism
- Renal tubular acidosis
- Rheumatoid arthritis
- Sickle cell disease
- Systemic mastocytosis
- Thalassemia
- Turner's syndrome

MEDICATIONS THAT CAUSE BONE LOSS

- Anti-androgens
- Anticonvulsants
- Aromatase inhibitors
- Glucocorticoids (oral)
- Gonadotropin-releasing hormone (GnRH) agonists
- Thyroid hormone (excessive doses)

MEDICATIONS WITH POSSIBLE LINKS TO BONE LOSS

- Antidepressants, particularly selective serotonin reuptake inhibitors (SSRIs)
- Barbiturates
- Canagliflozin (Invokana)
- Cyclosporine (Neoral, Sandimmune, others)
- Depot medroxyprogesterone (Depo-Provera)
- Glucocorticoids (inhaled)
- Heparin (when taken for extended periods)
- Lithium
- Loop diuretics
- Methotrexate
- Proton-pump inhibitors (PPIs)
- Tacrolimus (Prograf, others)
- Tenofovir (Viread, others)
- Thiazolidinediones (TZDs)
- Vitamin A (retinol), in excessive doses

have untreated hyperthyroidism (overactive thyroid), or it can happen if you take high doses of thyroid hormone to treat thyroid cancer. (By contrast, the small, daily doses of synthetic thyroid hormone that people take for an underactive thyroid are very unlikely to compromise bone health—they merely maintain your thyroid hormone levels in the normal range. Your doctor will monitor your levels with regular lab tests to prevent problems.)

Medications that might cause bone loss

In addition to medications that clearly cause bone loss, there is a lengthy list of drugs with *possible* links to bone loss (see "Medical conditions and medications associated with bone loss," page 9). The following are some that appear to be strongly associated, although researchers haven't yet demonstrated that the drugs themselves, rather than some other factor, caused the bone loss observed in studies.

Antidepressants. Researchers have uncovered a possible association between reduced bone strength and a class of antidepressants called selective serotonin reuptake inhibitors (SSRIs). These drugs may contribute to bone loss by enhancing the effects of osteoclasts. However, the link is far from certain. Although people who use SSRIs seem to have a modestly higher risk of fractures, it's not possible yet to show a definite cause-and-effect connection. In the meantime, if you are taking these medications long-term at your doctor's recommendation, you may want to discuss whether there is more you could do to protect yourself against fractures, such as being screened for low bone density or increasing your calcium, vitamin D, and exercise.

Diabetes drugs. Doctors have noticed bone fractures and decreased bone density in people taking the diabetes drug canagliflozin (Invokana), which is used to lower blood sugar in people with type 2 diabetes. In 2015, the FDA added a warning about bone loss to the drug's label. Canagliflozin belongs to a class of drugs called SGLT2 inhibitors. But so far, the FDA warning applies only to canagliflozin, but not other SGLT2 inhibitors. Another class of diabetes drugs called thiazolidinediones (TZDs), which includes pioglitazone (Actos) and rosiglitazone (Avandia), has also been linked to increased bone loss and fracture risk. Before you start taking one of these drugs, it may be worth discussing the bone risks with your doctor. Lastly, insulin use has also been linked to an increase in fracture risk, although it's likely that this is because patients with diabetes who are taking insulin also have other complications of the disease that increase the risk of falls.

Loop diuretics. Diuretics, or "water pills," make the body excrete water and salt. They are often used to treat high blood pressure. Those in the group known as loop diuretics cause the kidneys to release more calcium. Commonly prescribed loop diuretics that have this effect include bumetanide (Bumex) and furosemide (Lasix). Several studies have shown that people who take loop diuretics have slightly lower bone density in fracture danger zones, like the hip, and a greater overall fracture risk.

Proton-pump inhibitors (PPIs). This popular class of medications, used to reduce stomach acid, may erode bone strength and increase the risk of fractures. (Omeprazole, marketed as Prilosec, is one of the best-known PPIs.) By reducing stomach acid, PPIs may impair the absorption of calcium from food, potentially leading to weaker bones and a greater risk of bone fractures. Research to date suggests that the effect, if it is real, is modest, though not all studies agree. However, in a person already at risk of low bone density or fractures, long-term use of PPIs could pose a legitimate concern.

If you're at risk for fractures and you use a PPI for heartburn or to prevent ulcer flare-ups, ask your doctor how to counterbalance the effect of the PPI.

5 ways glucocorticoids hinder bone formation

This class of medications—including prednisone, dexamethasone, and hydrocortisone—do the following:

1. interfere with the body's ability to absorb calcium from food
2. increase the amount of calcium lost in the urine
3. fuel bone-destroying osteoclasts
4. hamper bone-building osteoblasts
5. reduce the production of estrogen in women and testosterone in men.

If you take calcium supplements, you may want to switch to a product with calcium citrate, which does not require stomach acid for absorption (unlike calcium carbonate, which does require acid for maximal absorption). Calcium citrate is often recommended for people taking PPIs long-term.

Organ transplant antirejection drugs. Some medications, such as cyclosporine (Neoral, Sandimmune) and tacrolimus (Prograf), that are used to prevent organ rejection after transplants may also further bone loss. People using any of these medications should be vigilant about protecting their bones, especially because these medications are often used together with prednisone, which has a definite link to fractures. Therefore, patients who have received an organ transplant should pay special attention to diet and exercise and strongly consider other steps—such as taking osteoporosis drugs (see "Protecting your bones: Medication," page 40)—to prevent bone loss and fractures.

Know your risk factors

Certain factors make you more vulnerable to developing osteoporosis. Some of these risk factors—like age and family history—aren't within your control. Others are modifiable with some relatively simple lifestyle changes.

If you haven't yet been diagnosed with osteoporosis, use these risk factors as a guide to launching a discussion about bone density testing with your doctor. If you have already been diagnosed, addressing the lifestyle factors you can change can help preserve the bone strength you still have.

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Race and ethnicity can influence bone health. White and Asian women face the highest osteoporosis risk, partly because their bones tend to be smaller than those of Black and Hispanic women.

Risk factors you can't control

Though you can't change these factors, awareness of your risks can motivate you to start protecting your bones before they are dangerously weakened.

Gender. For a variety of reasons, women have a higher risk than men do, though men can develop osteoporosis, too (see "Osteoporosis risk in women," page 13, and "Osteoporosis risk in men," page 14).

Aging. Advancing years inevitably bring a higher risk for osteoporosis—particularly for women. According to the CDC, nearly 20% of women and 5% of men ages 50 and over have osteoporosis as measured at the neck of the femur (near where the thighbone connects to the hip) or the lumbar spine (the vertebrae of the lower back). Other people in this age group typically show signs of low bone strength in the spine or femoral neck, making them more likely to eventually develop osteoporosis.

Family history of the disease. The genetic traits you inherit also strongly influence your risk. Between 70% and 80% of bone mineral density is genetically determined. Both men and women whose first-degree family members (parents, siblings) have had fractures are at greater risk. In fact, a woman whose mother or father had a fracture has twice the risk of a break—regardless of her measured bone density.

Race and ethnicity. There are many social, cultural, and genetic factors that influence bone health among different racial and ethnic groups. White and Asian women face the highest osteoporosis risk, partly because their bones tend to be smaller than those of Black and Hispanic women. Asian women also tend to have a lower dietary intake of calcium, in part because lactose intolerance is more common. Yet surprisingly, despite having smaller bones, Asian women are less likely to fracture a hip than white women. This lower risk may be due to a variety of factors, including anatomical differences in bone structure.

Risk factors you can control

A poor diet, lack of exercise, smoking, and alcohol use can all hasten the development of osteopenia or osteoporosis as you age. If you've already been diagnosed with bone loss, addressing these risks can help protect and preserve the integrity of your bones for as long as possible.

Inadequate calcium and vitamin D levels. Inadequate intake of calcium from your diet—as well as

conditions that may interfere with calcium absorption by the intestines—leads to lower calcium levels in the blood. The body compensates by releasing calcium from the bones, which weakens them. Your body needs vitamin D to properly absorb calcium, so adequate amounts of this vitamin are also necessary.

Sedentary lifestyle. When you are at rest, bone formation slows; when you are physically active, bones bulk up and become stronger in response to stresses placed on them. The research to date suggests that leading a physically active life is very important to maintain your overall bone health.

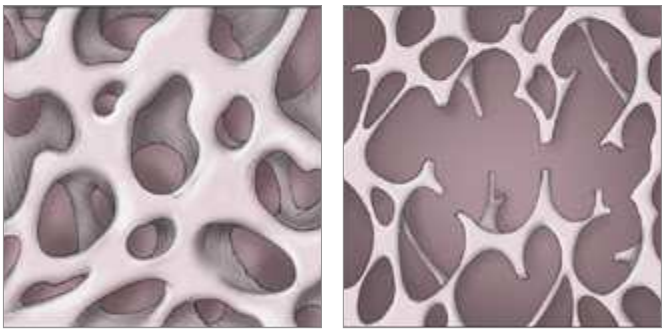
Smoking. Smokers tend to lose bone faster than nonsmokers. Smoking may both interfere with the absorption of calcium and lower the amount of bone-protective estrogen the body produces. A number of studies, some of them quite large, have found that men and women who smoked were more likely to have low bone mineral density and to experience fractures. In fact, a report from the U.S. Surgeon General on osteoporosis noted that smokers are 55% more likely than nonsmokers to break a hip.

Excess alcohol consumption. The amount of alcohol you drink can affect your bone health. Alcohol may interfere with the body's ability to convert inactive vitamin D into its active form. It also appears to hamper bone formation and increase losses of calcium and magnesium from the body. Excessive drinking may be accompanied by poor nutrition and an increased tendency to fall. People who consume more than two drinks per day may be at moderately higher risk of low bone density and fractures, compared with nondrinkers.

Medications. As described earlier in this report, some drugs contribute to bone loss, raising the risk for osteoporosis. If you're taking a medication known to affect bone density (see "Secondary osteoporosis," page 8), talk to your doctor about what steps you may need to take to keep your bones healthy.

Figure 4: A fragile state

Osteoporotic bone is more porous and less dense than healthy bone. The result is bone that is more fragile and more vulnerable to breaks. Areas that are particularly vulnerable include the vertebrae (spinal bones) and the femoral head (the top of the thighbone).



Normal, healthy bone | Osteoporotic bone

Osteoporosis risk in women

Women are more likely than men to develop osteoporosis because they have smaller skeletons, their bone loss begins earlier and occurs more rapidly, and they have a lower peak bone density to begin with. About 80% of the 10 million Americans with osteoporosis are women. The Study of Osteoporotic Fractures—a landmark National Institutes of Health study of almost 10,000 women ages 65 and older—found that, on average, bone mass fell by approximately 5% every five years in women after age 65.

The study looked at characteristics that are significantly more common among women who have osteoporosis. Together with other research, it provides a good idea of some factors that predispose certain women to the condition, in addition to the general risk factors above:

- Petite women tend to have lower bone density and a higher risk of fractures. It may be because their bones are smaller, but science doesn't give us a definite answer on this point. In the Study of Osteoporotic Fractures, women 65 and older with the smallest body size had twice the rate of hip fractures (10 in 1,000) compared with the rate among the largest women in the study (five in 1,000).
- Because estrogen slows bone resorption, women who are past menopause and those who have had their ovaries removed have higher risk. Also at higher risk are younger women who have too little body fat (sometimes because of excessive exercise, anorexia, or bulimia) and consequently too little estrogen to menstruate regularly.

Talk to your doctor about your risk and what, if anything, you should do about it, including having a bone density evaluation. The Bone Health and Osteoporosis Foundation recommends a dual energy x-ray absorptiometry (DEXA) test to measure bone density in women starting at age 65, and in younger postmenopausal women with risk factors for fractures. (For a more complete list of screening guidelines, see "Who should be screened with DEXA?" on page 19.)

Osteoporosis risk in men

It is a persistent misperception that osteoporosis is only a "women's disease." Although bone loss strikes women younger and harder, men, too, face significant risk for low bone density and the harmful fractures that can follow (see Figure 5, below). According to the Bone Health and Osteoporosis Foundation, two million American men have osteoporosis, and about 12 million more are at risk. Each year, about 80,000 men break a hip—and when they do, they are two to three times more likely to die of complications from their injuries than women are.

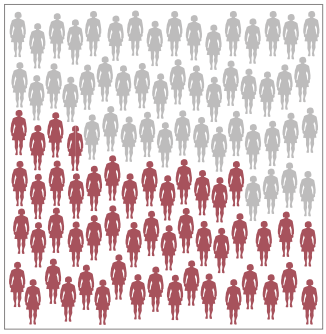
Nonetheless, men constitute only 20% of Americans with osteoporosis. Two factors make men less vulnerable than women to bone loss and fractures: they have greater bone density at skeletal maturity, and they experience a more gradual decline in hormone levels. When men under age 75 develop osteoporosis, it's often because of an underlying health condition. The underlying condition itself may lead to bone loss, or a medication may be responsible.

In other cases, men develop bone loss because of declining sex hormones. Testosterone, in particular, decreases with aging. But men's bodies also use testosterone to produce estrogen (though in smaller quantities than women), and declining estrogen with aging is likely the primary factor leading to age-related bone loss in men. In the ongoing Osteoporotic Fractures in Men Study, which has involved nearly 6,000 men 65 and older in the United States, participants who had low levels of both testosterone and estrogen were more likely to have osteoporosis than those with normal levels of these hormones. Researchers have also found that men with low hormone levels are more likely to fracture a hip.

The Bone Health and Osteoporosis Foundation recommends a DEXA scan to measure bone density in men at age 70, or as young as 50 if they have risk factors for fractures. However, the U.S. Preventive Services Task Force, an independent panel of experts, concluded that "the current evidence is insufficient to assess the balance of benefits and harms of screening for osteoporosis in men."

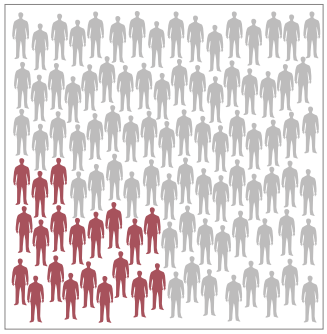
There is one thing that all experts agree on, however: men should protect their bones by following the same lifestyle recommendations suggested for women. That means engaging in regular weight-bearing and strengthening exercises, getting adequate amounts of calcium and vitamin D from food and (if needed) supplements, and avoiding habits known to deplete bone mass, such as smoking and drinking excessive amounts of alcohol. These habits will help maintain a solid reserve of bone mass to ward off fractures later in life.

Figure 5: Fracture risk



▲ FOR WOMEN

50% risk: One out of two women over age 50 will have an osteoporosis-related fracture in her lifetime.



▲ FOR MEN

20% risk: One out of five men over age 50 will have an osteoporosis-related fracture in his lifetime.

The consequences of osteoporosis

Osteoporosis was once known as a silent disease because it gives no warning signs as it gnaws away at bones. Eventually, it would make itself known when a bone fractured—often after a fall, but sometimes after something as innocent as a sneeze. These so-called fragility fractures can even happen out of the blue, with no obvious trigger.

Although any bone can be affected, most breaks related to osteoporosis occur in one of three sites: the hip, the spine, or the wrist. Fractures at these sites, particularly in women who are past menopause, are most common because these regions contain relatively high proportions of trabecular bone and are therefore especially vulnerable to the effects of bone loss.

Osteoporotic fractures exact a high toll, leaving some people in pain while stripping others of their ability to perform everyday activities or to move around independently. Three in five people who break a hip because of osteoporosis will never fully regain their previous level of functioning. Many people become so fearful of breaking another bone that they limit their activities, which causes them to feel helpless, isolated, and depressed, and can indirectly lead to further bone loss. Research has shown that fractures of the spine and hip have the greatest impact on quality of life.

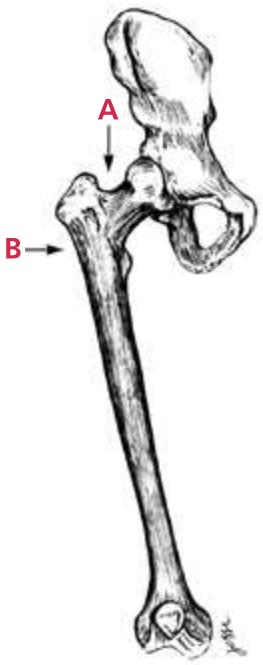
Hip fractures

About one in seven osteoporosis-related fractures occurs at the hip. Typically, these are the most serious osteoporotic fractures. Hip fractures usually involve either the neck or the intertrochanteric region of the thighbone (see Figure 6, at right). Breaks can also occur in bones of the pelvis. The impact of a hip fracture on your life and activity level depends in large part on your physical condition and other medical issues.

At best, these painful breaks are temporarily immobilizing, requiring confinement to bed or a wheelchair. Surgery is usually needed but may not be feasible because of other disorders, such as heart or lung disease, which increase the risk for complications following an operation. As a result, the damaged bone often heals badly, resulting in permanent disability.

The injury often has devastating effects on mobility and independence. Six out of 10 people who break a hip never fully regain their former level of independence. Some are permanently less able to perform ordinary daily activities, such as dressing themselves or rising from a chair. Even walking across a room may be difficult. These changes in mobility and daily functioning can make it necessary to seek home health care or to move to a facility that can provide care. Half of the people who suffer a hip fracture will need assistance walking, and one in five will need long-term nursing home care.

Figure 6: Common hip fractures



Most hip fractures occur in the top portion of the thighbone (femur)—either at the femoral neck (**A**) or at the intertrochanteric region (**B**).

Fracturing a hip can have serious consequences, such as impairing the ability to walk or to perform simple everyday chores, and the resulting immobility can lead to a downward spiral in health. There are more than 300,000 hip fractures in the United States every year.

While people seldom die directly from a hip fracture, this injury and its accompanying medical problems can trigger a downward spiral in health. Complications, such as pneumonia or blood clots, that result from the fracture itself or surgery to treat it are sometimes fatal. One in five people who have a hip fracture dies in the first year after the injury, with the risk of death higher in men than in women. Fractures are particularly deadly among nursing home residents and people with cognitive impairment or other health issues. The risk of death also disproportionately affects people ages 80 and older, who are 10 to 15 times more likely to fracture a hip than people 60 to 65. Those who do survive may have trouble living on their own.

Spinal (vertebral) fractures

Fractures in the spine are much more common than hip fractures. Unlike hip fractures, spinal fractures often occur without an impact like a fall. Even so, these injuries can be quite debilitating.

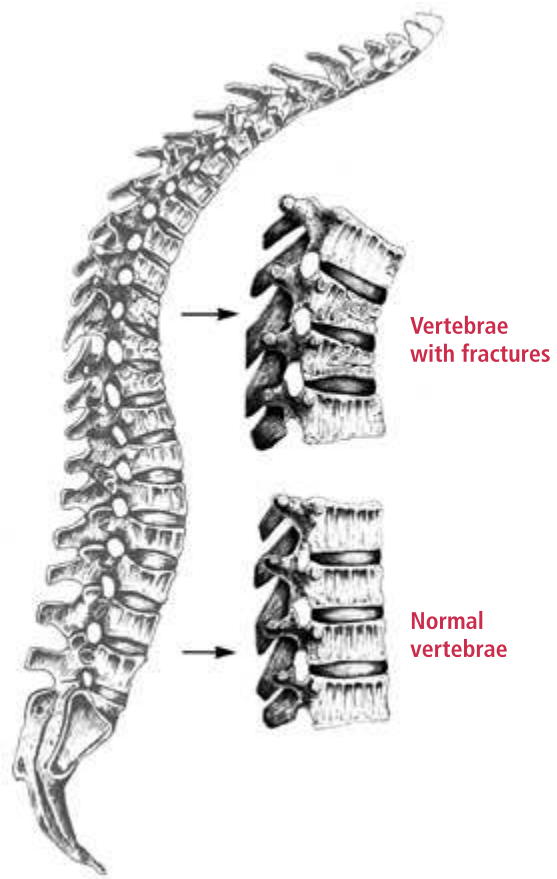
Simple acts of daily life, such as bending over, twisting, coughing, or lifting, can be enough to trigger a fracture that leads to the collapse of a vertebra weakened by osteoporosis. In such cases, the bones of the spine, which consist primarily of trabecular bone, aren't broken in the usual sense of the term. Rather than being snapped like twigs—as in the case of a broken arm or leg—the vertebrae are compressed, in the same way that a paper cup would be flattened when stepped on. Figure 7, at right, shows the effects of compression fractures on the spine. These fractures can cause a loss of height and, more seriously, spinal deformation—either a rounding of the back (kyphosis, sometimes called dowager's hump), a sideways curvature of the spine (scoliosis), or a combination of the two (kyphoscoliosis).

Compression fractures may be accompanied by pain that is sharp, dull, intense, or radiating around the side. Pain may also come from spasms in the muscles at the sides of the spine. It may come and go for several months, often recurring after the person sits in the same position for a long time. Discomfort from fractures can usually be relieved with pain medications such as aspirin or ibuprofen (Advil, Motrin).

In other instances, spinal fractures cause little or no pain. The principal clue that they have occurred is a gradual shrinkage or stooped posture. The amount of height lost and the degree of deformity will depend on the number, location, and severity of the compression fractures. However, narrowing of the cushion-like discs between vertebrae—which is not due to osteoporosis and often occurs as part of aging—may also cause deformity and a loss of height.

Most people who have spinal fractures have one or two, most commonly in the thoracic, or mid-back, region. While one or two mid-back compression fractures may produce only a slight loss of height, having many of them can profoundly affect your appear-

Figure 7: A look at normal and compressed vertebrae



Normal vertebrae align to form a gently curved stack, but if several vertebrae collapse, it can cause an abnormal curvature of the spinal column known as kyphosis, or dowager's hump. This condition can make it difficult to walk without a cane or walker and can interfere with proper breathing and digestion.

Can hip protectors prevent breaks?

A quick online search will turn up plenty of hip pads that are touted as a way to help prevent a hip fracture if you fall. The pads, which consist of a stiff plastic shield underlaid with foam padding, are meant to be strapped onto the hip.

For people living in nursing homes, who are at high risk of a fracture, some studies suggest hip protectors may reduce injuries. But scientific reviews of the best research available have failed to prove that providing hip protectors to older adults living independently reduces the incidence of hip fractures.

The main challenge is getting people to wear the hip protectors consistently and properly. The pads can be uncomfortable and awkward, and many people just don't like wearing them. Also, people may fall in circumstances in which they would not be wearing the pads, such as in the bath or shower. But if worn consistently by people at risk of hip fracture, these pads could theoretically be of benefit. An individual could also consider wearing protectors during activities that come with a higher risk of falling, such as playing pickleball or ice skating.

ance, mobility, and health. As the number of fractures increases, the spine becomes progressively more distorted. The upper body is thrust down and forward. The abdominal muscles sag, and the space between the ribs and pelvis closes. The chest wall becomes cramped, and the abdominal organs are compressed and pushed forward. Breathing may become difficult, and digestion may be impaired, leading to bloating and heartburn.

Severe spinal deformity affects mobility almost as significantly as a hip fracture. Since walking erect is difficult, a cane or walker becomes essential. Riding in a car for more than a few minutes can be very uncomfortable.

Wrist fractures

Wrist fractures account for up to 18% of all fractures in people older than 65, and osteoporosis underlies many of them. These injuries are usually the result of an attempt to break a fall. Typically, the force of the impact snaps the end of the radius, the long bone that runs from the elbow to the thumb, often producing a characteristic break known as a Colles' fracture. Normally, after a wrist fracture occurs, the arm is immobilized in a cast, splint, or sling and allowed to heal, although surgery is sometimes needed. Wrist fractures usually mend completely. However, they occasionally result in deformity and a loss of some function that interferes with the ability to perform everyday activities with ease.

Other consequences

Although trabecular bone loses strength more rapidly, compact bone eventually becomes vulnerable as well. As osteoporosis advances, bones with a high proportion of compact tissue—such as the tibia (shin), humerus (upper arm), and femur (thigh)—are fractured with increasing frequency. Ribs may be broken from the force of a cough.

Although the jawbone may not snap, it is not exempt from bone loss. As the jaw becomes increasingly porous, it provides less support for the teeth anchored into it. The result can be dental problems such as loose teeth and ill-fitting dental plates.

Detecting osteoporosis

In the past, osteoporosis was frequently diagnosed only after a bone fracture. For many people, that diagnosis came too late to be of much use. Today, osteoporosis can be detected earlier with a bone mineral density test. Such a test can also provide information regarding your risk of suffering a fracture and can help you and your doctor monitor your progress if you're taking bone-building medications.

Tests of bone density

Several technologies can assess bone density, but the most common is dual energy x-ray absorptiometry (DEXA or DXA), which came into widespread use in the 1990s. For this procedure, you lie on a table while a scanner passes over the central portion of your body and takes multiple x-rays (see Figure 8, at right). A computer analyzes the images and calculates bone density. The process takes about 20 minutes.

While DEXA scans can measure bone density at any spot in the body, they are usually used for three readings in particular:

- lumbar spine (in the lower back)
- total hip (at a specific site near the hip joint)
- femoral neck (at the top of the thighbone, or femur; see Figure 6, page 15).

DEXA accomplishes this with one-hundredth of the radiation exposure of a standard chest x-ray.

DEXA is considered the gold standard for osteoporosis screening. Ultrasound, which uses sound waves to measure bone density at the heel, shin, or finger, is sometimes used at health fairs and in some medical offices. Ultrasound is helpful if DEXA is not available, but it's not as good at predicting hip and spine fractures and therefore is not recommended as the first choice for screening. Quantitative computed tomography can also be used to measure bone density in the spine and hip. This technology is better than DEXA for measuring bone density, but it involves a lot more radiation (about 10,000 times as much) and therefore is not practical for use as a screening tool.

A bone density test gives you a number called a T-score, which represents how close you are to the average peak bone density of a healthy young individual.

Tips for getting a DEXA scan

- Do not take any supplements containing calcium in the 24 hours before your test, as they may affect the accuracy of the scan.
- Avoid other radiology tests that involve use of contrast agents (such as certain abdominal scans) in the seven days before the bone density test, as this can also affect the accuracy of the scan.
- Wear loose-fitting clothing that does not contain metal, such as zippers or buttons, which can show up on the scan and make it less accurate or more difficult to interpret. You may be asked to change into a hospital gown.
- Do not get a DEXA scan if you suspect you might be pregnant. DEXA involves a small amount of radiation that might be dangerous for a fetus.

Figure 8: Scanning for osteoporosis

Dual energy x-ray absorptiometry (DEXA) is the most common method for detecting osteoporosis today. Most physicians consider it the most accurate diagnostic procedure.

Every 1-point drop below zero represents a doubling of fracture risk. The World Health Organization has established the following classification system:

- If your T-score is –1 or greater: your bone density is considered normal.
- If your T-score is between –1 and –2.5: you have low bone density, known as osteopenia, but not osteoporosis.
- If your T-score is –2.5 or less: you have osteoporosis, even if you haven't yet broken a bone.

Once you know your bone density, you can also calculate your FRAX score, which tells you your likelihood of breaking a bone in the next 10 years (see "How likely are you to break a bone? Your FRAX score," page 20). The FRAX score incorporates not only your bone mineral density, but also specific risk factors (see "Key risk factors for a fracture," page 20).

Vertebral fracture assessment

Because fractures of the vertebrae are so common in older adults, and they often occur with no symptoms to warn of their presence, the Bone Health and Osteoporosis Foundation recommends that certain groups of people have a special scan of the spine at the same time as the DEXA test. A vertebral fracture assessment (VFA) uses the same type of x-ray as DEXA, but instead of measuring bone density, it shows the shape of the vertebrae. The goal is to see if any of the vertebrae are deformed—a possible sign of fracture. More vertebrae are scanned in a VFA than in a traditional DEXA test for bone density. If the VFA shows that you have one or more fractures, you likely have severe osteoporosis and will need more aggressive treatment.

VFA is recommended for

- women ages 65 and older who have a T-score of –1.0 or lower at the femoral neck
- women ages 70 or older and men ages 80 or older who have a T-score of –1.0 or lower at the lumbar spine, total hip, or femoral neck
- men ages 70 to 79 who have a T-score of –1.5 or lower at the lumbar spine, total hip, or femoral neck
- postmenopausal women and men ages 50 and older with specific risk factors, such as a fracture during adulthood, total height loss of 1.5 inches or more, recent height loss of 0.8 inches or more, a diagnosis of hyperthyroidism, or recent or long-term glucocorticoid treatment.

Unfortunately, many insurance companies consider VFA to be experimental and therefore do not cover it.

Who should be screened with DEXA?

DEXA screening for osteoporosis is not routinely given to everyone; instead, it is done on a case-by-case basis. Experts still debate some aspects of who should receive bone density screening, although there's widespread agreement that all women ages 65 and older should be screened. Talk to your doctor about whether testing is right for you.

The Bone Health and Osteoporosis Foundation recommends you be tested with DEXA if you are

- a woman age 65 or older or a man age 70 or older
- a postmenopausal woman under age 65 or a man age 50 to 69 with risk factors for osteoporosis
- a woman or man who has had a fracture at age 50 or older
- a woman or man who has a medical condition or is taking a medication associated with bone loss.

However, it's important to note that coverage varies among insurance plans. Some plans may refuse to pay for a DEXA scan. Others might specify how often you can have this test. For example, Medicare will cover the cost of one bone density test every two years, or more often if your doctor deems it medically necessary. So that you don't wind up footing the bill yourself, it pays to check with your plan first.

Tests of bone quality

Although DEXA remains the tool of choice for assessing bone mineral density—the volume of minerals within bone—some newer measurements assess another aspect of bone: the quality. There's no precise definition of bone quality, but it includes the structure, or architecture, at a microscopic level and any microscopic fractures. Bone quality is important to the extent that it reflects the strength of bone and its resistance to fracture.

Researchers have developed ways of estimating bone quality. Perhaps the best known is the trabecu-

How likely are you to break a bone? Your FRAX score

While bone density testing can identify people who have greater risk for fractures, it isn't the only predictor. A tool developed by the World Health Organization calculates an individual's real-life risk of suffering an osteoporosis-related fracture in the coming years. FRAX (which stands for fracture risk assessment tool) incorporates bone density scores and other key risk factors for a fracture (at right) to arrive at a percent probability that a person will break a hip or suffer another type of osteoporotic fracture within 10 years. A 3% chance of breaking a hip or a 20% chance of another type of major fracture (spine, forearm, or shoulder) is considered risky enough to treat.

The FRAX score is used to assess the risk for fractures in people with osteopenia (T-score between –1 and –2.5). If your FRAX score shows a high 10-year fracture risk, then your doctor may recommend medications regardless of your bone density results. Note that once you've started taking an osteoporosis drug, FRAX scores may not be as accurate.

If you've had a concerning bone density test or if you think you might be at risk for osteoporosis, you may want to ask your physician about calculating your FRAX score. The tool is geared for doctors' use, but you can find it online at www.shef.ac.uk/FRAX.

Key risk factors for a fracture

Osteoporosis is not the only thing that doctors consider in determining your chances of breaking a bone in the next 10 years. Even with osteopenia, you can be at a high risk of a fracture if you have enough risk factors. The FRAX score (see "How likely are you to break a bone? Your FRAX score," at left) takes the following factors into account:

- age (higher with greater age)
- sex
- race and ethnicity (although not yet validated in diverse populations)
- body mass index (below normal or very high)
- previous fracture (from age 20 on)
- parental history of hip fracture
- current smoking
- alcohol use (three or more drinks per day)
- long-term use of glucocorticoid drugs
- rheumatoid arthritis (the only medical condition directly included in FRAX)
- secondary osteoporosis (caused by another underlying health condition or medication).

Beyond the FRAX variables, there are other factors that may increase fracture risk, including low physical activity and anything that increases the risk of falls or frailty.

lar bone score (TBS). TBS estimates the quality of trabecular bone and how vulnerable it is to fracture. The score is calculated using an algorithm that interprets the shading in a DEXA scan, in which microscopic breaks show up as dark gray or black.

Research suggests that TBS helps predict fracture risk independently of DEXA and FRAX results. The International Society for Clinical Densitometry says TBS can be used along with these tests to adjust estimates of fracture risk for postmenopausal women and older men. However, this technology is relatively new and might not be covered by insurance.

Other tools are being developed to assess bone quality using noninvasive techniques.

Lab tests for bone turnover

Blood and urine tests are available that can provide information about bone turnover—how quickly bone is broken down and replaced (remodeled). The tests measure substances called bone turnover markers that are released during bone formation and resorption. High levels of markers associated with bone resorption can indicate high bone turnover, a red flag for declining bone health.

Although these tests are not performed routinely, a doctor may order one in certain circumstances to estimate your rate of bone loss or to monitor your response to a medication—for example, if there are concerns that you are not appropriately absorbing the medication. These tests are also sometimes used when a person takes a temporary "drug holiday" from bisphosphonate treatment or completes treatment with denosumab (Prolia). The test results can help your doctor decide when it's time to restart osteoporosis medications, based on whether you show signs of bone loss. If your doctor does order these tests for you, it's important to remember that it's best if they are performed in the morning and on an empty stomach.

Developing a plan of action

If you've been diagnosed with osteopenia or osteoporosis, your doctor will help you develop a plan to slow bone destruction and possibly even gain back a little of the bone you've lost. That plan will likely include three main strategies: diet, exercise, and medication. A fourth strategy—fall prevention—won't slow bone loss, but like the first three strategies, it helps lessen the chances of a devastating fracture. You'll find more detail on these strategies in later chapters.

If you have osteopenia (T-score between –1 and –2.5)

According to your T-score, your bone density is lower than normal. You may not need medicines at this point (although that depends on your overall risk profile), and you won't necessarily progress to osteoporosis. A few lifestyle interventions should slow down the rate of bone loss and may even help you regain a small amount of bone, although they won't restore you to youthful bone density.

To protect your bones, your doctor will likely suggest the following:

Exercise. Staying active slows bone loss, strengthens the muscles that support your skeleton, and improves your coordination and balance so you're less likely to fall. A combination of strength training (weight training) and weight-bearing exercises (walking, tennis, stair climbing) is ideal for preserving bones. The force exerted on bones from these types of exercise causes your body to keep reinforcing the bones.

Get enough calcium and vitamin D. These nutrients are important for both fall and fracture prevention. Ask your doctor whether you can get enough calcium and vitamin D from your diet alone or if you need to take a supplement.

Quit smoking. This habit, which is also bad for your heart, lungs, skin, and other organs, can increase your fracture risk. Ask your doctor about nicotine replacement products, medicines, and other strategies to help you kick the habit.

Don't drink too much alcohol. Excess alcohol consumption can decrease bone mass, and heavy alcohol use can also make you more apt to fall.

Take additional measures to help avoid a fall. Remove clutter that might cause you to trip, and be careful about using sedative medications and sleep aids that can make you unsteady on your feet.

Possibly take medicine. Your doctor may recommend an osteoporosis drug for treating osteopenia if all three of the following apply to you:

- You're age 50 or older.
- Your T-score is between –1 and –2.5 at the hip or spine.
- You have previously had fragility fractures (due to weak bones rather than a fall or other physical trauma) or you have other key risk factors for a fracture (see page 20) giving you a 10-year FRAX-estimated risk of at least 3% for a hip fracture or 20% for another type of major fracture (spine, forearm, or shoulder).

If you have osteoporosis (T-score –2.5 and below)

Once you've been diagnosed with osteoporosis, your doctor will likely start you on a medicine such as a bisphosphonate, SERM, monoclonal antibody, anabolic (bone-building) drug, or hormone (see "Protecting your bones: Medication," page 40). Osteoporosis drugs can help you maintain bone density and in some cases improve it. Your doctor will continually reassess your bone density to determine how well the medicine is working and how long you should stay on it.

Just because you start on medication, however, doesn't mean you should abandon lifestyle interventions. Although diet and exercise won't reverse bone loss once you've been diagnosed with osteoporosis,

they can slow it. Continue with all of the lifestyle interventions listed above—get enough calcium and vitamin D, do regular weight-bearing and strengthening exercises (see the Special Section, "Strength training and balance exercises for bone health," page 36), avoid smoking and excess alcohol consumption, and reduce your fall risks.

If your bone density is normal

While the basics of protecting your bones—such as getting enough calcium and engaging in weight-bearing exercises—remain the same throughout your life, there are different factors to consider as you get older.

If you are a woman at menopause

If you are a woman in the early years of menopause, you are probably in the stage of your greatest bone loss. All of the lifestyle recommendations above apply, and you should do the following as well.

Assess your risk. If you have reason to believe you're at elevated risk for developing osteoporosis (see "Know your risk factors," page 12), talk to your clinician about having a bone density evaluation. If you have conditions or take medications that reduce bone mass (see "Medical conditions and medications associated with bone loss," page 9), ask your doctor what you can do to counteract these effects.

Check your calcium and vitamin D levels. Meeting the recommended intake for these nutrients is a good start. But in addition, it's wise to have blood tests for both. Calcium tests are often part of standard blood testing, but you may have to ask for a vitamin D test. The level should be at least 30 ng/ml for people with osteopenia or osteoporosis, but 20 ng/ml is probably sufficient for those with normal bone density.

Re-evaluate your exercise regimen. Exercise can not only potentially build bone but also increase strength, flexibility, and balance. Now is a good time to incorporate weights into your routine, if you haven't already been using them. Another Harvard Special Health Report, *Exercises for Bone Strength*, provides a full program of bone-strengthening exercises, including two strength workouts, a cardio program, jump training, a running program, and yoga. Note that these workouts are intended for people who are still in the normal range for bone density or who have low bone density that does not yet qualify as osteoporosis. People who already have osteoporosis should check with their physician as to an appropriate exercise program. For one possible regimen, see the Special Section, "Strength training and balance exercises for bone health," page 36.

Discuss preventive medications with your doctor. Many medications can help prevent osteoporosis (see "Protecting your bones: Medication," page 40). Your doctor can help you determine if you should take one and, if so, which may be best suited for you.

If you are 65 or older

At this point, bone loss has slowed down for women, but it hasn't stopped. In fact, men and women are losing bone at a similar rate. All of the previous suggestions for bone maintenance still apply. In addition, consider these options.

Increase your calcium intake and get plenty of vitamin D. The recommended intake of calcium is 1,200 milligrams for most people in this age range (see Table 1, page 24). Make sure that you also take in sufficient vitamin D to help your body absorb the calcium. (For more detail on recommended amounts, see "Calcium and vitamin D," page 23.)

Keep up your exercise routine. In addition to strength training, work on balance exercises, such as tai chi, to lessen the likelihood of falling.

Consider medication. Some drugs are used for osteoporosis prevention and treatment, while others are for treatment only (see Table 6, page 42). You may want to talk to your doctor about whether you should take a preventive medication and, if so, which one.

Protecting your bones: Nutrition

A nutritious diet is just as important in later life as it was when your mother urged you to "drink your milk" to strengthen your bones. Along with exercise, nutrition is a cornerstone of bone health—and general health, too.

Even if you've been lax about eating right in the past, it's never too late to start making healthful changes. Although foods that are rich in the bone-building nutrients calcium, vitamin D, and (to a lesser extent) vitamin K won't reverse osteopenia or osteoporosis, they can help preserve the bone you have and keep you healthier over all. The ideal way to get these and other essential nutrients is through food, but if you're a little short, supplements may help you get the recommended amounts—particularly for vitamin D, which can be hard to get enough of solely from your diet.

Abundant calcium is found in dairy products, but there is also calcium in seafood (especially canned salmon and sardines, since you eat the bones). Eggs and some mushrooms contain vitamin D.

Calcium and vitamin D

Calcium and vitamin D have long been recognized as essential to bone health, as well as other important functions in the body. Calcium provides the building material for strong bones. Vitamin D helps your intestines absorb calcium into the bloodstream, which delivers it to your bones, muscles, and other body tissues.

While it's clear that you need calcium and vitamin D to keep your bones healthy, the effectiveness of these nutrients may depend on your baseline risk for bone disease. Among healthy adults who have a low risk of fracture to begin with, some studies have found that adding calcium or vitamin D to the diet, whether through food or supplements, increases bone density by only a minimal amount, which may not translate into a noticeably reduced fracture risk. However, among adults with low bone density or osteoporosis, studies have clearly shown that these nutrients can prevent bone loss and prevent fractures.

How much do you need every day? For this, there is now specific guidance, although experts have disagreed on the amounts of calcium and vitamin D for older adults.

In 2009, the Institute of Medicine (IOM)—now called the Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine—convened a group of distinguished physicians and researchers to review the available evidence on calcium and vitamin D and come to a consensus on basic daily requirements for these two vital nutrients. The 14-member IOM panel examined more than 1,000 studies and listened to testimony from experts. The panel weighed the evidence for a range of health benefits—not just for bone health, but also for reproductive health, immune and mental function, and reduced risk of cancer, heart disease, and diabetes.

One key outcome of the review was a 2011 update to the Recommended Dietary Allowances (RDAs) for calcium and vitamin D, specifying the amounts that meet the basic health needs of 97% of all people at a given age. The RDAs for calcium and vitamin D appear in Table 1, page 24.

Table 1: Recommended daily calcium and vitamin D intake in adults

The Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine (formerly the Institute of Medicine) establishes Recommended Dietary Allowances (RDAs) for various nutrients, including calcium and vitamin D. This table shows its recommendations for the general population. However, its vitamin D recommendations for older adults (ages 51 and up) are lower than those of the Bone Health and Osteoporosis Foundation, which are aimed at people with osteopenia and osteoporosis (see Table 4, page 29).

SEX/AGE	CALCIUM	VITAMIN D
WOMEN		
19 to 50	1,000 mg	600 IU
51 to 70	1,200 mg	600 IU
71 and older	1,200 mg	800 IU
MEN		
19 to 50	1,000 mg	600 IU
51 to 70	1,000 mg	600 IU
71 and older	1,200 mg	800 IU

Source: Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine (formerly the Institute of Medicine).

Controversy over the IOM recommendations

These recommendations were not met with universal approval, however. Some experts think that the IOM's recommendations underestimated the amount of vitamin D that people ages 51 and older should take to prevent bone loss and lower the chance of harmful fractures. The Bone Health and Osteoporosis Foundation, for example, concurs with the IOM on calcium, but boosts the recommendation for vitamin D to 800–1,000 international units (IU) daily for men and women in this age group. Some vitamin D researchers recommend even higher levels, particularly for adults diagnosed with osteopenia or osteoporosis, though the safe upper limit for vitamin D is 4,000 IU.

In a 2018 review by the U.S. Preventive Services Task Force, experts analyzed clinical trials of supplementation with vitamin D and calcium in healthy adults over 50. The review found insufficient evidence to determine the balance of risks and benefits of taking these supplements to prevent fractures at the amounts generally recommended for otherwise healthy older adults. This doesn't necessarily mean that calcium and vitamin D supplements are ineffective for healthy adults—it only states that the current evidence is insufficient to prove it, based on a strict weighing of the best data available. Furthermore, clinical trials clearly demonstrate a benefit of supplemental calcium and vitamin D among adults with established osteoporosis, who have a higher risk of fracture.

Why be so picky? Why not just take more than enough vitamin D, as a sort of insurance policy? One reason not to overconsume any vitamin or mineral supplement is that it requires time, effort, and money. Ideally, you want to take what you need and no more.

More important, taking too much of certain nutrients can be harmful (see "Can calcium supplements harm your heart?" below). The IOM report set the safe upper limit for calcium intake at 2,000 milligrams (mg) daily. Excessive vitamin D could also be harmful, although you would need to take quite a large amount of it to get into the danger zone. According to the IOM report, the daily safe upper limit for vitamin D is 4,000 IU.

So what should you do? Here's a reasonable approach: Get as much calcium and vitamin D as you can from food (up to the recommended amounts), and make up any shortfall with a daily supplement. You can also get your vitamin D for the day from 10 minutes or so of sun exposure without sunscreen, at

Can calcium supplements harm your heart?

About a decade ago, some research suggested that people who consume the highest levels of calcium from supplements are more likely to have heart disease and heart attacks or to die from heart problems. However, many subsequent research studies did not confirm this association. An expert panel convened by the Bone Health and Osteoporosis Foundation and the American Society for Preventive Cardiology found no clear link between calcium intake, including calcium supplements, and heart disease risk, based on moderate-quality evidence. That means, unless new and better scientific findings emerge, calcium intake from food and supplements up to the upper tolerable limit of 2,000 mg per day for people over 50 (or 2,500 mg per day for those ages 50 and younger) are unlikely to pose a risk to heart health.

least during the summer (see "Sources of vitamin D," page 28). If you are in your 50s or older, aim for 1,200 mg of calcium and 800 to 1,000 IU of vitamin D per day. And ask your doctor for advice if you are confused about mixed messages from the media.

Calcium in your diet

Most experts would agree that getting calcium from a balanced, nutritious diet is preferable to taking supplements. Foods typically don't have the side effects of calcium supplements, like constipation. Moreover,

Table 2: Calcium-containing foods

FOOD	CALCIUM (MG)
Cheeses (1 ounce, unless otherwise noted)	
ricotta, part-skim (½ cup)	337
Swiss	252
mozzarella, part-skim	222
provolone	214
cheddar	201
mozzarella, regular	143
feta	140
cottage cheese, 1% fat (½ cup)	69
Frozen desserts (½ cup)	
ice cream, light, vanilla	122
ice cream, regular, vanilla	85
Milk (1 cup)	
skim	325
1% fat	310
2% fat	309
whole	306
Milk substitutes (1 cup)	
almond milk, fortified	482
soy milk, fortified	300
rice milk, fortified	283
Yogurt (8 ounces)	
vanilla, low-fat	419
plain, whole-milk	296
Nuts and seeds (1 ounce, unless otherwise noted)	
almonds	76
sesame paste, tahini (1 tablespoon)	64
hazelnuts	32
sunflower seeds, raw kernels	32
peanuts, oil-roasted	28
Grain (1 cup)	
amaranth, cooked	115
quinoa, cooked	31

FOOD	CALCIUM (MG)
Legume products (½ cup, unless otherwise noted)	
tofu, firm, made with calcium sulfate (¼ block)	553
soybeans, green, boiled	130
navy beans, boiled	63
baked beans, canned, with franks	62
Vegetables (1 cup, boiled, unless otherwise noted)	
kale	177
broccoli	62
parsnips	58
brussels sprouts	56
artichoke (1 medium)	50
summer squash	49
cabbage	36
Fruits and fruit juices (1 cup, fresh, unless otherwise noted)	
orange juice, calcium-fortified	349
figs (4 small)	56
blackberries	42
orange juice, regular	25
kiwi (1 medium)	24
strawberries (whole)	23
apricots, dried (10 halves)	20
Fish (3 ounces, unless otherwise noted)	
sardines, Atlantic, canned in oil, including bones	324
salmon, pink, canned, including bones	183
bass, freshwater	88
anchovies, canned in oil, drained (5)	46
ocean perch, Atlantic	29
trout, rainbow	26
Shellfish (3 ounces)	
lobster, steamed	82
crab, blue, canned	77
shrimp	60
crab, Alaska king	50

Source: U.S. Department of Agriculture, FoodData Central.

calcium-rich fruits, vegetables, nuts, and legumes contain many other healthy nutrients that can help protect you against heart disease.

Luckily, if you want to increase your dietary calcium intake, you have plenty of foods from which to choose. Table 2, page 25, shows how much calcium is found in a number of common grocery items. You may be surprised at how much calcium you can add to your diet by making a few simple substitutions, such as choosing ricotta instead of cottage cheese, or opting for fortified orange juice over regular. Packaged oatmeals, breads, and cereals are fortified with calcium, with the amount varying quite a bit by brand.

Many osteoporosis experts favor dairy products as a source of calcium. Dairy provides the most concentrated sources. Moreover, milk is often fortified with vitamin D. And the many reduced-fat milks, yogurts, and cheeses available today make it possible to cut fat and calories without skimping on calcium. In fact, these products often contain slightly more calcium than their high-fat counterparts do.

Are there any risks to boosting your calcium intake? You may have heard that some studies have linked higher calcium intakes to prostate cancer. However, the evidence for this is weak. A more well-established concern is the connection between supplemental calcium intake and kidney stones. If you have a history of kidney stones, ask your doctor if it's safe to take calcium supplements.

Many people avoid dairy for other reasons—most commonly, lactose intolerance. If you're lactose intolerant and have trouble digesting dairy products, try taking the enzyme lactase—either as a pill or in liquid form—to help you enjoy these foods without worrying about unpleasant side effects. You can even find milk that is lactose-free (but still has the same amount of calcium as regular milk) and other dairy products that already have lactase added. Or switch to soy milk or almond milk, many of which also have calcium added.

Dairy products are not the only food sources of calcium. The plant kingdom is also calcium-rich, with spinach, dried beans, and nuts among the best sources. The amount of calcium found in laboratory analyses can't always be accepted at face value, however. For example, the oxalic acid in spinach and rhubarb binds the calcium in these plants so that the human digestive system can't readily absorb it. Insoluble fiber, such as that in wheat bran, also reduces calcium absorption. (Soluble fiber, such as the pectin in fruit, does not.) Unfortunately, there is no simple way to predict how much of the calcium content of a fruit or vegetable will actually get into your system.

Fortified foods are another option. Just one cup of fortified orange juice can supply 350 mg of calcium. Three-quarters of a cup of some fortified cereals, with half a cup of skim milk, offers 150 mg—15% of the daily amount most adults need to consume every day.

Food nutrition labels, while helpful, often require translating. Information on the Nutrition Facts label helps you determine how much calcium is in the preparation, not how much you need. Packaged foods list calcium content as a percentage of the Daily Value, which is 1,000 mg for most adults, based on a 2,000-calorie-per-day diet. However, if you are a woman age 51 or older, the RDA is 1,200 mg of calcium a day—not 1,000—so the percentages on the label will not be precisely accurate for you.

To determine how many milligrams of calcium per serving a product contains, multiply the percentage figure in the Nutrition Facts box by 10. For example, if a product's food label says that one serving provides 20% of your daily calcium requirement, that means it contains 200 mg of calcium. (This works for calcium because the Daily Value is 1,000 mg, but it will not work for other nutrients listed on the label.) Also know what constitutes a serving. It may be not be the same as the amount you normally eat.

Calcium supplements

While experts recommend getting your nutrients from foods instead of supplements, most people find that it isn't practical or possible to get all the calcium they need from their diet alone. If you're among them, a supplement can shore up your calcium intake.

The dizzying array of calcium supplements on the market includes pills, chewable tablets, flavored chews, and liquids (see Table 3, page 27). When purchasing, it's wise to consider cost, convenience, and how well your body tolerates the supplement. Most calcium supplements also contain vitamin D_3.

The calcium in supplements is in the form of a compound, usually calcium carbonate or citrate. Some products—typically found at health food stores—contain calcium phosphate, calcium lactate, or calcium gluconate instead.

Calcium carbonate. This tends to be the best value, because it contains the highest amount of elemental calcium—the actual amount of calcium in each supplement. The compound calcium carbonate contains 40% calcium by weight, versus 21% for calcium citrate. Because calcium carbonate requires stomach acid for absorption, it's best to take this product with food. Most people tolerate calcium carbonate well. However, some people complain of mild constipation or feeling bloated. Some well-known calcium carbonate products include Caltrate, Viactiv Calcium Chews, Os-Cal, and Tums.

Calcium citrate. These products are absorbed more easily than calcium carbonate. They can be taken on an empty stomach and are more readily absorbed by people who are taking an acid-reducing heartburn medication. But because calcium citrate is only 21% calcium, you may need to take more tablets to get your daily requirement. Calcium citrate products include Citracal, GNC Calcimate Plus 800, and Kirkland Calcium Citrate.

In weighing your options, check the labels. In most cases, the label on the back of the container will say how many milligrams of calcium each serving or pill contains. If not, look for the serving size and the "% Daily Value" for calcium. Then multiply the percentage by 10 to find out how much elemental calcium the product contains. For example, if the label says a serving of the product contains 40% of the Daily Value, it has 400 mg of elemental calcium.

Note that while products that yield a high amount of calcium may seem to be the best bet at first blush, they may not serve you best. Because your body is able

Table 3: Common calcium supplements

PRODUCT	TYPE OF CALCIUM COMPOUND	AMOUNT OF ELEMENTAL (ACTUAL) CALCIUM PER DOSE	DOSE SIZE*	COST PER DOSE**
Caltrate 600 + D3 Calcium Supplement	Calcium carbonate	600 mg	1 tablet	7–16 cents
Caltrate 600 + D3 Plus Minerals Chewables	Calcium carbonate	600 mg	1 chewable tablet	9–17 cents
Citracal Calcium + D3 Petites	Calcium citrate	400 mg	2 caplets	11–13 cents
Citracal Plus D3 and Magnesium	Calcium citrate	500 mg	2 tablets	16–25 cents
GNC Calcimate Plus 800 with Magnesium and Vitamin D3	Calcium citrate malate	800 mg	4 tablets	32–33 cents
GNC Calcium 1,000 with Magnesium and Vitamin D3	Calcium carbonate	1,000 mg	3 tablets	24–25 cents
GNC Calcium Citrate 1,000	Calcium citrate	1,000 mg	4 tablets	29–31 cents
Os-Cal Calcium with Vitamin D3	Calcium carbonate	500 mg	1 tablet	6–10 cents
Os-Cal Ultra 600 Plus Caplets	Calcium carbonate	600 mg	1 caplet	8–10 cents
Tums (regular strength)	Calcium carbonate	400 mg	2 chewable tablets	9–11 cents
Tums Extra Strength Antacid / Calcium Supplement	Calcium carbonate	600 mg	2 chewable tablets	13–15 cents
Tums Ultra	Calcium carbonate	800 mg	2 chewable tablets	10–13 cents
Viactiv Calcium Chews Plus Vitamin D and K Supplement for Women	Calcium carbonate	500 mg	1 flavored chew	10–12 cents

**Number of pills you must take to get the amount of elemental calcium listed here.*
***Based on a sampling of retailers and sizes. Prices may vary.*

to absorb only 500 mg to 600 mg of calcium at a time, more of the mineral may go to waste.

Here are some other things to keep in mind when choosing and taking a calcium supplement:

- Generally, calcium-only supplement pills are better choices than multivitamins, which tend to have smaller amounts of elemental calcium.
- Calcium is better absorbed when taken with food, which also decreases the risk for kidney stones associated with calcium supplementation.
- Vitamin D helps your body absorb calcium, but it's not necessary to take them at the same time. However, if you aren't getting enough vitamin D from sunlight, your diet, or your multivitamin, you may want to choose a calcium supplement that also contains vitamin D.
- Consider using a supplement that combines calcium and magnesium, since magnesium can help you absorb the calcium and may help counteract the constipating effect of calcium some people experience.
- Avoid calcium products made from unrefined oyster shell, bone meal, or dolomite—unless they say "purified" or have the United States Pharmacopeia (USP) symbol on them—since these products can contain higher levels of lead, a toxic metal.
- Also avoid coral calcium, a supplement made from Japanese coral. Coral calcium supplements have also been found to contain lead, along with mercury and cadmium (a metal that has been linked to cancer as well as kidney and lung diseases). And although manufacturers have asserted that the body absorbs more calcium from coral calcium than from other supplements, no evidence exists to back up this claim.
- Because calcium, iron, and zinc supplements interfere with each other, take them several hours apart.
- Delay consuming calcium (from either food or supplements) for two to four hours after taking tetracycline antibiotics, since calcium can decrease the drugs' effectiveness. People with hypothyroidism (underactive thyroid) should avoid calcium four hours before and after taking levothyroxine, because calcium can interfere with this drug's absorption. Ask your doctor or pharmacist whether a supplement will interact with any other prescription medications you're taking.
- Don't exceed the daily dose recommended by the supplement manufacturer, since doing so increases the risk for side effects.

A warning on strontium

Don't take strontium supplements for bone health. A prescription drug called strontium ranelate (Osseor, Protelos) is used to treat osteoporosis in Europe. But it has been linked to an increased risk for heart problems, and it is not FDA-approved for use in the United States. The over-the-counter supplements available here are strontium citrate or strontium chloride. Neither one has been proved safe or effective, and the use of strontium supplements may lead to unreliable bone density tests.

Sources of vitamin D

Vitamin D is called "the sunshine vitamin," and for good reason. Your skin cells use sunlight to produce a precursor chemical that the liver and kidneys then convert into active vitamin D. Some people make all the vitamin D they need by going outside for a few minutes a day with bare arms and legs. (Don't wear sunscreen during this short time, except on your face to avoid the photoaging effects of the sun.) Keep your exposure time short—just 10 minutes or so a day—to guard against skin cancer. And if you're out longer than that, do cover up or apply sunscreen.

However, sunlight alone may not generate adequate amounts of vitamin D for most Americans during much of the year. For example, if you live farther north than 40° latitude (the latitude of Denver, Indianapolis, and Philadelphia), the winter sunlight isn't strong enough to produce significant amounts of vitamin D. Sunscreen, glass, and clothing also interfere with your ability to produce the vitamin. People with dark skin produce less vitamin D than those with fair skin. And no matter who you are, as you age, your skin can't produce vitamin D as readily, your intestines have more difficulty absorbing this vitamin from food or supplements, and your kidneys convert less vitamin D to the active form that your body uses.

For this reason, many vitamin D experts would

Table 4: Recommended daily vitamin D intake in adults

The Bone Health and Osteoporosis Foundation recommends a daily intake of vitamin D that's higher than the RDA. (For the RDAs, see Table 1, page 24.)

SEX/AGE	VITAMIN D
Men and women under 50	400–800 IU
Men and women 50 and older	800–1,000 IU

Source: Bone Health and Osteoporosis Foundation.

recommend that you not only follow the Bone Health and Osteoporosis Foundation's recommendations for vitamin D intake (see Table 4, above), but also have your blood tested for vitamin D, especially if you have osteopenia or osteoporosis, to gauge how much is actually getting into your system.

Vitamin D in your diet

If your natural vitamin D supply is lacking, you can try to make up for the shortfall with your diet. This is difficult, because only a few foods—such as eggs, saltwater fish, and liver—naturally contain vitamin D (see Table 5, below right). Mushrooms have vitamin D if they've been exposed to sunlight, but don't assume they contain it unless the packaging says so.

In the United States, milk is fortified with vitamin D; an 8-ounce glass should have about 100 IU or more. In addition, the FDA has approved the use of a particular type of yeast that can quadruple vitamin D levels in bread. A slice of bread should have roughly 160 IU or more, if it's labeled "rich in" or "an excellent source of" vitamin D.

Vitamin D supplements

Given the difficulties of obtaining adequate vitamin D from the sun and food, most people find they need to supplement. Vitamin D_3, or cholecalciferol, is generally considered the form most easily absorbed by the body.

Most multivitamins contain 400 IU of vitamin D, though some may contain more. Check the amount carefully. If it's low, you may need to add an additional source, such as a vitamin D capsule or a teaspoon of cod-liver oil (which contains 450 IU of vitamin D). Just don't overdo it. It's not wise to double up on your multivitamins either, since that will deliver unhealthy amounts of other nutrients, such as vitamin A, which can actually lower bone density (see "Dietary cautions," page 30).

In supplements that contain only vitamin D, the amount in each pill or tablet can be quite high—1,000 IU, 2,000 IU, or much more. Although the maximum daily safe intake of vitamin D is 4,000 IU, you don't need that much, and you will not necessarily benefit from excess. You can also find supplement products that combine calcium and vitamin D in the same dose, making it more convenient to reach your daily minimums for bone health.

Vitamin K

You know that calcium and vitamin D are good for your bones, but did you know that the vitamin K in leafy greens may also help keep them strong? Vitamin K helps your body produce osteocalcin, a protein that is instrumental in bone formation. It also blocks substances that break down bone and helps regulate calcium excretion from the body in urine. How strongly

Table 5: Foods containing vitamin D

FOOD	SERVING	VITAMIN D (IU)
Sockeye salmon, cooked	3 ounces	447
Soy milk, fortified	1 cup	120*
Yogurt, fortified	6 ounces	115*
Almond milk, fortified	1 cup	107*
Orange juice, fortified	1 cup	100*
Whole milk, fortified	1 cup	96*
Tuna fish, canned in water, drained	3 ounces	68
Sardines, canned in oil	2 sardines	46
Beef liver, cooked	3 ounces	42
Egg	1 large	41
Ready-to-eat breakfast cereal, fortified	1 cup (without milk)	40*

** Levels of vitamin D in fortified products may vary; check the label.*
Source: U.S. Department of Agriculture, FoodData Central.

this might translate into improved bone strength is a matter of debate, as trials have shown mixed results.

Vitamin K in your diet

Current dietary recommendations call for 120 micrograms (mcg) of vitamin K per day for men and 90 mcg for women. Most diets easily supply this amount, so there's no need for supplements. For example, a cup of fresh raw spinach will deliver more than enough to meet the daily requirement, and so will a generous portion of cooked broccoli or brussels sprouts. Other good sources of vitamin K include collard greens and other green leafy vegetables. If you don't like those vegetables, try scallions, asparagus, or cabbage. Certain herbs, such as basil, sage, and thyme, also have significant amounts of vitamin K.

Some people have to be careful with vitamin K, however. If you take anticoagulants like warfarin (Coumadin), it's particularly important to keep your vitamin K intake consistent from day to day, since this vitamin influences blood clotting. If you take an anticoagulant, ask your doctor if you should avoid foods rich in vitamin K and supplements that contain it. (Note that vitamin K is in some calcium preparations.)

Dietary cautions

Researchers have identified some components of a typical American diet that may compromise bone health. In some cases, the science is not absolutely clear on how much of these foods is harmful. However, the evidence is strong enough that anyone who is at risk of low bone density—postmenopausal women, for example—might consider how much of these substances they take in. After all, it's easier to preserve bone than to rebuild it once it's lost.

Salt. In addition to raising blood pressure, too much sodium in your diet can increase the amount of calcium your body excretes in urine. Following nutritional guidelines by consuming no more than 2,300 mg daily can help counteract this effect. So can eating foods high in potassium, such as bananas, avocados, and leafy green vegetables.

Alcohol. Heavy drinking seems to sap calcium from bones and interfere with production of vitamin D (see "Excess alcohol consumption," page 13).

Caffeine. Caffeine has various biochemical effects that could, hypothetically, compromise bone health. For example, taking in high levels of caffeine increases calcium excretion by the kidneys, and could slow bone formation. But the evidence that caffeine is bad for bones is mixed, so more study is needed. In the meantime, you may want to forgo that fourth cup of coffee.

Vitamin A. Studies have found a link between high vitamin A intake and increased fracture risk. The safest way to get vitamin A is in its precursor form, beta carotene, which the body then converts into vitamin A as needed. Because your body doesn't necessarily convert all of the beta carotene you consume, it's hard to get too much vitamin A from beta carotene. Beta carotene—found in such healthy foods as carrots, sweet potatoes, and spinach—has not been linked to fractures. If you take a multivitamin, check to make sure that a significant part of its vitamin A comes from beta carotene rather than vitamin A itself. Also, avoid taking high-potency vitamin A supplements. The current RDA of vitamin A is 700 mcg for women and 900 mcg for men. (Note that vitamin A is also in a number of medications used to treat acne and psoriasis.)

Soda. A number of observational studies have linked consumption of soft drinks (particularly colas) with osteoporosis, lower bone density, or greater risk for fractures. But the ultimate cause behind these effects remains unclear. Either the phosphate or the caffeine (or both) in these drinks may impede absorption of calcium. Or maybe people who drink lots of sodas just drink less milk. Until research brings more clarity, people with osteoporosis might consider avoiding heavy consumption of soft drinks. (Popular caffeine-free seltzers, which do not contain phosphate, do not appear to be an issue for bone health.)

Protecting your bones: Exercise

Exercise plays a dual role in bone health. First, it can help preserve the bone strength you still have. Second, it improves coordination and balance, which can prevent falls that could lead to fractures. A study by Harvard researchers found that women who walked more than four hours per week had a significantly lower risk of hip fractures than women who walked less than an hour per week. While exercise, like diet, can't rebuild bone to the extent that medicine can, it might contribute to small increases in bone density.

However, bone health is not the only reason to work out. Regular exercise also lessens your chances of getting heart disease, lowers your blood pressure, helps prevent diabetes, reduces the risks for colon cancer and breast cancer, improves your mood, and adds years to your life. If these health benefits came in a pill, people would be clamoring for a prescription.

A well-rounded strength training program that works out all of the major muscle groups (arms, shoulders, legs, hips, back, chest, abdominals) can benefit practically all the bones in your body.

How weight-bearing exercise benefits bones

Weight-bearing exercise can significantly increase bone density during childhood and adolescence. The effects aren't as dramatic in adulthood. But it's helpful then, too, because movement that compels you to work against gravity stresses your bones enough that your body responds by reinforcing the bones that are under duress.

What exactly is weight-bearing exercise? It's not the same thing as strength training (also known as weight training or resistance training), where you challenge your muscles with weights or resistance bands, although some strength training exercises are also weight-bearing. Weight-bearing exercise refers to any form of activity that requires your body to support its own weight against gravity. That could include vigorous sports, such as tennis or running, which are options if you're trying to prevent osteoporosis.

If you already have osteoporosis, start with a gentler form of weight-bearing exercise, such as walking or tai chi. Avoid exercises that involve bending or twisting the spine. Talk with your doctor about the types of activity that are right for you. (Note that while swimming and bicycling are excellent ways to keep fit, they aren't weight-bearing, so they won't necessarily improve your bone mass or density but will help your muscles and endurance.)

There are a couple of rules of thumb to be aware of if you're aiming for maximum effect on bone and you are able to work out vigorously. Generally, higher-impact activities have a more pronounced effect on bone than lower-impact exercises. Velocity is also a factor; jogging or fast-paced aerobics will do more to strengthen bone than more leisurely movement.

Keep in mind that only those bones that bear the load of the exercise will benefit. For example, walking or running protects only the bones in your lower body, including the hip. That's why you also need a well-rounded strength training program that works out all the major muscle groups. This can benefit prac-

tically all of your bones, including the very sites most likely to sustain fractures from osteoporosis—bones of the hip, spine, and arms. (See the Special Section, "Strength training and balance exercises for bone health," page 36, for workout ideas, particularly if you're new to strength training.)

To keep your bones healthy, aim to get at least 30 minutes of general weight-bearing exercise a day—reserving strength training with weights or resistance bands for just two to three days a week, with at least 48 hours between sessions. It's important to exercise regularly; infrequent activity won't strengthen your bones.

In addition to helping maintain bone density, exercise helps protect against fractures in other ways. Strength training increases muscle mass, which in turn enhances muscle control, strength, balance, and coordination. Good balance and coordination can mean the difference between falling—and suffering a fracture—and staying on your feet. Strong evidence shows that regular physical activity can reduce falls by nearly a third in older adults at higher risk of falling.

Strength training

Compared with other types of exercise, strength training can deliver the most benefits to the maximum number of bones. A strength training program typically employs equipment such as weight machines, free weights, and resistance bands or tubing. Not only does strength training protect against bone loss, but it also builds muscle and improves your body's ratio of lean muscle mass to fat. As a result, it deserves an important place in your exercise routine.

The Physical Activity Guidelines for Americans, issued by the U.S. Department of Health and Human Services, recommend strengthening exercises for all major muscle groups (legs, hips, back, chest, abdominals, shoulders, and arms) two or three times per week. Generally each exercise is done multiple times—for example, you might do eight biceps curls in a row. These are known as repetitions, or "reps." Groups of eight to 12 reps make up one set. Though performing one set is effective, doing two to three sets may be better. Give yourself a minute or more to rest between sets.

No matter what routine you use, the following tips for safe and effective strength training will help you get the most from your workouts.

Warm up and cool down for five to 10 minutes. Warming up before your workout brings nutrient-rich, oxygenated blood to your muscles while raising your heart rate and breathing. Cooling down after your session slows breathing and heart rate to help prevent a sudden drop in blood pressure that can cause dizziness. End with stretches.

Focus on form, not weight. Align your body correctly and move smoothly through each exercise. Poor form can prompt injuries and delay gains. Many experts suggest starting with no weight, or very light weight, when learning a strength training routine. Concentrate on slow, smooth lifts and equally controlled descents while isolating a muscle group—that is, contracting and releasing the specific muscles that you want to strengthen.

Maintain a steady tempo. Tempo—for example, counting to three while lowering a dumbbell, then counting to three while raising it again—helps you

Can yoga help prevent osteoporosis?

Could regularly performing a series of poses help preserve bone strength? A study in the journal *Topics in Geriatric Rehabilitation* suggests that a daily yoga practice can do just that. The study included 741 people, who were on average 68 years old when they started. Most had lower-than-normal bone density. After participating in a daily 12-minute yoga routine over a period of two years, the participants underwent DEXA scans, which revealed gains in bone density in their spines, hips, and thighbones.

While promising, the study applies to people with osteopenia, not osteoporosis. Many of the yoga poses used in this study involved spinal twists, side bends, and back extensions that help with prevention, because they place stress on the muscles around the spine. However, people who already have osteoporosis should avoid exercises that involve forward flexion of the spine or deep twists. This could further damage vertebrae weakened by osteoporosis.

Yoga does have undeniable health benefits, including improved balance and coordination that could prevent falls. If you are interested in trying yoga, check with your doctor or a physical therapist first, to make sure it's appropriate for you and to be sure you know what poses are safe for your level of bone strength.

stay in control. Too much speed and momentum can undercut strength gains and undermine form.

Breathe. Blood pressure rises if you hold your breath while performing strength exercises. Exhale as you lift, push, or pull a weight; inhale as you release.

Keep challenging your muscles. Begin with a weight that you can comfortably lift for eight to 12 repetitions. The right weight differs depending on the exercise. Choose a weight that tires the targeted muscle or muscles by the last two reps while still allowing you to maintain good form. If you can't do the last two reps, choose a lighter weight. When the complete set feels too easy, challenge your muscles again by adding weight (roughly 1 to 2 pounds for arms, 2 to 5 pounds for legs) or adding another set of reps to your workout (up to three sets). If you add weight, remember that you should be able to do all the reps with good form and the targeted muscles should feel tired by the last two reps. Most sporting goods stores sell dumbbells with adjustable weights, as well as wrist and ankle bands that fasten with Velcro and have pockets for weights. Look for sets that allow you to add weights in half- to 1-pound increments.

Practice regularly. Working all the major muscles of your body two or three times a week is ideal. You can choose to do one full-body strength workout two or three times a week, or you may opt to break your strength workout into upper- and lower-body components. In that case, be sure that you perform each of these components two or three times a week.

Give your muscles time off. Strenuous exercise, such as a challenging strength training session, causes microscopic tears in muscle fibers. Muscles grow stronger as the tears knit up. Allow 48 hours between sessions for muscles to recover. So, if you do a full-body strength workout on Monday, wait until at least Wednesday to repeat it. Or you can do what's called split strength sessions: you might do upper-body exercises on Monday, lower-body exercises on Tuesday, upper-body exercises on Wednesday, lower-body exercises on Thursday, etc.

Keep it up. As with other forms of exercise, consistency is the key to getting good results from strength training. As little as four to six months of regular weight training can help you maintain—or even improve—bone density. But people who stick with it for a year or more achieve the greatest gains. If you stop working out, any increases in bone and muscle strength will disappear within five years.

Beyond bones: Putting together a total fitness routine for overall health

Exercise delivers powerful, wide-ranging health benefits, but to reap its full rewards, you must perform several different types of activities on a regular basis. Here are the various elements of a well-rounded program.

Aerobic. Each week, accumulate at least 150 minutes of moderate activity or 75 minutes of vigorous activity, or an equivalent mix of the two. Sustain activities for at least 10 minutes at a time.

Strength. Do strength exercises for all major muscle groups (legs, hips, back, chest, abdominals, shoulders, arms) at least twice weekly. Repeat each exercise eight to 12 times per set, aiming for two to three sets. Rest muscles for at least 48 hours between strength training sessions.

Balance. For older adults at risk for falls and others concerned about osteoporosis, include activities that enhance balance, such as tai chi or yoga, at least twice a week.

Flexibility. Do stretching or other flexibility exercises, preferably on days when you do aerobic or strength activities, or at least twice a week. Hold stretches for 10 to 30 seconds, repeating each stretch three to four times.

Safety first

A well-designed fitness program can improve your strength and mobility, but a poorly executed plan could actually lead to a fracture. With weak bones, it's imperative that you exercise safely. Here are some general guidelines to help anyone with osteopenia or osteoporosis make a smooth transition to a new workout routine:

Run the exercises by your doctor first to make sure they're safe for you to try. Getting your doctor's okay is especially important if you've fractured a bone in the past or if you have an additional condition, such as diabetes or heart disease.

Book a few sessions with a physical therapist. If possible, ask your doctor to write a referral for phys-

ical therapy. A therapist can go through each exercise with you, step by step, and check your form, so you can get the most benefit from each exercise with the least risk of injury. Keep going back to the therapist until you're completely comfortable doing the exercises on your own.

Pace yourself. No effective exercise program was created in a day. Start slowly, giving yourself time to adjust to the pace and movements. Gradually increase both the length and intensity of your workouts as you feel ready.

Avoid risky movements. Don't lift heavy weights. And stay away from any exercise that could end in a fall—for example, an unbalanced yoga pose.

Avoid spinal bends and twists. Be careful not to make any quick reaching or twisting motions, especially if you've broken a bone. In general, avoid any exercises like toe touches and abdominal crunches that produce a forward curvature in the spine, since this could cause a fracture in vertebrae that have been weakened by bone loss. Forgo exercises and gym machines that put added stress on the spine, such as leg press machines, leg raises performed lying down, and squats done with weight bars resting on the shoulders. Golf swings produce twists that could be harmful. Rolling backward on the spine (rocking) also place stress on the spine and may result in spinal fractures.

Don't overdo it. Expect to be sore during your early exercise sessions, but if you're in pain, ease back. You might be moving too quickly or pushing yourself too hard.

Tai chi improves balance, muscle strength, and flexibility

Evidence is growing that tai chi, a mind-body practice that originated in China as a martial art, has value in treating or preventing many health problems. Of interest to people with osteoporosis, tai chi helps improve balance, and there is preliminary evidence that it may help maintain bone strength, too. In a study that combined findings from 20 randomized controlled trials, practicing tai chi reduced losses of bone density in the lower spine, the top of the thighbone, and the hip. Study participants, ages 45 to 79, engaged in tai chi on a wide variety of schedules: 12 weeks to 12 months, two to seven times a week, for sessions lasting 45 to 90 minutes.

In this low-impact exercise program, you move slowly, without pausing, through a series of positions. Throughout these gentle movements, the muscles are relaxed rather than tensed, the joints are not fully extended, and connective tissues are not stretched. Because you are standing and you shift your body weight from leg to leg, you get the benefit of weight-bearing exercise, which may account for the potential bone-strengthening effect—though the impact is much lower and thus the effect on bone is less than with more vigorous exercise. On the other hand, tai chi is slow and gentle enough to be easily adapted for anyone, from the fittest individuals to people confined to wheelchairs or recovering from surgery. Especially important is that it is safe for people who are elderly, frail, and out of condition—individuals at particularly high risk for falls and broken bones.

In addition to its effects on bones, tai chi improves muscle strength, flexibility, and balance—all of which help you stay fit and avoid falls and fractures. It can also slightly improve aerobic conditioning, if it is done at a fairly rapid pace and is challenging enough. What's more, tai chi doesn't require any special equipment or facilities. Here is more detail on tai chi's benefits:

Muscle strength. Even without the assistance of weights or resistance bands, tai chi can help build muscle strength in the lower and upper extremities as well as the core muscles of the back and abdomen.

Flexibility. Tai chi significantly boosts upper- and lower-body flexibility.

Balance. Not only does tai chi help keep you from losing your balance, but if you do stumble, the muscle strength and flexibility you gain from tai chi can help you recover before a stumble turns into a fall.

Proprioception. Proprioception is the ability to sense the position of one's body in space, and it declines with age. Tai chi helps train this sense, which is a function of sensory neurons in the inner ear and stretch receptors in the muscles and ligaments.

Exercises and other measures to help prevent falls

In essence, the treatment and prevention of osteoporosis is aimed at a single goal: to forestall the fractures that can threaten independence, steal mobility, trigger depression, and result in pain, disability, or even death. You can do that either by fighting bone loss or by preventing the falls that often lead to fractures—or better yet, by doing both. Falling is one of the biggest causes of fractures, particularly among older people. More than 95% of hip fractures result from a spill. Therefore, researchers, doctors, and medical organizations focus quite a bit on this subject.

Two important ways of reducing falls are by improving your balance and enhancing your ability to react quickly to anything that threatens to upset your balance. Various types of exercise can help.

Balance exercises. All people are more susceptible to falls as they age, but women are even more likely than men to fall. You can help reduce the threat of falls by practicing exercises that improve your balance. (For specific examples, see "Balance exercises," page 39.) If you are already doing some strength training, you may find that many of your current exercises are helpful for improving balance as well, because they strengthen muscles that you use to maintain balance. Similarly, tai chi—which uses a long series of slow, flowing motions—can help improve your balance (see "Tai chi improves balance, muscle strength, and flexibility," page 34).

Power training. In addition to balance exercises, power exercises (strength exercises that emphasize speed) can help reduce falls by improving your reaction time if you start to trip or lose your balance. The strength exercises in the Special Section of this report (see page 36) all include variations that emphasize power.

10 more ways to prevent falls

Exercise is not the only thing you should do to prevent falls. Falls can result from a host of factors, some health-related and some environmental, such as failing vision or hearing, dizziness (sometimes caused by medications), bad lighting, wet floors, and obstacles in pathways. Here are some simple changes you can make around the house to minimize your risk of falling:

1. Clear your floors of clutter and any items that could trip you up, including loose wires, cords, and throw rugs.
2. Make sure that stairways, entrances, and walkways are well lit, and install night lights in your bedroom and bathroom.
3. Clean up spills immediately.
4. Wear rubber-soled shoes for better traction. Avoid walking around in socks.
5. Limit your intake of alcohol.
6. Keep items that you use often in easy-to-reach cabinets. Also, consider using reaching and grasping tools to get at difficult-to-reach items.
7. Add grab bars to your tub, and use nonskid mats on bathroom floors.
8. Be careful when pets are nearby. Tripping over a pet, most often a dog or cat, is a common cause of falls.
9. Talk to your doctor about whether any medications you are taking can cause dizziness or impair balance.
10. Have your eyes checked regularly.

Vibrating platforms: Do they help people who are unable to exercise?

A therapy called whole-body vibration is being promoted as a way to prevent bone loss in people who are too frail or too incapacitated to exercise. The idea is that by standing on a vibrating platform, you experience barely perceptible vibrations that cause muscle cells to react as they would to common activities. The tiny contractions are supposed to exert small stresses on bones, resulting in increased bone density and muscle mass.

But the platforms can be expensive, and most studies on vibration therapy have found very small effects or none at all. A review of studies on vibrating platforms for postmenopausal osteoporosis concluded that more research is needed to determine the mechanisms behind this therapy's potential effects on bone. And while the authors say a vibrating platform might provide some benefits when used as an add-on therapy, it is no substitute for standard treatments like bone-building medications and a bone-healthy diet.

SPECIAL SECTION

Strength training and balance exercises for bone health

"What type of exercise program should I follow?" This is one of the most common questions doctors hear from patients who have concerns about bone health. They are aware that exercise can play a role in slowing bone loss, but they don't know what type of exercise is best.

The short answer is any exercise that challenges your bones with weight or resistance. (See "Protecting your bones: Exercise," page 31, for more detail.) A well-rounded strength training program that works all the major muscle groups is most effective. This creates stresses on bones throughout the body, stimulating extra deposits of calcium and nudging bone-forming cells into action. The bones that benefit are those that attach to the muscles that are being worked. For example, the standing calf raise (page 37) benefits your shin bones. The bridge (page 37) is good for the hips and spine. Finally, strength training—particularly if it includes work on power and balance—enhances stability, which can help protect you from falling.

Like most strength training routines, the workout presented here calls for doing each exercise eight to 12 times, or repetitions ("reps"). Those repetitions make up one set. Typically, in a complete workout, you will do two to four sets each of approximately eight to 12 exercises that, combined, exercise all the major muscle groups. This workout does that. Most of these exercises include a "power move"—a variation designed to enhance speed as well as strength. In addition, at the end, we've included two exercises that directly target balance.

Our workout is designed for older adults and people who are new to strength training. Still, it's wise to talk to your doctor before trying these exercises, particularly if you've been diagnosed with osteoporosis.

For the best results, do this workout two or three times a week, allowing at least 48 hours for your muscles to recover between workouts. For the greatest overall health benefits, also try to get 30 minutes of moderate aerobic exercise on most days of the week.

Note: This workout is adapted from another Harvard Special Health Report, *Strength and Power Training for Older Adults: Two complete workouts to start rebuilding your muscles* by Elizabeth Pegg Frates, M.D. (Harvard Medical School, 2019).

Strength training exercises

All you'll need to begin this workout is a sturdy chair with armrests, a small pillow, athletic shoes with nonskid soles, an exercise mat, and appropriate weights. Begin by choosing very light weights for your first few training sessions, so you can concentrate on good form. After that, add enough weight so the maximum number of repetitions you can do is eight to 12. If an exercise starts to feel easy, it's time to increase the weight you are using (within safe limits set by your doctor).

As you perform each of these exercises, remember to breathe out when you are lifting or pushing, since holding your breath will increase your blood pressure. As you release, breathe in. Rest for 30 to 60 seconds between sets.

For further tips on performing these types of exercises, see "Strength training," page 32, and "Safety first," page 33.

Standing calf raise

Exercises the calf muscles

Stand with your feet flat on the floor. Hold on to the back of your chair for balance. Raise yourself up on the balls of your feet, as high as possible. Hold briefly, then lower yourself. Do eight to 12 repetitions. Rest and repeat the set.

▶ **Harder variation:** Once your balance and strength improve, do one-leg calf raises. Tuck one foot behind the other calf before rising on the ball of your foot; do sets for each leg. Or try doing calf raises without holding on to a chair.

▶ **Power move:** Rise up on the balls of your feet quickly. Hold briefly. Lower yourself at a normal pace. Do six to 10 repetitions.

Stair climbing

Exercises the muscles of the buttocks and fronts of the thighs

Walk up and down a flight of at least 10 stairs at a pace that feels comfortable, holding on to the handrail for balance if necessary. Pause at the top only if you need to do so. Rest when you reach the bottom. Repeat four times.

▶ **Power move:** If your balance is good, go up the stairs as briskly as you can and come back down at your normal pace. Repeat twice for a total of three times.

Bridge

Exercises the muscles of the back, backs of the thighs, and buttocks

Lie on your back on a mat with your knees bent and your feet flat on the floor. Put your hands next to your hips with the palms flat on the floor. Keep your back straight as you lift your buttocks as high as you can off the mat, using your hands for balance only. Pause. Lower your buttocks without touching the mat, then lift again. Do eight to 12 repetitions. Rest and repeat the set.

▶ **Power move:** Lift your buttocks quickly. Hold briefly. Lower your buttocks at a normal pace. Do six to 10 repetitions.

Hip extension

Exercises the muscles of the buttocks and backs of the thighs

Wearing a weight on your right ankle, stand 12 inches behind a sturdy chair. Holding on to the back of the chair for balance, bend your trunk forward 45°. Slowly raise your right leg straight out behind you. Lift it as high as possible without bending your knee. Pause. Slowly lower the leg. Aim for eight to 12 repetitions. Repeat with your left leg. This is one complete set. Rest and repeat the set.

▶ **Easier variation:** Do this move without the ankle weight.

▶ **Power move:** Lift your leg quickly. Hold briefly. Lower your leg at a normal pace. Do six to 10 repetitions.

Chair stand

Exercises the muscles of the abdomen, hips, fronts of the thighs, and buttocks

Place a small pillow at the back of your chair and position the chair so that the back of it is resting against a wall. Sit at the front of the chair, knees bent, feet flat on the floor and slightly apart. Lean back on the pillow in a half-reclining position with your arms crossed and your hands on your shoulders. While keeping your back and shoulders straight, raise your upper body forward until you are sitting upright. Stand up slowly, using your hands as little as possible. Slowly sit back down. Do eight to 12 repetitions. Rest and repeat the set.

► **Easier variation:** Use your hands to help you stand up.

► **Power move:** Rise from the chair quickly. Sit down again at a normal pace. Do six to 10 repetitions.

Triceps dip

Exercises the muscles of the chest, shoulders, and backs of the upper arms

Put a chair with armrests up against a wall. Sit in the chair and put your feet together flat on the floor. Lean forward a bit while keeping your shoulders and back straight. Bend your elbows and place your hands on the armrests of the chair, so they are in line with your torso. Pressing downward on your hands, try to lift yourself up a few inches by straightening out your arms. Raise your upper body and thighs, but keep your feet in contact with the floor. Pause. Slowly release until you're sitting back down again. Do eight to 12 repetitions. Rest and repeat the set.

► **Variation:** If you don't have a chair with armrests, sit on a staircase. Put your palms down on the stair above the one you are seated on. Press downward on the heels of your hands, lifting your body a few inches as you straighten your arms. Pause. Slowly release your body until you are sitting back down again. Do eight to 12 repetitions. Rest and repeat the set.

► **Power move:** Lift your body quickly. Hold briefly. Lower yourself at a normal pace. Do six to 10 repetitions.

Overhead press

Exercises the muscles of the shoulders, upper back, and backs of the upper arms

Stand with your feet slightly apart. Hold a dumbbell in each hand at shoulder height, with your elbows bent and the weights by your shoulders. Hold the weights so your palms are facing forward. Slowly press the weights straight up until your arms are fully extended. Pause. Slowly lower the dumbbells to shoulder level. Do eight to 12 repetitions. Rest and repeat the set.

► **Power move:** Lift the weights quickly. Hold briefly. Lower your arms at a normal pace. Do six to 10 repetitions.

Side leg raise

Exercises the muscles of the hips and sides of the thighs

Wearing a weight on your right ankle, stand behind a sturdy chair with your feet together. Hold on to the back of the chair for balance. Slowly raise your right leg straight out to the side until your foot is about eight inches off the floor. Keep your knee straight and foot flexed. Pause. Slowly lower your foot to the floor. Do eight to 12 repetitions. Repeat with the left leg. This is one complete set. Rest and repeat the set.

► **Easier variation:** Do this move without the ankle weight.

► **Power move:** Lift your leg quickly. Hold briefly. Lower your leg at a normal pace. Do six to 10 repetitions.

Double biceps curl

Exercises the muscles at the fronts of the upper arms

Stand or sit holding dumbbells down at your sides with your palms facing inward. Slowly bend both elbows, lifting the weights toward your upper chest. Keep your elbows close to your sides. As you lift, rotate your palms so they face your shoulders. Pause. Slowly lower your arms to the starting position. Do eight to 12 repetitions. Rest and repeat the set.

▶ **Power move:** Lift the weights quickly. Hold briefly. Lower the weights at a normal pace. Do six to 10 repetitions.

Reverse fly

Exercises the muscles of the shoulders and upper back

Sit in a chair holding weights about 12 inches in front of your chest. Your elbows should be up and slightly bent and your palms should be facing each other (as if your arms are wrapped around a large beach ball). Lean forward at a slight angle in the chair, bending from your hips and keeping your back straight. Now, pull the weights apart while trying to bring your shoulder blades as close together as possible. Let the movement pull your elbows back as far as possible. Pause. Return to the starting position. Do eight to 12 repetitions. Rest and repeat the set.

Balance exercises

An osteoporosis workout ideally has two goals—shoring up bones, and improving balance to prevent falls. Many of the previous exercises, including the standing calf raise, hip extension, chair stand, and side leg raise, are also useful for improving balance. But the following exercises are more specifically targeted at making you steadier on your feet.

Thigh raise

Wearing ankle weights, stand with your hands on your hips. Keeping your back straight, raise one knee up until your thigh is parallel to the floor (your foot will be lifted off the floor). Pause. Lower the leg to the starting position. Do eight to 12 repetitions. Repeat with the opposite leg. This is one complete set. Rest and repeat the set. Note: Ankle weights are optional, but if you use them for this exercise, they will provide added resistance and increased muscle strengthening.

▶ **Easier variation:** Stand next to a chair and hold on to the back of it for balance, if necessary. Raise the knee that's farthest away from the chair up to hip height. Pause. Lower the leg. Do eight to 12 repetitions. Rest and repeat the set. Then turn your other side to the chair and repeat with your other leg.

▶ **Power move:** Lift your leg quickly. Hold briefly. Lower your leg at a normal pace. Do six to 10 repetitions.

Heel-to-toe walk (not shown)

Position your heel just in front of the toes of the opposite foot each time you take a step. Heel and toes should actually touch as you walk forward for eight to 12 steps. If necessary, steady yourself by putting one hand on a counter as you walk at first, and then work toward doing this without support. Repeat two to four times.

Protecting your bones: Medication

Nutrition and exercise can do some of the heavy lifting when it comes to maintaining bone strength, but medication also plays a key role, especially for women who have reached menopause. Because medicines can have risks, they aren't recommended for everyone. According to Bone Health and Osteoporosis Foundation guidelines, your doctor is most likely to put you on a bone-strengthening drug if you

- have fractured a hip or vertebra
- have a T-score of –2.5 or less at the femoral neck, total hip, or lumbar spine
- are a postmenopausal woman or a man age 50 or older with a T-score between –1 and –2.5 at the femoral neck, total hip, or lumbar spine, together with a FRAX-estimated 10-year risk of 3% or higher for a hip fracture or 20% or greater for another type of major fracture (spine, forearm, or shoulder).

This chapter describes the types of medications used for osteoporosis. (A summary appears in Table 6, page 42.) Which one is right for you? That depends on your individual health status, fracture risk, and treatment preferences.

No matter which medicine your doctor prescribes, your goal isn't necessarily to stay on it indefinitely. The doctor will likely suggest that you repeat bone density testing a year or two after you start the drug, and then every two years after that. You might also have blood or urine tests for biochemical markers that show how well the drug is working, although not all doctors do this. These assessments will help your doctor determine whether and how much the medicine is helping, and if it's time to stop taking it or shift to another medication.

Bisphosphonates

Since the mid-1990s, when the FDA approved the first bisphosphonate, this class of drugs has become the first choice of doctors for treating or preventing osteoporosis. They are effective when used correctly, and generic versions are relatively inexpensive.

The oral bisphosphonates typically used for osteoporosis are alendronate (Binosto, Fosamax), ibandronate (formerly sold under the brand name Boniva), and risedronate (Actonel, Atelvia). Another drug in this class, zoledronic acid (Reclast), can be taken just once a year via an intravenous infusion that takes about 15 minutes.

Like most of the medications approved for treating osteoporosis, bisphosphonates reduce bone resorption, slowing bone loss and producing modest increases in bone density. They accomplish this by binding to hydroxyapatite and interfering with bone-depleting osteoclasts, giving bone-building osteoblasts an opportunity to catch up. As a result, bisphosphonates lower the risk for hip, wrist, and spinal fractures. They have become an attractive alternative to estrogen therapy, which was once widely used to prevent bone loss but has fallen out of favor because of safety concerns (see "Estrogen-related medications," page 46).

If taken correctly, oral bisphosphonates do not cause side effects in most people. But if they are not

A variety of medications can help protect your bones and even build greater bone density. These drugs target areas of the body where bone turnover is high, such as the hips and spine.

taken correctly, they may be hard to digest and can cause nausea, heartburn, or irritation of the stomach or esophagus (see "How to take oral bisphosphonates properly," below right). Many people find these instructions cumbersome. The inconvenience, coupled with the fact that osteoporosis doesn't have any outward symptoms, causes some people to question whether they need medication at all and to give up treatment. Others continue with therapy but fail to take their medicine properly. Experts hope that the development of more convenient formulations of bisphosphonates will help more people to take their medication as directed.

While bisphosphonates are usually well tolerated, a relatively small number of people taking these drugs develop bone, joint, or muscle pain. If present, these symptoms resolve for most patients after they stop using the medication. Long-term use of bisphosphonates has also been linked to rare instances of unusual thighbone fractures or damage to the jawbone. However, the chances of developing these rare side effects have to be weighed against the much more likely benefits of preventing fractures due to bone loss (see "How safe are bisphosphonates? What you need to know," page 48).

As with any prescription, you should report new or unusual symptoms to your doctor immediately. Work with your physician to decide whether and how to respond to a concerning symptom instead of dismissing it or just deciding to stop taking the medication.

Alendronate

Alendronate is FDA-approved to prevent and treat osteoporosis in postmenopausal women, to treat glucocorticoid-induced osteoporosis, and to treat osteoporosis in men. Alendronate comes as a daily pill in several doses, and in several preparations to be used once a week: a pill (Fosamax), a liquid, or an effervescent tablet that you dissolve in water (Binosto). An additional version combines alendronate and vitamin D (Fosamax Plus D).

Since 1995, when alendronate received its initial FDA approval, studies have consistently shown that it can slow or even halt bone loss, increase bone density, and reduce the risk for spinal and hip fractures. Clinical trials have established that alendronate reduces spine and hip fractures by about 50% over three years of treatment in people at high risk because they have osteoporosis or have already had fractures. It reduces risk of spinal fractures to a similar degree even in people who haven't already had fractures.

Alendronate is also effective for prevention of osteoporosis. Studies have found that the drug increases bone mass in the spine and hip as effectively as hormone therapy, but without the same risks. It travels preferentially to spots where bone turnover is high, such as the hips and spine.

Studies suggest that alendronate is safe and effective for five years in most patients and can be used for up to 10 years by patients who have high fracture risk. And it yields results quickly. A follow-up of the Fracture Intervention Trial, an important study conducted in the 1990s, found that alendronate was able to reduce the risk for spinal fractures within a year.

How to take oral bisphosphonates properly

Since oral bisphosphonate drugs—alendronate, risedronate, and ibandronate—can be difficult to digest, people taking these medications must follow instructions carefully to avoid unpleasant side effects such as heartburn, nausea, or difficulty swallowing.

First thing in the morning, take the pill on an empty stomach with a large glass of water (at least 8 ounces). (For liquid versions, check the written instructions to make sure you drink enough water with each dose.) Then remain upright for at least 30 minutes (60 minutes for once-a-month ibandronate). During this time, avoid eating, drinking, or taking another medication. It's important to take the pill versions with water, rather than coffee or orange juice, both of which can interfere with your body's ability to absorb and use the drug. Most people tolerate these medications well when they take them as instructed.

While bisphosphonates are quite effective in preventing fractures, the oral forms may not be the best choice for people who have recurrent heartburn, acid reflux, esophagitis, stomach ulcers, or difficulty swallowing. People who have Barrett's esophagus should not take oral bisphosphonates. If you have any of these conditions, ask your doctor about taking injectable or intravenous osteoporosis medications instead.

Furthermore, the benefits seem to linger even after people stop using the medication, according to a follow-up to the Fracture Intervention Trial. After five years of alendronate treatment, women who then stopped taking the drug had some bone loss, but their fracture risk did not increase for the most part. The researchers concluded that many women may be able to stop using alendronate after five years without putting themselves in greater jeopardy of breaking a bone. However, they noted that women at high risk of fractures may benefit from continuing the treatment beyond that five-year time frame.

Ibandronate

Ibandronate is approved to prevent and treat postmenopausal osteoporosis. It is available in a monthly

Table 6: Medications approved for osteoporosis

GENERIC NAME (BRAND NAME)	HOW IT'S TAKEN	APPROVED USES	BENEFITS	SIDE EFFECTS / COMMENTS
Bisphosphonates				
alendronate (Binosto, Fosamax, Fosamax Plus D)	Daily tablet or weekly liquid or tablet	Prevention and treatment of osteoporosis in postmenopausal women. Treatment of osteoporosis in men. Treatment of glucocorticoid-induced osteoporosis.	Increases bone density at the spine and hip. Reduces the risk for spine and hip fractures.	Difficult to digest. May cause nausea, heartburn, or irritation of the esophagus if not taken properly. Generally well tolerated.
ibandronate	Monthly tablet or quarterly intravenous infusion	Prevention and treatment of osteoporosis in postmenopausal women.	Increases bone density. Reduces the risk for spine fractures.	The oral versions can be difficult to digest; may cause ulcers, nausea, heartburn, or irritation of the esophagus if not taken properly. The intravenous infusion may cause fever and flu-like symptoms.
risedronate (Actonel, Atelvia)	Daily, weekly, or monthly tablet	Prevention and treatment of osteoporosis in postmenopausal women. Treatment of osteoporosis in men. Treatment of glucocorticoid-induced osteoporosis.	Increases bone density at the spine and hip. Reduces the risk for spine and hip fractures.	Difficult to digest. May cause nausea, heartburn, or irritation of the esophagus if not taken properly. Generally well tolerated.
zoledronic acid (Reclast)	15-minute infusion, given annually for treatment or every two years for prevention	Prevention and treatment of osteoporosis in postmenopausal women. Treatment of osteoporosis in men. Treatment of glucocorticoid-induced osteoporosis.	Increases bone density. Reduces the risk for spine and hip fractures.	May cause fever, flu-like symptoms, muscle and joint aches, and headache for several days after the infusion. Kidney function may be temporarily affected.
Monoclonal antibodies				
denosumab (Prolia)	Subcutaneous injection every six months	Treatment of osteoporosis in postmenopausal women and in men. Treatment of glucocorticoid-induced osteoporosis. Treatment to increase bone mass in people at high fracture risk who are taking aromatase inhibitors (women) or androgen deprivation therapy (men).	Increases bone density. Reduces the risk for spine and hip fractures.	An increase in infections, especially of the skin, has been reported. Patients who stop taking denosumab should transition to another drug to prevent rapid loss of bone density and an increase in risk for spinal fractures.
romosozumab (Evenity)	A pair of subcutaneous injections every month	Treatment of osteoporosis in postmenopausal women.	Increases production of new bone and bone density. Reduces the risk of spine and hip fractures.	Should not be taken by women who have had a heart attack or stroke in the past year. Because effects appear to wane and long-term safety data are lacking, should not be taken for more than one year.

tablet or as an intravenous infusion every three months. Like the other bisphosphonates, ibandronate increases bone density and reduces the risk of fractures of the spine in women with postmenopausal osteoporosis. Unlike other osteoporosis medications, it has not been shown to prevent fractures in the hip or other sites besides the spine.

The quarterly intravenous infusion of ibandronate is currently FDA-approved only for treating postmenopausal osteoporosis. (The pill is approved for both treatment and prevention.) Because the injected version bypasses the gastrointestinal tract, it doesn't cause the heartburn and esophageal problems often seen with the oral bisphosphonates. However, the drug has been linked to short-lived flu-like symptoms in a small percentage of people.

Table 6 *continued*

GENERIC NAME (BRAND NAME)	HOW IT'S TAKEN	APPROVED USES	BENEFITS	SIDE EFFECTS / COMMENTS
Parathyroid hormone–related				
abaloparatide (Tymlos)—synthetic parathyroid hormone–related protein, or hPTHrP	Daily injection	Treatment of osteoporosis in men and postmenopausal women at high risk for fractures.	Increases the rate of bone formation. Reduces the risk for fractures in the spine and elsewhere.	Use of abaloparatide limited to about two years. Not for anyone at risk for bone cancer. Taking an antiresorptive drug after stopping helps preserve bone mass.
teriparatide (Bonsity, Forteo)—synthetic parathyroid hormone, or PTH	Daily injection	Treatment of osteoporosis in men and postmenopausal women. Treatment of glucocorticoid-induced osteoporosis.	May double the rate of bone formation. Reduces the risk for fractures in the spine and elsewhere.	May cause leg cramps, nausea, and dizziness. Not for anyone at risk for bone cancer. Taking an antiresorptive drug after stopping helps preserve bone mass.
Estrogen-related				
estrogen (Activella, Climara, FemHRT, Ogen, Premarin, Premphase, Prempro, Vivelle-Dot, others)	Tablets and patches	Prevention of osteoporosis in women.	Increases bone density. Reduces the risk for fractures. Helps alleviate the symptoms of menopause, including hot flashes, vaginal dryness, and insomnia. Improves cholesterol levels.	Estrogen alone increases the risk for stroke and uterine cancer. Prempro, an estrogen-plus-progestin formula, increases the risk for heart attack, stroke, blood clots, and breast cancer; other estrogen-plus-progestin formulas have not been studied as extensively, so it is unclear if they carry the same risks.
raloxifene (Evista)	Daily tablet	Prevention and treatment of osteoporosis in postmenopausal women.	Increases bone density, although not as much as the bisphosphonates. Reduces the risk for spine fractures. Reduces the risk for invasive breast cancer. Lowers LDL (bad) cholesterol.	Side effects are uncommon, but can include hot flashes, leg cramps, and blood clots.
bazedoxefine and estrogen (Duavee)—SERM and hormone combination	Daily tablet	Prevention of osteoporosis in postmenopausal women and treatment of menopause symptoms.	Increases bone density in the spine and hip. Reduces hot flashes.	Side effects are uncommon, but can include muscle spasms, throat pain, and abdominal pain. The estrogen component of Duavee increases the risk for heart attack, stroke, blood clots, breast cancer, and uterine cancer.
Calcitonin				
calcitonin	Daily injection or nasal spray	Treatment of postmenopausal osteoporosis.	Increases bone density, but not as dramatically as any of the other approved medications. Reduces the risk for spine fractures.	The injected form can cause flushing of the face and hands, nausea, increased urination, and rash. The nasal spray can cause a runny nose. Consider only if other options are not available.

Risedronate

Like its cousin alendronate, risedronate (Actonel, Atelvia) is approved to prevent and treat osteoporosis in postmenopausal women; to prevent and treat glucocorticoid-related osteoporosis in men and women; and to treat osteoporosis in men. Also like alendronate, risedronate has been shown to impede bone loss, increase bone density, and reduce the risk for fractures in the hip and spine.

A handful of studies, including one randomized clinical trial, have directly compared alendronate and risedronate. In the trial, once-weekly alendronate raised bone density in postmenopausal women more than risedronate after a year of treatment, although the rate of fractures in both groups was the same. Like alendronate, risedronate works relatively quickly and helps to reduce bone loss in men as well as women.

The generic drug is available as a daily, weekly, or monthly tablet. Brand-name Actonel comes in both daily and weekly formulations. An additional weekly version of risedronate goes by the brand name Atelvia.

Zoledronic acid

Zoledronic acid (Reclast) is a bisphosphonate given as an infusion once a year to treat osteoporosis, or every other year to prevent bone loss. When zoledronic acid earned FDA approval in 2007, many women wondered whether they should switch to it. Not only was this new drug more convenient for patients, but it also showed an impressive ability to reduce fractures and boost bone density.

In a key clinical trial, postmenopausal women with osteoporosis received either an annual infusion of zoledronic acid or a placebo. Over three years, the treatment reduced the risk of spinal fractures by 70% and hip fractures by 41%. Women on the drug also tested higher for bone density at the hip and spine.

While these results are promising, some women taking zoledronic acid experience a variety of transient side effects, including fever, muscle and joint aches, and headaches, for several days after the infusion. These side effects often can be treated (or even prevented) by taking acetaminophen (Tylenol) or ibuprofen (Advil, Motrin); some people find that it helps to take the first dose before the infusion.

Monoclonal antibodies

Human antibodies, manufactured with genetically engineered cells, can block the formation and activity of osteoclasts (the cells that break down bone), boost the activity of osteoblasts (the cells that build it up), or both. When injected into a patient, the antibodies attach to special proteins, called receptors, on the surfaces of cells, triggering these reactions. Two monoclonal antibody drugs have been approved to treat osteoporosis.

Denosumab

Denosumab (Prolia) is a human monoclonal antibody that acts to reduce the formation and action of osteoclasts. It falls into a class of drugs known as RANKL inhibitors, which block a substance known as a RANK ligand that attaches to a receptor on the surface of osteoclasts and their precursors. Denosumab is taken every six months as a subcutaneous (under the skin) injection, like a flu shot.

The FDA has approved denosumab for osteoporosis in postmenopausal women and men at high risk of fracture; glucocorticoid-induced osteoporosis; and bone loss in women taking aromatase inhibitors for breast cancer or in men receiving hormone-blocking therapy for prostate cancer. It is not approved for prevention of osteoporosis.

In clinical trials, denosumab reduced bone resorption, increased bone density, and reduced fractures in both men and women (including a 68% lower risk for spinal fracture) over three years. It represents another option for people who have trouble taking oral bisphosphonates or other osteoporosis drugs.

Denosumab can cause hypocalcemia, or low blood calcium levels, particularly among individuals with kidney problems. This can be dangerous, so blood levels of calcium may need to be monitored. It's important to get adequate amounts of calcium and vitamin D while on denosumab. The drug is also associated with unusual fractures in the thighbone and damage to bone in the jaw, although these side effects are very rare.

Although denosumab is very effective at preventing fractures while you are receiving it, stopping treatment may be tricky. Multiple spinal fractures have been reported in some people in the months after

they stopped taking denosumab. This can occur as the bone resorption formerly blocked by the drug kicks back in, leading to rapid bone loss. In 2017, the FDA added a warning on the label about this risk. According to the label, doctors should consider prescribing another antiresorptive drug to reduce the risk of spinal fractures in patients who stop denosumab. Following denosumab with a bisphosphonate, such as alendronate, has been shown to preserve bone mass.

Romosozumab

Another antibody-based treatment, romosozumab (Evenity), received FDA approval in 2019 for treating osteoporosis in postmenopausal women who have a very high risk of fracture or who can't take other drugs for this purpose. (As of 2023 it was not yet approved for treating men.) Romosozumab is given once a month by injection—two shots, one after the other.

Romosozumab is classified as a sclerostin inhibitor. It binds to and blocks the effects of sclerostin, a protein that normally signals osteoblasts to decrease production of new bone. By blocking this chemical message, romosozumab tricks the body into producing more bone. It also inhibits bone resorption. It can increase bone mass dramatically. In a clinical trial involving 7,180 postmenopausal women with osteoporosis, 12 months of treatment with romosozumab lowered the risk of spinal fracture by 73% compared with a placebo. It also prevented fractures at other sites, including the hip.

Treatment should continue no more than 12 months, because the drug's bone-building effect wanes over time. After a year, you should switch to another drug to maintain or further improve bone density. In a clinical trial of 4,093 postmenopausal women at high risk for fracture, half received romosozumab for 12 months, followed by alendronate for another 12 months. A separate group took only alendronate for the whole 24 months. At the end of two years, treatment with romosozumab followed by alendronate reduced the risk of fracture significantly more than alendronate alone.

The most common side effects of romosozumab are joint pains and headaches. In one clinical trial, women on romosozumab had a slightly higher rate of nonfatal heart attacks and strokes as well as death from cardiovascular causes. A second, larger trial did not show this risk. However, the FDA still requires a warning on the drug's label, saying that romosozumab should not be taken by women who have had a heart attack or stroke in the past year, and that anyone who has a stroke or heart attack while on the drug should stop taking it. If you are concerned about heart trouble, talk to your doctor.

Romosozumab has also been linked with very rare instances of unusual fractures in the thighbone and damage to bone in the jaw—even rarer than the low rates seen with denosumab or bisphosphonates.

Parathyroid hormone–related medications

Bone loss can also be treated with a class of drugs that mimic or alter the activity of parathyroid hormone (PTH) and its role in bone metabolism (see "Other key players," page 4). PTH works in several ways to increase the amount of calcium in circulation. It promotes calcium absorption in the intestines and slows its excretion by the kidneys. While too much of the hormone (hyperparathyroidism) accelerates bone loss, low doses of PTH taken intermittently can increase bone mass and strengthen bone.

Teriparatide

The FDA has approved teriparatide (Bonsity, Forteo), a synthetic version of PTH, for the treatment—but not prevention—of osteoporosis in both men and postmenopausal women and for treating glucocorticoid-induced osteoporosis.

Research suggests that teriparatide improves bone quality, as measured by the trabecular bone score (see "Tests of bone quality," page 19). It is recommended for people at high risk for a fracture. This includes people who have already suffered a nontraumatic fracture of the spine, hip, or another major bone. ("Nontraumatic" in this case means that the break is caused by a fall from a standing height or less, as opposed to happening in an automobile accident or a fall from a ladder, porch, chair, or some other elevated place.) Teriparatide is also prescribed for people with multiple risk factors for

fractures (such as a family history of osteoporosis, poor calcium intake, and a T-score of less than –2.5).

Teriparatide helps build new bone by increasing the activity and number of bone-building osteoblasts. It can lead to large increases in bone mass, particularly at the spine (see Figure 9, below). Teriparatide appears to reduce spinal fractures by about 65% and fractures at other sites by about 50%.

Teriparatide is available only as a once-a-day injection. Although it tends to become less effective after about two years, longer treatment may be helpful in people at relatively high risk of fracture. After a person stops taking teriparatide, bone loss can be rapid. It's common to follow with a bisphosphonate or other antiresorptive agent to preserve or augment any gains in bone density.

Side effects can include nausea, dizziness, and leg cramps. Studies in rats have found an increased risk of bone cancer, but only with much higher doses than are used in people. Teriparatide has been around for almost two decades, and to date, no studies have shown that it increases bone cancer risk in humans.

Abaloparatide

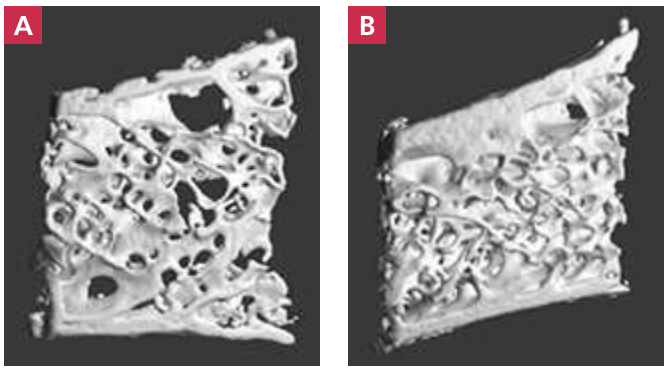
Abaloparatide (Tymlos) is FDA-approved for treatment of osteoporosis in postmenopausal women and men at high risk of fracture. It's a synthetic version of human parathyroid hormone–related protein (hPTHrP), which works in a way similar to teriparatide to build new bone.

In clinical trials, abaloparatide increased bone density scores for the lumbar spine, total hip, and femoral neck, and it reduced fracture risk—including a reduction of 86% in new spinal fractures after 18 months of therapy. Research also suggests that it improves bone quality, as measured by the trabecular bone score (see "Tests of bone quality," page 19).

Like teriparatide, abaloparatide is available only as a daily subcutaneous injection. Side effects are usually mild but can include leg cramps, dizziness, nausea, headache, palpitations, and excess calcium in the blood.

Use of abaloparatide should be limited to two years. Taking an antiresorptive drug after stopping abaloparatide can help maintain or increase bone mineral density.

Figure 9: Parathyroid hormone and bone



These pictures from a scanning electron microscope show bone biopsies taken from a 64-year-old woman, before (A) and after (B) parathyroid hormone treatment. Improvements can be seen in interior structure (microarchitecture) and outer (cortical) thickness.

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Estrogen-related medications

Naturally occurring estrogen has beneficial effects on bone metabolism, and estrogen or medications that mimic its effects can be used to prevent or treat osteoporosis. In the case of the class of drugs known as selective estrogen receptor modulators (SERMs), treatment for osteoporosis can also help prevent breast cancer.

Estrogen formulations

Many women use hormones in the years leading up to and following menopause to ease hot flashes, insomnia, and vaginal dryness. At one time, hormone therapy was also widely prescribed to reduce menopausal bone loss. A clinical trial found that oral estrogen reduced hip fractures by 34% and other osteoporotic fractures by 23%.

The use of estrogen to prevent osteoporosis has fallen sharply, however, since the Women's Health Initiative—the only large, long-term randomized controlled trial of hormone therapy. The WHI was halted in 2002, after women taking a combination of oral estrogen and progestin were found to be at higher risk of breast cancer, heart disease, stroke, and blood clots in the veins and lungs.

Critics of the WHI say the risks were exaggerated. They point out that only one hormone preparation was used in each arm of the trial and that other formulas might not carry the same risks or benefits. Others note that the women who suffered the most health problems in the study began taking the hormones in their 60s and 70s, long after the start of menopause.

Nevertheless, the North American Menopause Society and other authorities advise caution, recommending that women limit their use of hormones to the smallest effective dose for the shortest period of time—and only if they have no contraindications (reasons not to take it), such as a history of breast cancer. Since by definition, taking hormones to preserve bone involves long-term use of the therapy, most doctors no longer prescribe hormone therapy just for preventing osteoporosis—especially since other drugs can effectively prevent and treat the problem.

That said, if you do choose systemic hormone therapy, which delivers estrogen to your bloodstream via a patch or pill, you can expect a boost to bone health, since hormone therapy both increases bone strength and reduces the risk of fracture in the spine and hip—at least during the time you're using it. Unfortunately—as is the case for most osteoporosis medications—as soon as you stop taking hormones, the bone benefit begins to fade. Within a year or two, bone density can drop back to where you started.

Raloxifene

Raloxifene (Evista) is in a drug class called selective estrogen receptor modulators (SERMs), also known as estrogen agonist/antagonists. These "designer estrogens" reproduce the hormone's beneficial effects on bone metabolism without some of its harmful consequences.

In the body, SERMs attach to receptors on the surfaces of cells, in the way a key would fit into a lock. When a natural estrogen molecule binds to such a receptor, it stimulates a response in the cell—and not always a desirable one. For example, estrogen can stimulate the growth of certain kinds of breast, uterine, and ovarian cancers.

But SERMs don't fit the cell receptors quite as perfectly as natural estrogen molecules. That turns out to be good. It means that SERMs have different effects in different parts of the body, depending on the type of tissue—presumably because the estrogen receptors on these tissues are somewhat different. As a result, SERMs can help build bone but without promoting cancer.

Raloxifene was the first SERM approved for preventing and treating osteoporosis. Raloxifene is also approved to reduce the risk of invasive breast cancer in women who have postmenopausal osteoporosis or who have a high risk of breast cancer. It's taken in a single tablet every day, with or without food.

In clinical trials, raloxifene reduced spinal fractures by 30% to 40% in women who'd already had such a fracture and by 55% in those who had not. It did not prevent other types of fractures. But the research has also found reason for caution. While raloxifene did not increase the overall risk of stroke, women using the drug who did have a stroke were more likely to die from it. Also, the risk of blood clots in the legs was higher. On the plus side, the women were much less likely to develop invasive breast cancer.

In its treatment guidelines, the American College of Physicians concluded that the evidence for raloxifene is insufficient to recommend it over bisphosphonates or denosumab. However, the Endocrine Society's guidelines do recommend raloxifene for reducing fracture risk in women if they have a low risk of blood clots, they can't take bisphosphonates or denosumab, or if they have had breast cancer or are at high risk for it.

Bazedoxifene-plus-estrogen combination drug

The FDA has approved a combination drug, called Duavee, consisting of bazedoxifene (a SERM) and estrogen. Duavee is used to reduce symptoms of menopause, such as hot flashes, and also to prevent, but not treat, osteoporosis in postmenopausal women who haven't had surgery to remove the uterus. Duavee has not been shown to reduce the risk of fractures.

In Europe and Japan, bazedoxifene is available as a single-ingredient drug. Clinical trials show that it reduces bone loss and spinal fractures by percentages similar to those observed in studies of raloxifene. The potential risks are similar as well. Unlike raloxifene, however, bazedoxifene has not been shown to reduce the risk of breast cancer.

How safe are bisphosphonates? What you need to know

Media reports have fueled concerns about a connection between bisphosphonates and some troubling side effects, leading many women to ask their doctors whether they should continue taking these medications. To help you sort facts from unfounded fears, here are the answers to common questions that patients ask about bisphosphonates.

Do bisphosphonates put you at higher risk for breaking your thighbone?

In the vast majority of people, bisphosphonate drugs strengthen bones rather than weakening them. This bone strengthening is the primary means by which bisphosphonates reduce spine and hip fractures. However, in very rare cases, some women on long-term treatment with bisphosphonates have experienced unusual fractures of the thighbone (atypical femoral fractures). The concern about atypical femoral fractures dates back to around 2007 or 2008, when reports first emerged of unusual thighbone fractures in women who had been taking alendronate for about five years. The fractures occurred in a location a little lower down on the femur than usual, and without the blunt-force trauma of an accident or fall. Since then, there have been other reports of so-called nontraumatic thighbone fractures in patients who had been on long-term bisphosphonate therapy. (A fracture is considered nontraumatic if it occurs from a fall from standing height or less.) Sometimes patients notice achiness or pain in their thighs or hips before this fracture occurs.

The cause of atypical femoral fractures remains unclear. Some researchers speculate that it has to do with the way bisphosphonates suppress the breakdown (resorption) of old bone. In the short term, slowing bone resorption increases bone density because new bone formation continues. But over time, it may impair new bone formation and reduce the bone's ability to repair microscopic cracks in the bone from normal wear and tear.

It's also important to note that some atypical femoral fractures occur in people who have never taken a bisphosphonate, which suggests that there are other factors involved. More than two decades of research on alendronate and similar drugs has overwhelmingly concluded that bisphosphonates are highly effective at improving bone density and reducing standard fractures. The likelihood of preventing painful and disabling fractures needs to be weighed against the very small chance of a bisphosphonate-induced atypical fracture.

Can bisphosphonates damage your jawbone?

You may have heard about a connection between bisphosphonates and damage to bone tissue (osteonecrosis) in the jaw. Symptoms include pain, swelling, or infection of the gums or jaw; gums that aren't healing; loose teeth; and numbness in the jaw. This is another rare side effect seen in a small number of patients taking bisphosphonates over the long term. However, roughly 95% of cases on record have occurred in patients receiving intravenous bisphosphonates to treat very high blood calcium levels and bone damage associated with certain cancers. The dosages of these versions of the medications—pamidronate (Aredia) and zoledronic acid (Zometa)—are 10 times higher than are used for the treatment of osteoporosis. This side effect is much less common among patients who are taking the lower doses of bisphosphonates used for osteoporosis treatment, although risk is higher for patients who are undergoing tooth extractions or implants.

Although the risk is real, it is very small. According to one estimate, for every 10,000 to 100,000 people who take a bisphosphonate for a year to treat bone loss, one may develop osteonecrosis in the jaw. Still, as a general precaution, you may want to have a dental exam and complete any necessary extractions or implants before you start taking a bisphosphonate. If you are already taking a bisphosphonate, tell your dentist.

Women with a uterus who take estrogen alone for menopause symptoms face an increased risk of uterine cancer. Most often, such women take estrogen combined with a synthetic form of the hormone progesterone to offset this risk. The bazedoxifene in Duavee plays a similar role, discouraging excess cell growth in the uterus.

Calcitonin

If you are unable to take other osteoporosis medications, calcitonin is a last resort. It is not commonly used in this country, in part because of its side effects, but also because it is not as effective as other drugs.

Calcitonin is a hormone approved only for the treatment, not the prevention, of osteoporosis. It's produced by the thyroid gland, but its function in the body is not well understood. Salmon is the most common source of calcitonin used in medications. Taken as either an injection or a nasal spray, it inhibits bone resorption by osteoclasts.

Although calcitonin has been tested in a large number of clinical trials and has been used to treat women with bone loss for many years, it doesn't build

Should you consider taking a "drug holiday" from bisphosphonates?

This is a very common question among patients. A drug holiday means taking a break from a medication, temporarily or permanently, to reduce the overall risk of long-term side effects. Most people who are taking extended bisphosphonate treatment will likely be advised to take a drug holiday at some point, although there is only limited research on the subject. Yet based on the available evidence, experts have offered some guidance for postmenopausal women with osteoporosis.

In the first study to suggest that some women can eventually stop taking a bisphosphonate, participants who had taken alendronate for at least five years were randomly assigned to continue the drug or switch to a placebo for five more years. Those who discontinued the drug showed a gradual decline in bone density, but 10 years later their bone density was still higher than it was before treatment started. Their risk for spinal fractures causing pain or other symptoms increased slightly, but the rate of hip fracture—a far more serious injury—was the same in the two groups.

A follow-up study investigated the long-term safety and effectiveness of zoledronic acid (Reclast) in postmenopausal women with osteoporosis. It found that women who stuck with six yearly injections had fewer spinal fractures than those who switched to a placebo after three years.

After taking into consideration the combined results of these and other studies, a task force of the American Society for Bone and Mineral Research in 2016 recommended that doctors re-evaluate their patients after five years on oral bisphosphonates, or three years on intravenous bisphosphonates.

For some women—including those who have a high fracture risk score, a low hip T-score, or a past fracture—it may be worth staying on the drug for longer (up to 10 years for oral bisphosphonates, and six years for intravenous bisphosphonates). Women who aren't at such high risk may be able to take a two- or three-year holiday after three to five years of treatment, without suffering significant bone degeneration.

Whatever you do, don't simply stop taking the drug without first talking to your doctor. Bisphosphonates stay in bone for years. But if you do decide to stop the medication, be sure to have your bone density tested after a year or two. If it has declined significantly, you can always resume therapy, although when to do so is unclear and awaits further study.

Can you safely take bisphosphonates after fracture surgery?

Bisphosphonates strengthen bones and reduce the risk of fractures. In years past, some experts raised concerns that these drugs might interfere with bone remodeling and delay recovery after surgery to repair fractured bone. However, research has since established that bisphosphonates do not impair the healing process. In fact, the ability of these drugs to reduce bone resorption (and thus increase overall bone density) should lower the rate of fractures following surgery and potentially speed recovery.

What are the most important takeaways for patients?

Since bisphosphonates first came on the market in 1995, there's been a decrease in hip fractures. That reduction is likely the result of a combination of factors—not only the use of bisphosphonates and other osteoporosis drugs, but also earlier diagnosis and treatment and increasing emphasis on nutrition and exercise for slowing bone loss. However, bisphosphonates play an important role, and millions of people have benefited from them. If anything, not enough people who need these drugs are taking them. Over all, the drugs are extremely safe. Major side effects are rare if they are taken properly, for the shortest time necessary to achieve the beneficial effect and with collaboration between the patient and physician.

bone as robustly as other medications. Women who take it usually see a slowing of bone loss or just a slight increase in bone mass. It reduces the risk for spinal fractures by about 30% but hasn't been shown to lessen the risk for other kinds of fractures. An FDA review found minimal benefit for treating osteoporosis, and recommends that it be used only in cases where other osteoporosis medications are not an option.

People who take calcitonin by injection generally experience more side effects than do those who use the nasal spray version. Many of these side effects are minor, including flushing in the face and hands, dizziness, nausea, rash, and increased urination. The spray formulation can cause nasal symptoms, including a runny nose and irritation. However, a few studies found slightly higher cancer risks in people taking calcitonin. The data were not specific enough to single out particular types of cancer.

Calcitonin has been taken off the market in Canada and Europe because of safety concerns. It is still used, though infrequently, in the United States. If you're considering this treatment, weigh its side effects carefully when deciding. It should be used only if you are unable to use other available options.

Coping with fractures

Breaking a bone can be painful and disruptive to your life. Recovery can take months, and a break can threaten your ability to perform simple everyday tasks such as carrying groceries, making your own meals, or cleaning. But there is a lot you can do to recover from a fracture and prevent future breaks. The first step may be as simple as reaching out for help. Physical therapists, occupational therapists, and support groups can assist you. This chapter offers additional suggestions for getting back on track.

Meanwhile, getting enough calcium and vitamin D, performing weight-bearing and strengthening exercises regularly, taking steps to prevent falls, and taking an osteoporosis medication can help guard your bones against future fractures.

Living with spinal fractures

Spinal fractures can be very painful, and they often take two to four months to heal. Obtaining effective pain relief can support your overall recovery. The most common way to treat pain after a fracture is with over-the-counter medications such as aspirin, acetaminophen (Tylenol), ibuprofen (Advil, Motrin), or naproxen (Aleve, Naprosyn). Sometimes doctors prescribe stronger medications for pain, such as narcotics, for a limited period. But be careful, as these medications may cause drowsiness, confusion, and a drop in blood pressure—all of which increase your chances of falling. In addition, narcotic pain medications can lead to dependence and addiction, even if taken for a relatively short term.

Another staple of treatment is bed rest to allow the bone to heal, although it should be short-term because prolonged inactivity can lead to further bone loss. Your doctor may also recommend that you use ice or heat packs to ease pain. Massage, acupuncture, biofeedback, and the use of a lumbar corset or back brace may also help for certain fractures.

If these interventions do not help (or don't help enough), there are two surgical procedures—vertebroplasty and kyphoplasty (see page 51)—that are available for treating spinal fractures in certain circumstances. They are intended to stabilize compressed vertebrae and, in turn, relieve pain and improve daily functioning. However, the evidence regarding whether these procedures are effective is mixed, and they are only potentially helpful in reducing pain if the fracture is treated promptly. However you ultimately treat the pain, you will also probably find it useful to make some lifestyle adjustments. You may want to enlist your physical therapist's help in selecting a cane or walker, if you need one. He or she can assess your needs and help you choose the one that best suits your purpose (see "Easing the strain with a cane," page 52).

Exercise regularly, too. Talk with your orthopedist or the physician overseeing your care about what exercises are safe for you at each stage of recovery. Ultimately, your routine should include weight-bearing and strengthening exercises, which can build bone, and balance and flexibility exercises, which can make future falls less likely.

You may find that you also need to make a few practical changes around your house to help you continue your normal daily activities and remain self-sufficient. An occupational therapist can give you expert advice. For example, if you can't reach the top shelves of cabinets any longer, he or she can suggest a number of solutions, from tools to help you grasp objects to ways of reorganizing your kitchen. An assistive device called a dressing stick can help people with limited mobility to put on and remove clothing without bending too much.

Finding clothing that fits correctly may also become a concern as your body changes. If you've had fractures in several vertebrae, you may notice that you become hunched over and your ribcage has moved closer to your hip bones. As a result, many women find that their

Vertebroplasty and kyphoplasty

When the usual strategies of pain relievers and bed rest don't help with pain from vertebral compression fractures, people look for other solutions. Two procedures—vertebroplasty and kyphoplasty—involve injecting surgical cement into a damaged vertebra.

Vertebroplasty is an outpatient procedure that takes less than an hour. After you are mildly sedated, the physician inserts a needle into the affected vertebra, using a continuous x-ray viewing scanner called a fluoroscope. Then bone cement is injected into the compressed vertebra, filling the holes and crevices. The cement hardens in about 15 to 20 minutes, stabilizing the vertebra to prevent further collapse and, hopefully, alleviating pain.

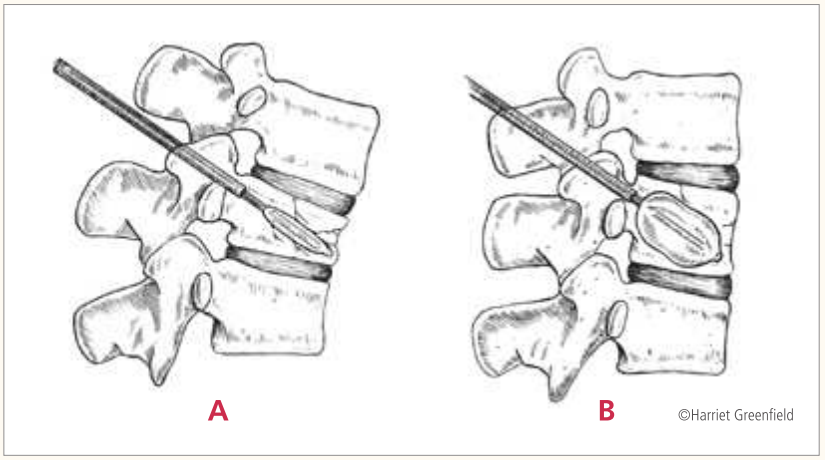
Kyphoplasty (see Figure 10, at right) is a refinement of vertebroplasty. Like vertebroplasty, kyphoplasty takes less than an hour, although it may require an overnight hospital stay. The physician inserts a small tube-like instrument into the affected vertebra. At the tip of the tube is a small balloon. This is inflated to create a cavity inside the bone, which is filled with surgical cement. Besides stabilizing the vertebra and relieving pain, this procedure can potentially restore some height to the collapsed vertebra.

Do they work?

The scientific evidence for the benefit of these procedures is mixed and controversial. The American Society for Bone and Mineral Research convened a task force to review the evidence. In 2019, the task force reported that it found little to no conclusive evidence that either procedure improves pain, physical functioning, and quality of life. However, a 2023 study of vertebroplasty for pain suggests that there may be some benefit. Complications can include bleeding, infection, nerve damage, and cement leakage. Some people have developed new fractures in vertebrae above and below the one treated.

It's also important to know that the appropriate timing of these procedures is unclear. Some data suggest that vertebroplasty and kyphoplasty are not likely to work if you wait more than 12 weeks for the fracture to heal on its own, but the 2023 trial suggests that vertebroplasty may be useful even in people with pain lasting more than 12 weeks. Given the uncertainties, it's important to find a physician who is experienced with the procedure and is willing to engage in a full and frank conversation about the benefits and risks.

Figure 10: Repairing a compressed vertebra with kyphoplasty



Kyphoplasty treats the pain associated with vertebral compression fractures and may also restore some of the height of the treated vertebra. First, a tube is inserted into the vertebra (**A**). Then a balloon at the end is inflated and deflated, leaving a hollow in the bone (**B**). Finally, surgical cement is injected into the cavity, shoring up the endplates of the vertebra.

garments are too tight at the waist, while a larger size is too baggy in other places. Some women solve this problem by buying maternity clothes. The elastic panels in slacks and skirts are roomy in the front without giving too much in the back, and the loose-fitting tops are well suited for accommodating spinal changes.

Low-heeled, comfortable shoes that provide good arch support are also essential. There are many styles of walking shoes that fill the bill. If you have difficulty finding shoes that fit properly, you may want to have orthotic devices—supportive insoles that affect the distribution of weight—fitted by a podiatrist.

Living with a hip fracture

After a hip fracture, proper rehabilitation can make the difference between returning to active life and requiring long-term care. If the hip fracture doesn't heal properly, you may become limited in your ability to walk and function in an independent manner. Both

physical and occupational therapy can be very helpful.

Physical therapists can teach you exercises to strengthen your hips, improve your coordination and balance, and increase your flexibility. A home visit with a physical therapist may help you transition from a hospital or rehab facility to a suitable at-home exercise program that can get you up and moving again and help condition your body to reduce the risk of falling. The therapist can also teach you safety measures that will reduce the chance of injuries and improve your day-to-day functioning.

You should also schedule a home visit with an occupational therapist for guidance on how to eliminate potential hazards in your home—such as electrical cords and loose rugs in pathways, poor lighting, or a lack of handrails or grab bars.

Talk to your doctor about other factors that can lead to falls, such as alcohol consumption or the use of certain medications.

You might also consider signing up for a medical alert system, which allows you to get help quickly if you are injured in a fall. There are many options, and the costs vary. An occupational therapist can help you figure out if you would benefit from this service, make recommendations, and even help you set it up.

Support groups

Osteoporosis doesn't affect only your bones. It can leave you feeling depressed, isolated, anxious, or afraid. You may worry about breaking another bone or losing your independence. Or perhaps you're overwhelmed by pain or upset by changes in your appearance. Maybe you are discouraged because you are no longer able to perform certain activities.

A support group may help you cope with these feelings and move ahead with your recovery. Talk to your doctor about finding a program, or check with your insurer, local hospital, or the Bone Health and Osteoporosis Foundation (see "Resources," page 53), which sponsors an online support community of more than 80,000 members.

Easing the strain with a cane

For something so low-tech and simple in design, a cane performs complex functions. You hold the cane in the hand opposite the side that needs support, about four inches to the side of your stronger leg. This redistributes weight to improve stability, helps reduce demand on muscles that may be weak, and takes the load off weight-bearing structures such as the hip, knee, and spine.

A cane can help you maintain mobility and ward off further disability if you have one or more fractures, as well as assist in recovery after surgery. So don't let self-consciousness stop you from using a cane if your doctor recommends that you try one.

A physical therapist or other clinician can help you select a cane, check that it's the proper height, and show you how to use it. He or she may also suggest certain muscle-strengthening exercises before you start walking with your cane.

Canes are available at medical supply stores and pharmacies, through specialty catalogs, and from online retailers. They generally come in standard, offset, and multiple-legged versions. Government or private insurance usually covers the cost of a basic cane if you have a written prescription from your doctor.

Standard canes. These are low-tech, lightweight, and generally inexpensive. They usually come with a curved or T-shaped handle and a rubber-capped tip at the bottom. Many people find that a T-shaped handle is more comfortable than a curved one. A standard model is good for people who need help with balance but don't need the cane to bear a lot of weight.

Offset canes. The upper shaft of an offset cane bends outward, and the handle grip is usually flat—often a good choice for people whose hands are weak or who need a cane that bears more weight than the standard type.

Multiple-leg canes. Multiple legs offer considerable support and allow the cane to stand on its own when not in use. One drawback to using such a cane is that for maximum support, you must plant all the legs solidly on the ground. Doing so takes time and can slow the pace of walking.

Standard cane | Offset cane | Multiple-leg canes

Resources

Organizations

American Academy of Orthopaedic Surgeons
https://orthoinfo.aaos.org

This medical association offers information on osteoporosis for laypeople. The website features fact sheets on such topics as keeping your bones healthy, recognizing the warning signs of osteoporosis, and preventing hip fractures.

Bone Health and Osteoporosis Foundation
www.bonehealthandosteoporosis.org

This nonprofit organization supports research on osteoporosis and develops educational programs and materials. Membership benefits include a quarterly newsletter, *The Osteoporosis Report*. The foundation also hosts a large, national online support group.

National Center for Injury Prevention and Control
www.cdc.gov/injury

This arm of the Centers for Disease Control and Prevention supports fall-prevention programs, and its website includes fall-prevention fact sheets and tips and an online fall-prevention tool kit for seniors, at www.cdc.gov/falls.

National Institute of Arthritis and Musculoskeletal and Skin Diseases
www.niams.nih.gov

This branch of the National Institutes of Health supports medical research on musculoskeletal diseases. Its website includes information on how to manage osteoporosis. (From the main page, go to "Health Topics," then "Muscle and Bone Diseases.")

Publications from Harvard Medical School

The following reports from Harvard Medical School elaborate on topics in this report. To order, go to www.health.harvard.edu/special-health-reports or call 877-649-9457 (toll-free).

Better Balance: Simple exercises to improve stability and prevent falls

If you have osteoporosis, it's important to avoid falls. This Harvard Special Health Report helps you improve your balance, with safe exercises that also improve flexibility, sharpen reflexes, increase muscle strength and speed, and firm up your core.

Exercises for Bone Strength: 7 workouts to help prevent osteoporosis and keep you standing tall

If you do not yet have osteoporosis but are afraid of developing it, this report can help, by offering a variety of workouts with proven bone-protecting effects—including two strength workouts, three cardio workouts, jump training, and yoga.

An Introduction to Tai Chi: A gentle exercise program for mental and physical well-being

Studies show that tai chi can help with everything from lowering blood pressure and managing depression to building strength and improving balance—a key skill that can help you prevent falls and broken bones. This report provides a beginner program.

Preventing Falls

This guide includes exercises to strengthen your core and tips for removing hazards at home and learning to fall without injury.

Glossary

bone density (bone mineral density): The amount of mineralized bone tissue in a given area, usually calculated in grams per square centimeter.

bone mass: The total amount of bone tissue in the body.

compact bone: Very dense bone tissue that forms the outer shell of bones and constitutes a large part of the long bones of the arms, legs, and ribs. Also called cortical bone.

compression fracture: The collapse of a bone, most often a vertebra.

femoral neck: The fracture-prone top portion of the femur, or thighbone, just below the hip joint.

fragility fracture: A break caused by a weak bone rather than a fall or other physical trauma.

hydroxyapatite: The mature, hard, somewhat crystalline mineral compounds in bone tissue.

osteoblasts: Bone-forming cells.

osteoclasts: Bone-removing cells.

osteocytes: Osteoblasts that have completed their bone-forming function and have become trapped in new bone tissue, evolving into structural bone cells.

parathyroid hormone (PTH): A hormone that regulates calcium levels. It prevents the level of blood calcium from going too low by stimulating the breakdown of bone. Paradoxically, small, intermittent doses of synthetic PTH can help increase bone mass.

peak bone mass: The greatest amount of bone tissue that a person has during his or her life; typically reached by age 30.

primary osteoporosis: Bone loss that doesn't result from an identifiable medical condition or medication.

remodeling: The body's mechanism for systematically removing old bone tissue and replacing it with new bone to preserve the strength of the skeleton.

resorption: The removal of bone tissue—both protein and minerals—by osteoclasts.

secondary osteoporosis: Bone loss associated with an identifiable medical condition or treatment with certain drugs.

total hip: A term used in bone scanning to refer to the bone density measurement at a specific area in the hip, near the hip joint.

trabecular bone: Bone tissue arranged in a meshwork of thin plates or beams that is commonly found at the center of long bones and that constitutes a large part of the hip and vertebrae. Also called cancellous bone or spongy bone.

vertebral fracture assessment: A scan of the spine to look for deformities in the vertebrae. These deformities may indicate fractures.

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Inflammation
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Mobility & Independence
Neck Pain
Nutrition
Osteoarthritis
Osteoporosis
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