Calcium

Dietary Supplement Fact Sheet

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Introduction

Calcium, the most abundant mineral in the body, is found in some foods, added to others, available as a dietary supplement, and present in some medicines (such as antacids). Calcium is required for vascular contraction and vasodilation, muscle function, nerve transmission, intracellular signaling and hormonal secretion, though less than 1% of total body calcium is needed to support these critical metabolic functions [1]. Serum calcium is very tightly regulated and does not fluctuate with changes in dietary intakes; the body uses bone tissue as a reservoir for, and source of calcium, to maintain constant concentrations of calcium in blood, muscle, and intercellular fluids [1].

The remaining 99% of the body's calcium supply is stored in the bones and teeth where it supports their structure and function [1]. Bone itself undergoes continuous remodeling, with constant resorption and deposition of calcium into new bone. The balance between bone resorption and deposition changes with age. Bone formation exceeds resorption in periods of growth in children and adolescents, whereas in early and middle adulthood both processes are relatively equal. In aging adults, particularly among postmenopausal women, bone breakdown exceeds formation, resulting in bone loss that increases the risk of osteoporosis over time [1].

Recommended Intakes

Intake recommendations for calcium and other nutrients are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies (formerly National Academy of Sciences) [1]. DRI is the general term for a set of reference values used for planning and assessing the nutrient intakes of healthy people. These values, which vary by age and gender, include:

- Recommended Dietary Allowance (RDA): average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.
- Adequate Intake (AI): established when evidence is insufficient to develop an RDA and is set at a level assumed to ensure nutritional adequacy.
- Estimated Average Requirement (EAR): average daily level of intake estimated to meet the requirements of 50% of healthy individuals. It is usually used to assess the adequacy of nutrient intakes in populations but not individuals.
- Tolerable Upper Intake Level (UL): maximum daily intake unlikely to cause adverse health effects [1].

The FNB established RDAs for the amounts of calcium required for bone health and to maintain adequate rates of calcium retention in healthy people. They are listed in Table 1 in milligrams (mg) per day.

Table 1: Recommended Dietary Allowances (RDAs) for Calcium [1]

Age	Male	Female	Pregnant	Lactating
0–6 months*	200 mg	200 mg		
7–12 months*	260 mg	260 mg		
1–3 years	700 mg	700 mg		
4–8 years	1,000 mg	1,000 mg		
9–13 years	1,300 mg	1,300 mg		
14–18 years	1,300 mg	1,300 mg	1,300 mg	1,300 mg
19–50 years	1,000 mg	1,000 mg	1,000 mg	1,000 mg

Table 1: Recommended Dietary Allowances (RDAs) for Calcium [1]

Age	Male	Female	Pregnant	Lactating
19–50 years	1,000 mg	1,000 mg	1,000 mg	1,000 mg
51–70 years	1,000 mg	1,200 mg		
71+ years	1,200 mg	1,200 mg		

* Adequate Intake (AI)

Sources of Calcium

Food

Milk, yogurt, and cheese are rich natural sources of calcium and are the major food contributors of this nutrient to people in the United States [1]. Nondairy sources include vegetables, such as Chinese cabbage, kale, and broccoli. Spinach provides calcium, but its bioavailability is poor. Most grains do not have high amounts of calcium unless they are fortified; however, they contribute calcium to the diet because they contain small amounts of calcium and people consume them frequently. Foods fortified with calcium include many fruit juices and drinks, tofu, and cereals. Selected food sources of calcium are listed in Table 2.

Table 2: Selected Food Sources of Calcium [2]

Food	Milligrams (mg) per serving	Percent DV*
Yogurt, plain, low fat, 8 ounces	415	42
Mozzarella, part skim, 1.5 ounces	333	33
Sardines, canned in oil, with bones, 3 ounces	325	33
Yogurt, fruit, low fat, 8 ounces	313–384	31–38
Cheddar cheese, 1.5 ounces	307	31
Milk, nonfat, 8 ounces**	299	30
Soymilk, calcium-fortified, 8 ounces	299	30
Milk, reduced-fat (2% milk fat), 8 ounces	293	29
Milk, buttermilk, lowfat, 8 ounces	284	28
Milk, whole (3.25% milk fat), 8 ounces	276	28
Orange juice, calcium-fortified, 6 ounces	261	26
Tofu, firm, made with calcium sulfate, ½ cup***	253	25
Salmon, pink, canned, solids with bone, 3 ounces	181	18
Cottage cheese, 1% milk fat, 1 cup	138	14
Tofu, soft, made with calcium sulfate, ½ cup***	138	14
Ready-to-eat cereal, calcium-fortified, 1 cup	100–1,000	10–100
Frozen yogurt, vanilla, soft serve, ½ cup	103	10
Turnip greens, fresh, boiled, ½ cup	99	10
Kale, raw, chopped, 1 cup	100	10
Kale, fresh, cooked, 1 cup	94	9
Ice cream, vanilla, ½ cup	84	8
Chinese cabbage, bok choi, raw, shredded, 1 cup	74	7
Bread, white, 1 slice	73	7
Pudding, chocolate, ready to eat, refrigerated, 4 ounces	55	6
Tortilla, corn, ready-to-bake/fry, one 6" diameter	46	5
Tortilla, flour, ready-to-bake/fry, one 6" diameter	32	3
Sour cream, reduced fat, cultured, 2 tablespoons	31	3
Bread, whole-wheat, 1 slice	30	3
Broccoli, raw, ½ cup	21	2
Cheese, cream, regular, 1 tablespoon	14	1

* DV = Daily Value. DVs were developed by the U.S. Food and Drug Administration to help consumers compare the nutrient contents among products within the context of a total daily diet. The DV for calcium is 1,000 mg for adults and children aged 4 years and older. Foods providing 20% of more of the DV are considered to be high sources of a nutrient, but foods providing lower percentages of the DV also contribute to a healthful diet. The U.S. Department of Agriculture's (USDA's) Nutrient Database Web site lists the nutrient content of many foods and provides comprehensive list of foods containing calcium arranged by nutrient content and by food name.
** Calcium content varies slightly by fat content; the more fat, the less calcium the food contains.
*** Calcium content is for tofu processed with a calcium salt. Tofu processed with other salts does not provide significant amounts of calcium.

In its food guidance system, *MyPlate*, the U.S. Department of Agriculture recommends that persons aged 9 years and older eat 3 cups of foods from the milk group per day [3]. A cup is equal to 1 cup (8 ounces) of milk, 1 cup of yogurt, 1.5 ounces of natural cheese (such as Cheddar), or 2 ounces of processed cheese (such as American).

Dietary supplements

Dietary Supplements

The two main forms of calcium in supplements are carbonate and citrate. Calcium carbonate is more commonly available and is both inexpensive and convenient. Due to its dependence on stomach acid for absorption, calcium carbonate is absorbed most efficiently when taken with food, whereas calcium citrate is absorbed equally well when taken with or without food [4]. Calcium citrate is also useful for people with achlorhydria, inflammatory bowel disease, or absorption disorders [1]. Other calcium forms in supplements or fortified foods include gluconate, lactate, and phosphate. Calcium citrate malate is a well-absorbed form of calcium found in some fortified juices [5].

Calcium supplements contain varying amounts of elemental calcium. For example, calcium carbonate is 40% calcium by weight, whereas calcium citrate is 21% calcium. Fortunately, elemental calcium is listed in the Supplement Facts panel, so consumers do not need to calculate the amount of calcium supplied by various forms of calcium supplements.

The percentage of calcium absorbed depends on the total amount of elemental calcium consumed at one time; as the amount increases, the percentage absorption decreases. Absorption is highest in doses ≤500 mg [1]. So, for example, one who takes 1,000 mg/day of calcium from supplements might split the dose and take 500 mg at two separate times during the day.

Some individuals who take calcium supplements might experience gastrointestinal side effects including gas, bloating, constipation, or a combination of these symptoms. Calcium carbonate appears to cause more of these side effects than calcium citrate [1], so consideration of the form of calcium supplement is warranted if these side effects are reported. Other strategies to alleviate symptoms include spreading out the calcium dose throughout the day and/or taking the supplement with meals.

Medicines

Because of its ability to neutralize stomach acid, calcium carbonate is found in some over-the-counter antacid products, such as Tums® and Rolaids®. Depending on its strength, each chewable pill or softchew provides 200 to 400 mg of elemental calcium. As noted above, calcium carbonate is an acceptable form of supplemental calcium, especially for individuals who have normal levels of stomach acid.

Calcium Intakes and Status

In the United States, estimated calcium intakes from both food and dietary supplements are provided by the National Health and Nutrition Examination Survey (NHANES), 2003–2006 [6]. Mean dietary calcium intakes for males aged 1 year and older ranged from 871 to 1,266 mg/day depending on life stage group; for females the range was 748 to 968 mg/day. Groups with mean intakes falling below their respective EAR—and thus with a prevalence of inadequacy in excess of 50%—include boys and girls aged 9–13 years, girls aged 14–18 years, women aged 51–70 years, and both men and women older than 70 years [1,6]. Overall, females are less likely than males to get adequate amounts of calcium from food [7].

About 43% of the U.S. population (including almost 70% of older women) uses dietary supplements containing calcium, increasing calcium intakes by about 330 mg/day among supplement users [1,6]. According to NHANES 2003–2006 data, mean total calcium intakes from foods and supplements ranged from 918 to 1,296 mg/day for people aged 1 year and older [6]. When considering total calcium intakes, calcium inadequacy remains a concern for several age groups. These include females aged 4 years and older—particularly adolescent girls—and males aged 9 to 18 years and older than 51 years [1,8]. At the other end of the spectrum, some older women likely exceed the UL when calcium intakes from both food and supplements are included [1].

Not all calcium consumed is actually absorbed in the gut. Humans absorb about 30% of the calcium in foods, but this varies depending upon the type of food consumed [1]. Other factors also affect calcium absorption including the following:

- Amount consumed: the efficiency of absorption decreases as calcium intake increases [1].
- Age and life stage: net calcium absorption is as high as 60% in infants and young children, who need substantial amounts of the mineral to build bone [1,9]. Absorption decreases to 15%–20% in adulthood (though it is increased during pregnancy) and continues to decrease as people age; compared with younger adults, recommended calcium intakes are higher for females older than 50 years and for both males and females older than 70 years [1,9,10].
- Vitamin D intake: this nutrient, obtained from food and produced by skin when exposed to sunlight of sufficient intensity, improves calcium absorption [1].
- Other components in food: phytic acid and oxalic acid, found naturally in some plants, bind to calcium and can inhibit its absorption. Foods with high levels of oxalic acid include spinach, collard greens, sweet potatoes, rhubarb, and beans. Among the foods high in phytic acid are fiber-containing whole-grain products and wheat bran, beans, seeds, nuts, and soy isolates [1]. The extent to which these compounds affect calcium absorption varies. Research shows, for example, that eating spinach and milk at the same time reduces absorption of the calcium in milk [11]. In contrast, wheat products (with the exception of wheat bran) do not appear to lower calcium absorption [12]. For people who eat a variety of foods, these interactions probably have little or no nutritional consequence and, furthermore, are accounted for in the overall calcium DRIs, which factor in differences in absorption of calcium in mixed diets.

Some absorbed calcium is eliminated from the body in urine, feces, and sweat. This amount is affected by such factors as the following:

- Sodium and protein intakes: high sodium intake increases urinary calcium excretion [13,14]. High protein intake also increases calcium excretion and was therefore thought to negatively affect calcium status [13,14]. However, more recent research suggests that high protein intake also increases intestinal calcium absorption, effectively offsetting its effect on calcium excretion, so whole body calcium retention remains unchanged [15].
- Caffeine intake: this stimulant in coffee and tea can modestly increase calcium excretion and reduce absorption [16]. One cup of regular brewed coffee, for example, causes a loss of only 2–3 mg of calcium [14]. Moderate caffeine consumption (1 cup of coffee or 2 cups of tea per day) in young women has no negative effects on bone [17].
- Alcohol intake: alcohol intake can affect calcium status by reducing its absorption [18] and by inhibiting enzymes in the liver that help convert

- Alcohol intake: alcohol intake can affect calcium status by reducing its absorption [18] and by inhibiting enzymes in the liver that help convert vitamin D to its active form [19]. However, the amount of alcohol required to affect calcium status and whether moderate alcohol consumption is helpful or harmful to bone is unknown.
- Phosphorus intake: the effect of this mineral on calcium excretion is minimal. Several observational studies suggest that consumption of carbonated soft drinks with high levels of phosphate is associated with reduced bone mass and increased fracture risk. However, the effect is probably due to replacing milk with soda rather than the phosphorus itself [20,21].
- Fruit and vegetable intakes: metabolic acids produced by diets high in protein and cereal grains increase calcium excretion [22]. Fruits and vegetables, when metabolized, shift the acid/base balance of the body towards the alkaline by producing bicarbonate, which reduces calcium excretion. However, it is unclear if consuming more fruits and vegetables affects bone mineral density. These foods, in addition to reducing calcium excretion, could possibly reduce calcium absorption from the gut and therefore have no net effect on calcium balance.

Calcium Deficiency

Inadequate intakes of dietary calcium from food and supplements produce no obvious symptoms in the short term. Circulating blood levels of calcium are tightly regulated. Hypocalcemia results primarily from medical problems or treatments, including renal failure, surgical removal of the stomach, and use of certain medications (such as diuretics). Symptoms of hypocalcemia include numbness and tingling in the fingers, muscle cramps, convulsions, lethargy, poor appetite, and abnormal heart rhythms [23]. If left untreated, calcium deficiency leads to death.

Over the long term, inadequate calcium intake causes osteopenia which if untreated can lead to osteoporosis. The risk of bone fractures also increases, especially in older individuals [1]. Calcium deficiency can also cause rickets, though it is more commonly associated with vitamin D deficiency [1].

Groups at Risk of Calcium Inadequacy

Although frank calcium deficiency is uncommon, dietary intakes of the nutrient below recommended levels might have negative health consequences over the long term. The following groups are among those most likely to need extra calcium.

Postmenopausal women

Menopause leads to bone loss because decreases in estrogen production both increase bone resorption and decrease calcium absorption [10,24,25]. Annual decreases in bone mass of 3%–5% per year frequently occur in the first years of menopause, but the decreases are typically less than 1% per year after age 65 [26]. Increased calcium intakes during menopause do not completely offset this bone loss [27,28]. Hormone replacement therapy (HRT) with estrogen and progesterone helps increase calcium levels and prevent osteoporosis and fractures. Estrogen therapy restores postmenopausal bone remodeling to the same levels as at premenopause, leading to lower rates of bone loss [24], perhaps in part by increasing calcium absorption in the gut. Several medical groups and professional societies support the use of HRT as an option for women who are at increased risk of osteoporosis or fractures [29-31]. Such women should discuss this matter with their health care providers. In addition, consuming adequate amounts of calcium in the diet might help slow the rate of bone loss in all women.

Amenorrheic women and the female athlete triad

Amenorrhea, the condition in which menstrual periods stop or fail to initiate in women of childbearing age, results from reduced circulating estrogen levels that, in turn, have a negative effect on calcium balance. Amenorrheic women with anorexia nervosa have decreased calcium absorption and higher urinary calcium excretion rates, as well as a lower rate of bone formation than healthy women [32]. The "female athlete triad" refers to the combination of disordered eating, amenorrhea, and osteoporosis. Exercise-induced amenorrhea generally results in decreased bone mass [33,34]. In female athletes and active women in the military, low bone-mineral density, menstrual irregularities, certain dietary patterns, and a history of prior stress fractures are associated with an increased risk of future stress fractures [35]. Such women should be advised to consume adequate amounts of calcium and vitamin D. Supplements of these nutrients have been shown to reduce the risk of stress fractures in female Navy recruits during basic training [36].

Individuals with lactose intolerance or cow's milk allergy

Lactose intolerance refers to symptoms (such as bloating, flatulence, and diarrhea) that occur when one consumes more lactose, the naturally occurring sugar in milk, than the enzyme lactase produced by the small intestine can hydrolyze into its component monosaccharides, glucose and galactose [37]. The symptoms vary, depending on the amount of lactose consumed, history of consumption of lactose-containing foods, and type of meal. Although the prevalence of lactose intolerance is difficult to discern [38], some reports suggest that approximately 25% of U.S. adults have a limited ability to digest lactose, including 85% of Asians, 50% of African Americans, and 10% of Caucasians [39,40,41].

Lactose-intolerant individuals are at risk of calcium inadequacy if they avoid dairy products [1,38,39]. Research suggests that most people with lactose intolerance can consume up to 12 grams of lactose, such as that present in 8 ounces of milk, with minimal or no symptoms, especially if consumed with other foods; larger amounts can frequently be consumed if spread over the day and eaten with other foods [1,38,39]. Other options to reduce symptoms include eating low-lactose dairy products including aged cheeses (such as Cheddar and Swiss), yogurt, or lactose-reduced or lactose-free milk [1,38,39]. Some studies have examined whether it is possible to induce adaptation by consuming incremental lactose loads over a period of time [42,43], but the evidence in support of this strategy is inconsistent [38].

Cow's milk allergy is less common than lactose intolerance, affecting 0.6% to 0.9% of the population [44]. People with this condition are unable to consume any products containing cow's milk proteins and are therefore at higher risk of obtaining insufficient calcium.

To ensure adequate calcium intakes, lactose-intolerant individuals and those with cow's milk allergy can choose nondairy food sources of the nutrient (such as kale, bok choy, Chinese cabbage, broccoli, collards and fortified foods) or take a calcium supplement.

Vegetarians

Vegetarians

Vegetarians might absorb less calcium than omnivores because they consume more plant products containing oxalic and phytic acids [1]. Lacto-ovo vegetarians (who consume eggs and dairy) and nonvegetarians have similar calcium intakes [45,46]. However, vegans, who eat no animal products and ovo-vegetarians (who eat eggs but no dairy products), might not obtain sufficient calcium because of their avoidance of dairy foods [47,48]. In the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition, bone fracture risk was similar in meat eaters, fish eaters and vegetarians, but higher in vegans, likely due to their lower mean calcium intake [49]. It is difficult to assess the impact of vegetarian diets on calcium status because of the wide variety of eating practices and thus should be considered on a case by case basis.

Calcium and Health

Many claims are made about calcium's potential benefits in health promotion and disease prevention and treatment. This section focuses on several areas in which calcium is or might be involved: bone health and osteoporosis; cardiovascular disease; blood pressure regulation and hypertension; cancers of the colon, rectum, and prostate; kidney stones; and weight management.

Bone health and osteoporosis

Bones increase in size and mass during periods of growth in childhood and adolescence, reaching peak bone mass around age 30. The greater the peak bone mass, the longer one can delay serious bone loss with increasing age. Everyone should therefore consume adequate amounts of calcium and vitamin D throughout childhood, adolescence, and early adulthood. Osteoporosis, a disorder characterized by porous and fragile bones, is a serious public health problem for more than 10 million U.S. adults, 80% of whom are women. (Another 34 million have osteopenia, or low bone mass, which precedes osteoporosis.) Osteoporosis is most associated with fractures of the hip, vertebrae, wrist, pelvis, ribs, and other bones [50]. An estimated 1.5 million fractures occur each year in the United States due to osteoporosis [51].

When calcium intake is low or ingested calcium is poorly absorbed, bone breakdown occurs as the body uses its stored calcium to maintain normal biological functions. Bone loss also occurs as part of the normal aging process, particularly in postmenopausal women due to decreased amounts of estrogen. Many factors increase the risk of developing osteoporosis, including being female, thin, inactive, or of advanced age; smoking cigarettes; drinking excessive amounts of alcohol; and having a family history of osteoporosis [52].

Various bone mineral density (BMD) tests are available. The T-score from these tests compares an individual's BMD to an optimal BMD (that of a healthy 30-year old adult). A T-score of -1.0 or above indicates normal bone density, -1.0 to -2.5 indicates low bone mass (osteopenia), and lower than -2.5 indicates osteoporosis [53]. Although osteoporosis affects individuals of all races, ethnicities, and both genders, women are at highest risk because their skeletons are smaller than those of men and because of the accelerated bone loss that accompanies menopause. Regular exercise and adequate intakes of calcium and vitamin D are critical to the development and maintenance of healthy bones throughout the life cycle. Both weight-bearing exercises (such as walking, running, and activities where one's feet leave and hit the ground and work against gravity) and resistance exercises (such as calisthenics and that involve weights) support bone health.

Supplementation with calcium plus vitamin D has been shown to be effective in reducing fractures and falls (which can cause fractures) in institutionalized older adults [54]. However, among community-dwelling older adults over age 50, the benefits of supplementation with these nutrients on fracture resistance are much less clear. A recent systematic review of 26 randomized controlled trials found that calcium supplements, with or without vitamin D, modestly but significantly reduced the risk of total and vertebral fractures, but not fractures of the hip or forearm [55]. But the four trials with the lowest risk of bias, involving a total of 44,505 individuals, showed no effect of supplementation on risk of fracture at any site. A related meta-analysis of calcium intake on bone mineral density found that calcium supplementation produced only a small, initial, and non-progressive increase in bone mineral density that was unlikely to result in a clinically significant reduction in the risk of bone fractures [56]. The U.S. Preventive Services Task Force (USPSTF) concluded that the current evidence is insufficient to assess the balance of benefits and harms of combined vitamin D and calcium supplementation to prevent bone fractures in premenopausal women or in men [57]. For non-institutionalized postmenopausal women, the USPSTF concluded that while current evidence was insufficient to assess the balance of benefits and harms of combined supplementation with vitamin D (at more than 400 IU/day) and calcium (at more than 1,000 mg/day) to prevent bone fractures, there was clearly no benefit in supplementing with smaller doses of these nutrients for this purpose.

In 1993, the U.S. Food and Drug Administration authorized a health claim related to calcium and osteoporosis for foods and supplements [58]. In January 2010, this health claim was expanded to include vitamin D. Model health claims include the following: "Adequate calcium throughout life, as part of a well-balanced diet, may reduce the risk of osteoporosis" and "Adequate calcium and vitamin D as part of a healthful diet, along with physical activity, may reduce the risk of osteoporosis in later life" [58].

Cancer of the colon and rectum

Data from observational and experimental studies on the potential role of calcium in preventing colorectal cancer, though somewhat inconsistent, are highly suggestive of a protective effect [1]. Several studies have found that higher intakes of calcium from foods (low-fat dairy sources) and/or supplements are associated with a decreased risk of colon cancer [59-62]. In a follow-up study to the Calcium Polyp Prevention Study, supplementation with calcium carbonate led to reductions in the risk of adenoma (a nonmalignant tumor) in the colon, a precursor to cancer [63,64], even as long as 5 years after the subjects stopped taking the supplement [65]. In two large prospective epidemiological trials, men and women who consumed 700–800 mg per day of calcium had a 40%–50% lower risk of developing left-side colon cancer [66]. But other observational studies have found the associations to be inconclusive [62,67,68].

In the Women's Health Initiative, a clinical trial involving 36,282 postmenopausal women, daily supplementation with 1,000 mg of calcium and 400 International Units (IU) of vitamin D_3 for 7 years produced no significant differences in the risk of invasive colorectal cancer compared to placebo [69]. The authors of a Cochrane systematic review concluded that calcium supplementation might moderately help prevent colorectal adenomas, but there is not enough evidence to recommend routine use of calcium supplements to prevent colorectal cancer [70]. Given the long latency period for colon cancer development, long-term studies are needed to fully understand whether calcium intakes affect colorectal cancer risk.

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Cancer of the prostate

Several epidemiological studies have found an association between high intakes of calcium, dairy foods or both and an increased risk of developing prostate cancer [71-77]. However, others have found only a weak relationship, no relationship, or a negative association between calcium intake and prostate cancer risk [78-81]. The authors of a meta-analysis of prospective studies concluded that high intakes of dairy products and calcium might slightly increase prostate cancer risk [82].

Interpretation of the available evidence is complicated by the difficulty in separating the effects of dairy products from that of calcium. But overall, results from observational studies suggest that total calcium intakes >1,500 mg/day or >2,000 mg/day may be associated with increased prostate cancer risk (particularly advanced and metastatic cancer) compared with lower amounts of calcium (500–1,000 mg/day [1,83]. Additional research is needed to clarify the effects of calcium and/or dairy products on prostate cancer risk and elucidate potential biological mechanisms.

Cardiovascular disease

Calcium has been proposed to help reduce cardiovascular disease (CVD) risk by decreasing intestinal absorption of lipids, increasing lipid excretion, lowering cholesterol levels in the blood, and promoting calcium influx into cells [1]. However, data from prospective studies of calcium's effects on CVD risk are inconsistent, and whether dietary calcium has different effects on the cardiovascular system than supplemental calcium is not clear. In the Iowa Women's Health Study, higher calcium intake from diet and/or supplements was associated with reduced ischemic heart disease mortality in postmenopausal women [84]. Conversely, in a cohort of older Swedish women, both total and dietary calcium intakes of 1,400 mg/day and higher were associated with higher rates of death from CVD and ischemic heart disease than intakes of 600–1,000 mg/day [85]. Other prospective studies have shown no significant associations between calcium intake and cardiac events or cardiovascular mortality [83]. Data for stroke are mixed, with some studies linking higher calcium intakes to lower risk of stroke, and others finding no associations or trends in the opposite direction [83,85].

Several studies have raised concerns that calcium from supplements might increase the risk of CVD, including myocardial infarction and coronary heart disease [86-89]. For example, Xiao and colleagues reported that men who took more than 1,000 mg/day supplemental calcium had a 20% higher risk of total CVD death than men who did not take supplemental calcium, but supplemental calcium intake in women was unrelated to CVD mortality [90]. A reanalysis of data from the Women's Health Initiative (WHI) found that calcium supplements (1,000 mg/day) taken with or without vitamin D (400 IU/day) increased the risk of cardiovascular events in women who were not taking calcium supplements when they entered the study [91]. While there is no established biological mechanism to support an association between calcium and CVD, some scientists hypothesize that excessively high calcium intakes from supplements might override normal homeostatic controls of serum calcium levels and produce a temporary hypercalcemia [85,91,92]. Hypercalcemia is associated with increased blood coagulation, vascular calcification, and arterial stiffness, all of which raise CVD risk [90,91,93,94].

Many scientists question the strength of the available evidence linking supplemental calcium intake with CVD risk, noting that no clinical trials were designed primarily to evaluate this potential relationship, so researchers have only considered CVD outcomes in secondary analyses of trial data [93,95,96]. Based on a 2016 systematic review and meta-analysis of 4 randomized trials and 27 observational studies [97], the American Society for Preventive Cardiology and the National Osteoporosis Foundation concluded that there is "moderate-quality evidence" that calcium with or without vitamin D (from supplements or foods) "has no relationship (beneficial or harmful) with the risk for cardiovascular and cerebrovascular disease, mortality, or all-cause mortality in generally healthy adults" [92]. They added that based on the evidence to date, "calcium intake from food and supplements that does not exceed the [UL] should be considered safe from a cardiovascular standpoint."

Blood pressure and hypertension

Several clinical trials have demonstrated a relationship between increased calcium intakes and both lower blood pressure and risk of hypertension [98-100], although the reductions are inconsistent. In the Women's Health Study, calcium intake was inversely associated with risk of hypertension in middle-aged and older women [101]. However, other studies have found no association between calcium intake and incidence of hypertension [83]. The authors of a systematic review of the effects of calcium supplements for hypertension found any link to be weak at best, largely due to the poor quality of most studies and differences in methodologies [102].

Calcium's effects on blood pressure might depend upon the population being studied. In hypertensive subjects, calcium supplementation appears to lower systolic blood pressure by 2–4 mmHg, whereas in normotensive subjects, calcium appears to have no significant effect on systolic or diastolic blood pressure [83].

Other observational and experimental studies suggest that individuals who eat a vegetarian diet high in minerals (such as calcium, magnesium, and potassium) and fiber and low in fat tend to have lower blood pressure [48,103-106]. The Dietary Approaches to Stop Hypertension (DASH) study was conducted to test the effects of three different eating patterns on blood pressure: a control "typical" American diet; one high in fruits and vegetables; and a third diet high in fruits, vegetables, and low-fat dairy products. The diet containing dairy products resulted in the greatest decrease in blood pressure [107], although the contribution of calcium to this effect was not evaluated. Additional information and sample DASH menu plans are available on the National Heart, Lung, and Blood Institute Web site.

Preeclampsia

Preeclampsia is a serious medical condition in which a pregnant woman develops hypertension and proteinuria, usually after 20 weeks' gestation [108]. It is a leading cause of maternal and neonatal morbidity and mortality, affecting about 5–8% of pregnancies in the United States and up to 14% of pregnancies worldwide [108,109].

Studies suggest that calcium supplementation during pregnancy reduces the risk of preeclampsia, but the benefits may apply only to populations with inadequate calcium intakes [109,110]. For example, in a randomized clinical trial among 524 healthy women in India with mean baseline calcium intakes of only 314 mg/day, daily supplementation with 2,000 mg calcium starting between 12 and 25 weeks' gestation and continuing until delivery

significantly reduced the risk of preeclampsia, as well as preterm birth, compared to placebo [111]. Conversely, in a randomized trial of 4,589 healthy women in the United States, daily supplementation with 2,000 mg calcium from 13–21 weeks' gestation through the remainder of pregnancy did not reduce the incidence of preeclampsia, pregnancy-induced hypertension, or other adverse perinatal outcomes compared to placebo [112]. The mean baseline calcium intake among these women, however, was about 1,100 mg/day. The authors of a 2014 Cochrane review of 13 clinical trials concluded that daily supplementation with 1,000 mg or more of calcium during pregnancy reduced the risk of preeclampsia by 55% [113]. The reduction in risk was greatest for women at high risk of preeclampsia and those with low baseline calcium intakes (less than about 900 mg/day). For women with higher dietary calcium intakes, however, the reduction in preeclampsia risk was not statistically significant.

Several professional organizations recommend calcium supplements during pregnancy for women with low calcium intakes to reduce the risk of preeclampsia. For example, the American College of Obstetrics and Gynecology (ACOG) states that daily supplementation with 1,500–2,000 mg calcium may reduce the severity of preeclampsia in pregnant women who have calcium intakes less than 600 mg/day [109]. Similarly, the World Health Organization (WHO) recommends 1,500–2,000 mg calcium for pregnant women with low dietary calcium intakes, particularly those at higher risk of gestational hypertension [110]. The WHO recommends dividing the total daily dose into three doses, preferably to be taken at mealtimes, and taking the supplements from 20 weeks' gestation until delivery. The WHO also recommends separating calcium and prenatal iron supplements by several hours to minimize the inhibitory effects of calcium on iron absorption. But some researchers argue that this interaction has minimal clinical significance and suggest that providers not counsel patients to separate the supplements to simplify the supplement regimen and facilitate adherence [114]. The Canadian Hypertensive Disorders of Pregnancy Working Group [115], the International Society for the Study of Hypertension in Pregnancy [116], and the Society of Obstetric Medicine of Australia and New Zealand [117] have all issued similar recommendations to ACOG and the WHO.

Kidney stones

Kidney stones in the urinary tract are most commonly composed of calcium oxalate. Some, but not all, studies suggest a positive association between supplemental calcium intake and the risk of kidney stones, and these findings were used as the basis for setting the calcium UL in adults [1]. In the Women's Health Initiative, postmenopausal women who consumed 1,000 mg of supplemental calcium and 400 IU of vitamin D per day for 7 years had a 17% higher risk of kidney stones than subjects taking a placebo [118]. The Nurses' Health Study also showed a positive association between supplemental calcium intake and kidney stone formation [117]. High intakes of *dietary* calcium, on the other hand, do not appear to cause kidney stones and may actually protect against developing them [1,119-122]. For most individuals, other risk factors for kidney stones, such as high intakes of oxalates from food and low intakes of fluid, probably play a bigger role than calcium intake [123].

Weight management

Several studies have linked higher calcium intakes to lower body weight or less weight gain over time [124-127]. Two explanations have been proposed. First, high calcium intakes might reduce calcium concentrations in fat cells by decreasing the production of parathyroid hormone and the active form of vitamin D. Decreased intracellular calcium concentrations in turn increase fat breakdown and discourage fat accumulation in these cells [126]. Secondly, calcium from food or supplements might bind to small amounts of dietary fat in the digestive tract and prevent its absorption [126,128,129]. Dairy products, in particular, might contain additional components that have even greater effects on body weight than their calcium content alone would suggest [127,130-134].

Despite these findings, the results from clinical trials have been largely negative. For example, dietary supplementation with 1,500 mg/day of calcium (from calcium carbonate) for 2 years was found to have no clinically significant effects on weight in 340 overweight and obese adults as compared with placebo [133]. Three reviews of published studies on calcium from supplements or dairy products on weight management came to similar conclusions [83,136,137]. A meta-analysis of 13 randomized controlled trials published in 2006 concluded that neither calcium supplementation nor increased dairy product consumption had a statistically significant effect on weight reduction [136]. More recently, a 2009 evidence report from the Agency for Healthcare Research and Quality concluded that, overall, clinical trial results do not support an effect of calcium supplementation on weight loss [83]. Also, a 2012 meta-analysis of 29 randomized controlled trials found no benefit of an increased consumption of dairy products on body weight and fat loss in long-term studies [137]. Overall, the results from clinical trials do not support a link between higher calcium intakes and lower body weight or weight loss.

For additional information on calcium and weight management, see our health professional fact sheet on **Weight Loss**.

Health Risks from Excessive Calcium

Excessively high levels of calcium in the blood known as hypercalcemia can cause renal insufficiency, vascular and soft tissue calcification, hypercalciuria (high levels of calcium in the urine) and kidney stones [1]. Although very high calcium intakes have the potential to cause hypercalcemia [85], it is most commonly associated with primary hyperparathyroidism or malignancy [1].

High calcium intake can cause constipation. It might also interfere with the absorption of iron and zinc, though this effect is not well established [1]. High intake of calcium from supplements, but not foods, has been associated with increased risk of kidney stones [1,116,117]. Some evidence links higher calcium intake with increased risk of prostate cancer, but this effect is not well understood, in part because it is challenging to separate the potential effect of dairy products from that of calcium [1]. Some studies also link high calcium intake, particularly from supplements, with increased risk of cardiovascular disease [85-88,90,91].

The Tolerable Upper Intake Levels (ULs) for calcium established by the Food and Nutrition Board are listed in Table 3 in milligrams (mg) per day. Getting too much calcium from foods is rare; excess intakes are more likely to be caused by the use of calcium supplements. NHANES data from 2003–2006 indicate that approximately 5% of women older than 50 years have estimated total calcium intakes (from foods and supplements) that exceed the UL by about 300–365 mg [1,6].

Table 3: Tolerable Upper Intake Levels (ULs) for Calcium [1]

Calcium [1]

Age	Male	Female	Pregnant	Lactating
0–6 months	1,000 mg	1,000 mg		
7–12 months	1,500 mg	1,500 mg		
1–8 years	2,500 mg	2,500 mg		
9–18 years	3,000 mg	3,000 mg	3,000 mg	3,000 mg
19–50 years	2,500 mg	2,500 mg	2,500 mg	2,500 mg
51+ years	2,000 mg	2,000 mg		

Interactions with Medications

Calcium supplements have the potential to interact with several types of medications. This section provides a few examples. Individuals taking these medications on a regular basis should discuss their calcium intake with their healthcare providers.

Calcium can decrease absorption of the following drugs when taken together: biphosphonates (to treat osteoporosis), the fluoroquinolone and tetracycline classes of antibiotics, levothyroxine, phenytoin (an anticonvulsant), and tiludronate disodium (to treat Paget's disease) [138-140].

Thiazide-type diuretics can interact with calcium carbonate and vitamin D supplements, increasing the risks of hypercalcemia and hypercalciuria [139].

Both aluminum- and magnesium-containing antacids increase urinary calcium excretion. Mineral oil and stimulant laxatives decrease calcium absorption. Glucocorticoids, such as prednisone, can cause calcium depletion and eventually osteoporosis when they are used for months [139].

Calcium and Healthful Diets

The federal government's 2015-2020 *Dietary Guidelines for Americans* notes that "Nutritional needs should be met primarily from foods. ... Foods in nutrient-dense forms contain essential vitamins and minerals and also dietary fiber and other naturally occurring substances that may have positive health effects. In some cases, fortified foods and dietary supplements may be useful in providing one or more nutrients that otherwise may be consumed in less-than-recommended amounts."

For more information about building a healthy diet, refer to the *Dietary Guidelines for Americans* and the U.S. Department of Agriculture's MyPlate.

The *Dietary Guidelines for Americans* describes a healthy eating pattern as one that:

- Includes a variety of vegetables, fruits, whole grains, fat-free or low-fat milk and milk products, and oils.

  Many dairy products, such as milk, cheese, and yogurt, are rich sources of calcium. Some vegetables provide significant amounts of calcium, as do some fortified cereals and juices.

- Includes a variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), nuts, seeds, and soy products.

  Tofu made with calcium salts is a good source of calcium (check the label), as are canned sardines and canned salmon with edible bones.

- Limits saturated and *trans* fats, added sugars, and sodium.

  Low-fat and nonfat dairy products provide amounts of calcium that are roughly similar to the amounts in their full-fat versions.

- Stays within your daily calorie needs.

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Updated: November 17, 2016