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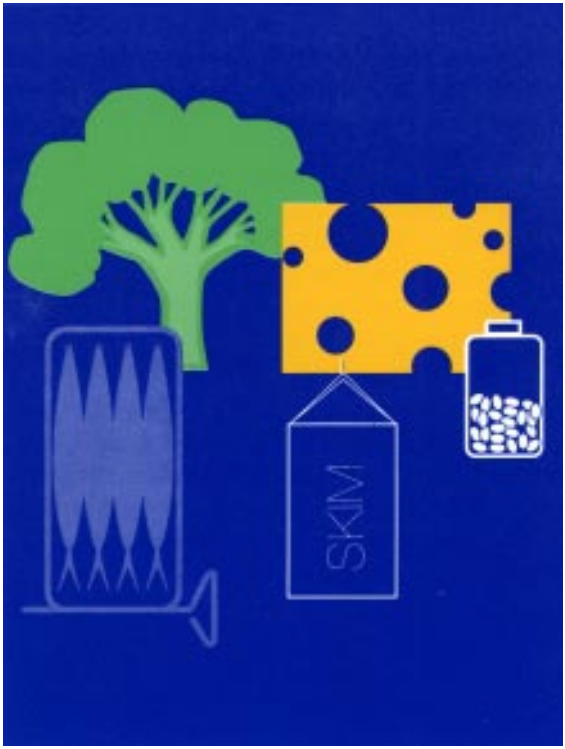

Optimal Calcium Intake

NATIONAL INSTITUTES OF HEALTH
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About the NIH Consensus Development Program

NIH Consensus Development Conferences are convened to evaluate available scientific information and resolve safety and efficacy issues related to a biomedical technology. The resultant NIH Consensus Statements are intended to advance understanding of the technology or issue in question and to be useful to health professionals and the public.

NIH Consensus Statements are prepared by a nonadvocate, non-Federal panel of experts, based on (1) presentations by investigators working in areas relevant to the consensus questions during a 2-day public session, (2) questions and statements from conference attendees during open discussion periods that are part of the public session, and (3) closed deliberations by the panel during the remainder of the second day and morning of the third. This statement is an independent report of the panel and is not a policy statement of the NIH or the Federal Government.

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Reference Information

For making bibliographic reference to the consensus statement from this conference, it is recommended that the following format be used, with or without source abbreviations, but without authorship attribution:

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This statement reflects the panel's assessment of medical knowledge available at the time the statement was written. Thus, it provides a "snapshot in time" of the state of knowledge on the conference topic. When reading the statement, keep in mind that new knowledge is inevitably accumulating through medical research.

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Abstract

The National Institutes of Health Consensus Development Conference on Optimal Calcium Intake brought together experts from many different fields including osteoporosis and bone and dental health, nursing, dietetics, epidemiology, endocrinology, gastroenterology, nephrology, rheumatology, oncology, hypertension, nutrition and public education, and biostatistics, as well as the public, to address the following questions: (1) What is the optimal amount of calcium intake? (2) What are the important cofactors for achieving optimal calcium intake? (3) What are the risks associated with increased levels of calcium intake? (4) What are the best ways to attain optimal calcium intake? (5) What public health strategies are available and needed to implement optimal calcium intake recommendations? and (6) What are the recommendations for future research on calcium intake? The consensus panel concluded that:

- A large percentage of Americans fail to meet currently recommended guidelines for optimal calcium intake.
- On the basis of the most current information available, optimal calcium intake is estimated to be 400 mg/day (birth–6 months) to 600 mg/day (6–12 months) in infants; 800 mg/day in young children (1–5 years) and 800–1,200 mg/day for older children (6–10 years); 1,200–1,500 mg/day for adolescents and young adults (11–24 years); 1,000 mg/day for women between 25 and 50 years; 1,200–1,500 mg/day for pregnant or lactating women; and 1,000 mg/day for postmenopausal women on estrogen replacement therapy and 1,500 mg/day for postmenopausal women not on estrogen therapy. Recommended daily intake for men is 1,000 mg/day (25–65 years). For all women and men over 65, daily intake is recommended to be 1,500 mg/day, although further research is needed for this age group. These guidelines are based on calcium from the diet *plus* any calcium taken in supplemental form.

- Adequate vitamin D is essential for optimal calcium absorption. Dietary constituents, hormones, drugs, age, and genetic factors influence the amount of calcium required for optimal skeletal health.
- Calcium intake, up to a total intake of 2,000 mg/day, appears to be safe in most individuals.
- The preferred source of calcium is through calcium-rich foods such as dairy products. Calcium-fortified foods and calcium supplements are other means by which optimal calcium intake can be reached in those who cannot meet this need by ingesting conventional foods.
- A unified public health strategy is needed to ensure optimal calcium intake in the American population.

The full text of the consensus panel's statement follows.

Introduction

It has been a decade since the 1984 Consensus Development Conference on Osteoporosis first suggested that increased intake of calcium might help prevent osteoporosis. Osteoporosis affects more than 25 million people in the United States and is the major underlying cause of bone fractures in postmenopausal women and the elderly. Previous surveys have revealed that the U.S. population experiences more than 1.5 million fractures annually at a cost in excess of $10 billion per year to the health care system. Two important factors that influence the occurrence of osteoporosis are optimal peak bone mass attained in the first two to three decades of life and the rate at which bone is lost in later years. Adequate calcium intake is critical to achieving optimal peak bone mass and modifies the rate of bone loss associated with aging. A number of publications have addressed the possible role of calcium intake in the prevention of disorders other than osteoporosis, including other bone diseases, oral bone loss, colon cancer, hypertension, and preeclampsia, a hypertensive disorder of pregnancy. The results of recent research investigating these issues indicate that the optimal amount of calcium intake may be greater than the amount consumed by most Americans. At the same time, the general public and scientists have been exposed to a body of information emphasizing the value of ensuring adequate calcium intake throughout life.

Calcium is an essential nutrient. Optimal calcium intake may vary according to a person's age, sex, and ethnicity. Other factors play a role in calcium intake, including vitamin D, which is needed for adequate calcium absorption. Many factors can negatively influence calcium availability, such as certain medications or food components. Optimal calcium intake may be achieved through diet, calcium-fortified foods, calcium supplements, or various combinations of these.

In view of the great public interest in nutrition and disease prevention, the scientific community has an obligation to integrate new data and to provide health care practitioners and the public with guidance, even though all of the necessary long-term studies may not have been completed. In some cases, the new data, however exciting, point to the need for further research rather than to specific recommendations. Future investigations in this rapidly expanding area of research will undoubtedly lead to more definitive information, which will provide the basis for new recommendations.

To address issues related to optimal calcium intake, the National Institute of Arthritis and Musculoskeletal and Skin Diseases together with the Office of Medical Applications of Research of the National Institutes of Health, convened a Consensus Development Conference on Optimal Calcium Intake on June 6–8, 1994. The conference was cosponsored by the Office of Research on Women's Health, Office of the Director; the National Institute on Aging; the National Cancer Institute; the National Institute of Child Health and Human Development; the National Institute of Diabetes and Digestive and Kidney Diseases; the National Heart, Lung, and Blood Institute; and the National Institute of Dental Research—all of the National Institutes of Health. Conference participants included experts from many different fields, including osteoporosis and bone and dental health, nursing, dietetics, epidemiology, endocrinology, gastroenterology, nephrology, rheumatology, oncology, hypertension, nutrition and public education, and biostatistics, as well as representatives from the public.

After 1 1/2 days of presentations by experts in the relevant fields and audience discussion, an independent, non-Federal consensus panel weighed the scientific evidence and formulated a consensus statement in response to the following six questions:

- What is the optimal amount of calcium intake?
- What are the important cofactors for achieving optimal calcium intake?
- What are the risks associated with increased levels of calcium intake?
- What are the best ways to attain optimal calcium intake?
- What public health strategies are available and needed to implement optimal calcium intake recommendations?
- What are the recommendations for future research on calcium intake?

The consensus panel prepared a draft report summarizing the evidence pertinent to the key issues regarding optimal calcium intake.

What Is the Optimal Amount of Calcium Intake?

Calcium is a major component of mineralized tissues and is required for normal growth and development of the skeleton and teeth. Optimal calcium intake refers to the levels of consumption that are necessary for an individual (a) to maximize peak adult bone mass, (b) to maintain adult bone mass, and (c) to minimize bone loss in the later years.

Calcium requirements vary throughout an individual's life time, with greater needs during the periods of rapid growth in childhood and adolescence, during pregnancy and lactation, and in later adult life (see Table 1). Because 99 percent of total body calcium is found in bone, the need for calcium is largely determined by skeletal requirements. Most studies examining the efficacy of calcium intake on bone mass have used measures of external calcium balance and bone densitometry as primary outcomes. The results of balance studies suggest a threshold effect for calcium intake: Body retention of calcium increases with increasing calcium intake up to a threshold, beyond which further calcium intake causes no additional increment in calcium retention.

A great deal of recent data related to calcium intake and its effects on calcium balance, bone mass, and the prevention of osteoporosis was reviewed, with attention given to the calcium requirements over the life cycle. The current *Recommended Dietary Allowances* (RDA) (10th edition, 1989) for calcium intake were considered as reference levels and used as guidelines to determine optimal calcium intake in light of new data on calcium-related disorders.

Infants (Birth–12 Months) and Young Children (1–10 Years)

Calcium intake of exclusively breast-fed infants during the first 6 months of life is in the range of 250–330 mg/day, with a fractional calcium absorption between 55 and 60 percent. A lower fractional absorption of 40 percent is found with cow milk–based formulas. These formulas contain nearly twice the calcium content of human milk; this results in comparable calcium retentions of 150–200 mg/day from both formula

and breast milk. Net calcium absorption from soy-based formulas is comparable to, or higher than, that of breast milk or cow milk formulas because of its considerably higher calcium content. For infants between the ages of 6 and 12 months, calcium intake ranges from 400 to 700 mg/day. On the basis of balance data, the current RDAs for calcium, 400 mg/day for infants from birth to 6 months and 600 mg/day for those from 6 to 12 months, seem sufficient to provide optimal calcium intake. However, special circumstances such as low birth weight may require higher calcium intake.

Available data suggest that optimal calcium intake in children 1–10 years of age is 800 mg/day. Limited data from one recent study suggest that in children 6–10 years of age, intake above 800 mg/day may lead to increased rates of bone accumulation. Coupled with calcium balance data, this suggests that an intake of greater than 800 mg/day may be optimal for this age group. It should also be noted that poor calcium nutrition in childhood may be related to development of enamel hypoplasia and accelerated dental caries.

Table 1. Optimal Calcium Requirements

Group	Optimal Daily Intake (in mg of calcium)
Infants	
Birth–6 months	400
6 months–1 year	600
Children	
1–5 years	800
6–10 years	800–1,200
Adolescents/Young Adults	
11–24 years	1,200–1,500
Men	
25–65 years	1,000
Over 65 years	1,500
Women	
25–50 years	1,000
Over 50 years (postmenopausal)	
On estrogens	1,000
Not on estrogens	1,500
Over 65 years	1,500
Pregnant and nursing	1,200–1,500

Children and Young Adults (11–24 Years)

Calcium accumulation in bone during preadolescence is between 140 and 165 mg/day and may be as high as 400–500 mg/day during the pubertal period. Fractional intestinal absorption is very efficient and estimated to be approximately 40 percent. Peak adult bone mass, depending on the skeletal site examined, is largely achieved by 20 years of age, although important additional bone mass may accumulate through the third decade of life. Furthermore, cross-sectional studies reveal a small but positive association between life-long calcium intake and adult bone mass. Therefore, optimal calcium intake in childhood and young adulthood is critical to achieving peak adult bone mass.

Recent evidence suggests that adding 500–1,000 mg/day to current calcium intake may, at least temporarily, increase bone accretion rates in preadolescent boys and girls. With this supplementation, total calcium intake in these studies exceeded the current RDA of 1,200 mg/day; however, it is unclear whether the effect on bone accretion rates persists beyond the reported 18–month to 3–year periods of treatment and whether these increased rates of bone formation translate into higher peak adult bone mass. Recent balance studies in adolescents indicate a calcium intake threshold in the range of 1,200–1,500 mg/day.

Collectively, these data suggest that calcium intake in the range of 1,200–1,500 mg/day might result in higher peak adult bone mass. Additional research is necessary, particularly longitudinal, long-term dose-ranging studies of the effects of varying calcium intake on bone mass, to more precisely define optimal calcium intake for this age group. Importantly, population surveys of girls and young women 12–19 years of age show their average calcium intake to be less than 900 mg/day, which is well below the calcium intake threshold. The consequences of low calcium intake during this crucial period of rapid skeletal accrual raise concerns that achievement of optimal peak adult peak bone mass may be seriously compromised. Special education and public measures aimed at improving dietary calcium intake in this age group are essential.

Calcium Intake in Adults (25–65 Years of Age)

Once peak adult bone mass is reached, bone turnover is stable in men and women such that bone formation and bone resorption are balanced. In women, resorption rates increase and bone mass declines beginning with the fall in estrogen production that is associated with the onset of menopause. The decline in circulating 17ß-estradiol is the predominant factor in the accelerated bone loss that begins after the onset of menopause and continues for 6–8 years. Unlike hormone replacement therapy, supplemental calcium during this initial phase will not slow the decline in bone mass due to estrogen deficiency. Although the effects of calcium can be shown more clearly in postmenopausal women after the period when the effects of estrogen deficiency are no longer dominant (approximately 10 years after menopause), it is likely that the early postmenopausal years are also an important time to ensure optimal calcium intake. Between 25 and 50 years of age, women who are otherwise healthy should maintain a calcium intake of 1,000 mg/day (Osteoporosis. NIH Consens Statement 1984 Apr 2–4;5(3):1–6). For postmenopausal women who are receiving estrogen replacement therapy, a calcium intake of 1,000 mg/day is recommended to maintain calcium balance and stabilize bone mass. For postmenopausal women who are not taking estrogen, it is estimated that a calcium intake of 1,500 mg/day may limit loss of bone mass but should not be considered a replacement for estrogen. Therefore, recommended calcium intake for postmenopausal women up to 65 years of age is 1,000 mg/day in conjunction with hormonal replacement and 1,500 mg/day in the absence of estrogen replacement.

Adult men also sustain fractures of the hip and vertebrae, although at a lower frequency than women. In several prospective and cross-sectional studies, hip fracture risk in men has been found to be inversely correlated with calcium intake. Although the data are less extensive for men than for women, the evidence for men suggests that inadequate calcium intake is associated with reduced bone mass and increased fracture risk. Available data, although sparse, indicate an optimal calcium intake for adult men similar to that for women, namely 1,000 mg/day.

Calcium Intake in Adults (Older Than 65 years)

In men and women 65 years of age and older, calcium intake of less than 600 mg/day is common. Furthermore, intestinal calcium absorption is often reduced because of the effects of estrogen deficiency in women and the age-related reduction in renal 1,25-dihydroxyvitamin D production. Calcium insufficiency due to low calcium intake and reduced absorption can translate into an accelerated rate of age-related bone loss in older individuals. Among the homebound elderly and persons residing in long-term care facilities, vitamin D insufficiency has been detected and may contribute to reduced calcium absorption. Calcium intake among women later in menopause, in the range of 1,500 mg/day, may reduce the rates of bone loss in selected sites of the skeleton such as the femoral neck. (These findings also indicate that the calcium threshold for reducing bone loss may vary for different regions of the skeleton.)

The physiology of calcium homeostasis in aging men over 65 is similar to that in women with respect to the rate of bone loss, calcium absorption efficiency, declining vitamin D levels, and changes in markers of bone metabolism. It seems reasonable, therefore, to conclude that in aging men, as in aging women, prevailing calcium intakes are insufficient to prevent calcium-related erosion of bone mass.

Thus, in women and in men over 65, calcium intake of 1,500 mg/day seems prudent.

Pregnant and Lactating Women

The current RDA for calcium intake during pregnancy and lactation is 1,200 mg/day. Pregnancy represents a significant physiological stress on maternal skeletal homeostasis. A full-term infant accumulates approximately 30 grams of calcium during gestation, most of which is assimilated into the fetal skeleton during the third trimester. Available data suggest that, with pregnancy, no permanent decline in body calcium occurs if recommended levels of dietary calcium intake are maintained. There is no association between parity and bone mass. Furthermore, there is no evidence to support changing the current recommendation of calcium intake for

well-nourished pregnant women. There is, however, a large population of pregnant women who are not ingesting sufficient calcium, especially those who are undernourished. These women need to be identified, and appropriate adjustments in their calcium intake should be made. Data are not available regarding the calcium requirement for pregnant women at the extremes of reproductive years, for those who experience nonsingleton births, and for those with closely spaced pregnancies.

During lactation, 160–300 mg/day of maternal calcium is lost through production of breast milk. Longitudinal studies in otherwise healthy women demonstrate acute bone loss during lactation that is followed by rapid restoration of bone mass with weaning and the resumption of menses. Women who are lactating should ingest at least 1,200 mg of calcium per day. Lactating adolescents and young adults should ingest up to 1,500 mg of calcium per day.

Diseases Other Than Osteoporosis

Low calcium intake has been implicated as a determinant of preeclampsia and several other chronic conditions including colon cancer and hypertension. Data regarding the role of supplemental calcium in reducing preeclampsia are conflicting. A large multicenter trial to evaluate this question is under way; the results, which will be available in 1996, should provide the information needed to judge the utility of increased calcium for preeclampsia.

In some recent epidemiological studies, higher calcium intake has been associated with a lower risk for the development of colon cancer. However, the findings are inconsistent, and the number of reports addressing this relationship are limited. Results of short-term clinical trials of the effect of increased calcium intake on rectal mucosal cell proliferation have been mixed and suffer from considerable methodological constraints. Currently, there are insufficient data to establish the role of calcium in colon cancer risk; therefore, a recommendation for increased calcium intake for colon cancer prevention is not warranted at this time.

There are considerable epidemiological and clinical trial data on the relationship between blood pressure levels and calcium intake. Although a number of epidemiological studies suggest an inverse association between blood pressure and calcium intake, most of these studies have been of cross-sectional design, and few prospective studies are available to confirm this association. Results of randomized controlled trials of calcium supplementation on blood pressure have been equivocal. Pooled analyses indicate a small reduction in systolic blood pressure and no effect on diastolic blood pressure. There is speculation that only a subgroup of individuals respond to calcium supplementation; however, randomized trial data are currently not available. A recommendation for increased calcium intake for prevention of hypertension is not warranted at this time, but additional information is needed to identify subpopulations that may benefit from his treatment.

What Are the Important Cofactors for Achieving Optimal Calcium Intake?

Several cofactors modify calcium balance and influence bone mass. These include dietary constituents, hormones, drugs, and the level of physical activity. Unique host characteristics may also modify the effects of dietary calcium on bone health. These include the individual's age and ethnic and genetic background, the presence of gastrointestinal disorders such as malabsorption and the postgastrectomy syndrome, and the presence of liver and renal disease. Interactions among these diverse cofactors may affect calcium balance in either a positive or negative manner and thus alter the optimal levels of calcium intake.

Cofactors That Enhance Calcium Absorption

Vitamin D metabolites enhance calcium absorption. The major metabolite, 1,25-Dihydroxyvitamin D, stimulates active transport of calcium in the small intestine and colon. Deficiency of 1,25-dihydroxyvitamin D, caused by inadequate dietary vitamin D, inadequate exposure to sunlight, impaired activation of vitamin D, or acquired resistance to vitamin D, results in reduced calcium absorption. In the absence of 1,25-dihydroxyvitamin D, less than 10 percent of dietary calcium may be absorbed. Vitamin D deficiency is associated with an increased risk of fractures. Elderly patients are at particular risk for vitamin D deficiency because of insufficient vitamin D intake from their diet, impaired renal synthesis of 1,25-dihydroxyvitamin D, and inadequate sunlight exposure, which is normally the major stimulus for endogenous vitamin D synthesis. This is especially evident in homebound or institutionalized individuals. Supplementation of vitamin D intake to provide 600–800 IU/day has been shown to improve calcium balance and reduce fracture risk in these individuals. Sufficient vitamin D should be ensured for all individuals, especially the elderly who are at greater risk for development of a deficiency. Sources of vitamin D, besides supplements, include sunlight, vitamin D–fortified liquid dairy products, cod liver oil, and fatty fish. Calcium and vitamin D need not be taken together to be effective. Excessive doses of vitamin D may introduce risks

such as hypercalciuria and hypercalcemia and should be avoided. Anticonvulsant medications may alter both vitamin D and bone mineral metabolism, particularly in certain disorders, in the institutionalized, and in the elderly. Although symptomatic skeletal disease is uncommon in noninstitutionalized settings, optimal calcium intake is advised for persons using anticonvulsants.

Sex hormone deficiency is associated with excessive bone resorption in women and men. Low calcium intake can exacerbate the deleterious consequences of sex hormone deficiency. One study suggested that calcium supplementation can decrease the minimum estrogen dosage required to maintain bone mass in postmenopausal women. However, oral calcium alone does not prevent the postmenopausal bone loss resulting from estrogen deficiency. In addition to estrogen, other endogenous cofactors that could enhance net calcium absorption include growth hormone, insulin-like growth factor-I, and parathyroid hormone.

An interrelationship between physical activity and calcium balance has not been established conclusively. In a single study, increased physical activity enhanced the beneficial effect of oral calcium supplementation on bone mass in young adults. Thus far, studies of elderly individuals and perimenopausal women have failed to establish a positive interaction between calcium intake and exercise to increase bone mass. Therefore, the positive effects of exercise on skeletal health are not likely to be related to calcium intake.

Immobilization has been shown to produce a rapid decrease in bone mass. This loss has been well documented in individuals placed on bed rest and in individuals with regional forms of immobilization such as that seen in para- and quadriplegia. Under these circumstances, the rate of bone loss may be rapid, which is in part related to an increase in bone resorption accompanied by a decrease in bone formation. There is concern that increased calcium intake may increase the risk of hypercalcemia, ectopic calcification, ectopic ossification, and nephrolithiasis in these individuals. Thus, any recommendations for increasing calcium intake are tempered in these individuals by the potential for undesirable consequences.

Factors That Decrease Calcium Availability

Calcium intake, intestinal absorption, urinary excretion, and endogenous fecal loss influence calcium balance. Intake and absorption account for only 25 percent of the variance in calcium balance, whereas urinary loss accounts for approximately 50 percent. The typical American diet consists of high amounts of sodium and animal protein, both of which can significantly increase urinary calcium excretion. High oxalate and phytate in a limited number of foods can reduce the availability of calcium in these foods. With the exception of large amounts of wheat bran, fiber has not been found to affect calcium absorption significantly. Other dietary components, including fat, phosphate, magnesium, and caffeine, have not been found to affect calcium absorption or excretion significantly. Aluminum in the form of antacid medication, when taken in excess, may significantly increase urinary calcium excretion in association with impaired bone mineralization.

Glucocorticoids decrease calcium absorption. States of glucocorticoid excess are associated with negative calcium balance and a marked increase in fracture risk. In a recent study, oral calcium supplements plus 1,25-dihydroxyvitamin D decreased glucocorticoid-associated bone loss. On the basis of these observations and other studies, oral calcium supplements should be considered in all patients who are receiving exogenous glucocorticoids. The specific disease for which the glucocorticoid therapy is used (e.g., rheumatoid arthritis, inflammatory bowel disease, asthma) can be a determining factor in the occurrence and degree of bone loss.

Genetic and ethnic factors significantly influence many aspects of calcium and skeletal metabolism. Twin studies indicate a significant influence of genetic factors on peak bone mass. However, environmental factors appear to be more important in determining rates of bone loss in postmenopausal women. Racial and ethnic differences in bone mass and fracture incidence have been described, but these are not accounted for by differences in calcium intake. Whether there are genetic and ethnic differences in optimal calcium requirements needs to be determined.

What Are the Risks Associated With Increased Levels of Calcium Intake?

High levels of calcium intake have several potentially adverse effects. The efficiency of calcium absorption decreases as intake increases, thereby providing a protective mechanism to lessen the chances of calcium intoxication. This adaptive mechanism can, however, be overcome by a calcium intake of greater than approximately 4 g/day. It is well known that calcium toxicity, with high blood calcium levels, severe renal damage, and ectopic calcium deposition (milk-alkali syndrome), can be produced by overuse of calcium carbonate, encountered clinically in the form of antacid abuse. Even at intake levels of less than 4 g/day, certain otherwise healthy persons may be more susceptible to developing hypercalcemia or hypercalciuria. Likewise, subjects with mild or subclinical illnesses marked by dysregulation of 1,25-dihydroxyvitamin D synthesis (e.g., primary hyperparathyroidism, sarcoidosis) may be at increased risk from higher calcium intakes. Nevertheless, in intervention studies (albeit of relatively short duration—less than 4 years), no adverse renal effects of moderate supplementation up to 1,500 mg/day have been reported. Furthermore, one large study suggested that within the current ranges of calcium intake in the population, a higher calcium intake in men is associated with a decreased risk of stone formation. However, a dose–response relationship was not detected. Caution must be used, however, in supplementing individuals who have a history of kidney stones, because high calcium intakes can increase urinary calcium excretion and might increase the risk of stone formation in these patients.

The strategy of increasing calcium intake by increasing dairy products could tend to increase the intake of saturated fat. These potential problems can be averted by the use of low-fat dairy products. Reduced-fat or no-fat dairy products contain as much calcium per serving size as high-fat dairy products. The use of dairy products to increase calcium intake could increase side effects in people who are sensitive to milk products. Nondairy alternative sources are indicated in these individuals.

Concern has been raised that increased calcium intake might interfere with absorption of other nutrients. Iron absorption can be decreased by as much as 50 percent by many forms of calcium supplements or milk ingestion but not by forms that contain citrate and ascorbic acid, which enhance iron absorption. Thus, increased intakes of specific sources of calcium might induce iron deficiency in individuals with marginal iron status. Population studies suggest that this is not a common or severe problem, but more study is needed. Whether calcium supplements interfere with absorption of other nutrients has not been thoroughly studied. Calcium may also interfere with absorption of certain medications, such as tetracycline.

Gastrointestinal side effects of calcium supplements have been observed, usually at relatively high dosages. A variable effect on the incidence of constipation has been reported in controlled studies of calcium supplements. The calcium ion stimulates gastrin secretion and gastric acid secretion, which can produce a "rebound hyperacidity" when calcium carbonate is used as an antacid. These side effects should not be major problems with a modest increase in calcium intake.

Certain preparations of calcium (e.g., bone meal, dolomite) can have significant contamination with lead and other heavy metals. However, most commercial calcium preparations are tested to ensure that they do not contain significant heavy metal contamination.

In conclusion, a modest increase in calcium intake should be safe for most people. Practices that might encourage total calcium intake to approach or exceed 2,000 mg/day seem more likely to produce adverse effects and should be monitored closely.

What Are the Best Ways to Attain Optimal Calcium Intake?

The preferred approach to attaining optimal calcium intake is through dietary sources. Additional strategies include the consumption of calcium-fortified foods and calcium supplements. For many Americans, dairy products are the major contributors of dietary calcium because of their high calcium content (e.g., approximately 250–300 mg/8 oz milk) and frequency of consumption. It may be necessary for individuals with lactose intolerance to limit or exclude liquid dairy foods, but adequate calcium intake can be achieved through the use of low-lactose-containing dairy products (solid dairy food) or through milk rendered lactose deficient. Vegans, who voluntarily limit their intake of dairy products, can obtain dietary calcium through other sources. Other good food sources of calcium include some green vegetables (e.g., broccoli, kale, turnip greens, Chinese cabbage), calcium-set tofu, some legumes, canned fish, seeds, nuts, and certain fortified food products. Breads and cereals, although relatively low in calcium, contribute significantly to calcium intake because of their frequency of consumption.

Recommended calcium intake levels are based on the total calcium content of the food. To maximize calcium absorption, food selection decisions should include information on their bioavailability. Bioavailability (absorption) of calcium from food depends on the food's total calcium content and the presence of components that enhance or inhibit absorption. As mentioned previously, oxalate, which is present at high levels in some vegetables (e.g., spinach), has been found to depress absorption of the calcium present in the food but not of calcium in coingested dairy or other calcium-containing foods. Phytate also depresses calcium absorption but to a lesser extent. Dietary fiber, except for wheat bran, has little effect on calcium absorption. When present in high concentration, wheat bran has been found to depress calcium absorption from milk.

A number of calcium-fortified food products are currently available, including fortified juices, fruit drinks, breads, and cereals. Although some of these foods provide multiple nutrients and

may be frequently consumed, their quantitative contribution and role in the total diet are not currently defined.

For some individuals, calcium supplements may be the preferred way to attain optimal calcium intake. Calcium supplements are available as various salts, and most preparations are well absorbed except when manufactured such that they do not disintegrate during oral ingestion. Absorption of calcium supplements is most efficient at individual doses of 500 mg or less and when taken between meals. Ingesting calcium supplements between meals supports calcium bioavailability, because food may contain certain compounds that reduce calcium absorption (e.g., oxalates). However, absorption of one form of calcium supplementation, calcium carbonate, is impaired in fasted individuals who have an absence of gastric acid. Absorption of calcium carbonate can be improved in these individuals when it is taken with certain foods. The potential for calcium supplementation to interfere with iron absorption is an important consideration when it is ingested with meals. Alternatively, calcium supplementation in the form of calcium citrate does not require gastric acid for optimal absorption and thus could be considered in older individuals with reduced gastric acid production. In individuals with adequate gastric acid production, it is preferable to ingest calcium supplements between meals.

Maintenance of optimal bone health depends on an adequate supply of calcium and other essential nutrients. Current dietary intake data indicate that calcium intake is below recommended levels in most individuals. To attain the optimal calcium levels proposed, a change in dietary habits, including increased frequency of consumption of dairy products and/or calcium-rich vegetable sources, is needed. This approach of recommending the consumption of calcium-rich foods is consistent with current dietary guidelines (the U.S. Department of Agriculture (USDA) Food Guide Pyramid), which includes 2–3 servings per day of dairy products and 3–5 servings of vegetables. Recommendations for supplements should be made in the context of the total diet because recommendations are for calcium from all sources. The task for individuals to meet calcium requirements on a continuing daily basis is a formidable challenge.

What Public Health Strategies Are Available and Needed to Implement Optimal Calcium Intake Recommendations?

Optimizing the calcium intake of Americans is of critical importance. Recent improvements in calcium intake have been reported for most age groups (phase 1 of the Third National Health and Nutrition Examination Survey, 1988–1991—NHANES III). However, contemporary 6– to 11–year-old children showed a decrease in calcium intake, as compared with those a decade earlier (NHANES II, 1976–1980). NHANES III also documents that a large percentage of Americans still fail to meet currently recommended guidelines for calcium intake. The impact of suboptimal calcium intake on the health of Americans and the health care cost to the American public is a vital concern. It is thus appropriate that increasing calcium intake is a national health promotion and disease prevention objective in the *Healthy People 2000* agenda (Department of Health and Human Services Publication Number 91.50212). Public health strategies to promote optimal calcium intake should have a broad outreach and should involve educators, health professionals, and the private and public sectors.

Public Education

A public education program is needed to do the following:

- Disseminate consensus recommendations to the public.
- Convene meetings of public leaders and representatives of national groups to disseminate information on optimal calcium intake for the general population and high-risk groups and to develop action plans for public education.
- Develop health education materials and programs to address the diverse linguistic and cultural needs of the multiethnic American population.
- Work with existing national organizations and the mass media to distribute information, decrease consumer confusion, and encourage consumers, including children, adolescent girls, postmenopausal women, and older Americans, to adopt health-promoting changes in their daily calcium intake.

Health Professionals

Primary care physicians, dentists, and other health professionals should play a strong role in educating their patients about bone health and calcium intake. An educational program to support this work of health professionals would:

- Disseminate consensus recommendations to health professionals.
- Develop and distribute educational materials, by serving as a clearinghouse for information on calcium-related research, and developing curricula for health professional training programs.
- Distribute educational materials through health professional organizations at their national and regional meetings.
- Initiate sessions at national meetings of health professionals focusing on promoting optimal calcium intake or initiating national meetings focusing specifically on calcium-related research.

Private Sector

The private sector can play an active part in promoting optimal calcium intake.

- Manufacturers and producers of food products should continue to develop and market a wide variety of calcium-rich foods to meet the needs and tastes of our multiethnic population.
- Restaurants, grocery stores, and other food outlets should increase the accessibility and visibility of calcium-rich products for the consumer.
- Biotechnology research groups should develop accessible cost-effective technologies to screen for populations who are at high risk of fracture and who would be candidates for increased calcium intake.

Public Sector

The Federal Government should take the following actions:

- The Government should ensure that guidelines for calcium intake across all agencies, departments, and institutions are consistent and that these guidelines reflect the current state of scientific knowledge.
- The National Center for Health Statistics and the USDA should widely disseminate their data on nutrient intakes and food consumption patterns, with respect to calcium, as well as their information on relevant trends in these nutrient intakes and food consumption patterns. To maximize educational, programmatic, and policy efforts, these data should be specific to age, gender, ethnic group, region, and socioeconomic status where possible.
- Existing Federal food and food subsidy programs and federally regulated facilities for infants, children, low-income populations, and the elderly in the Department of Health and Human Services, the Department of Veterans Affairs, the Department of Defense, and other agencies should ensure achievement of optimal calcium intake for program recipients.
- The USDA should direct school food services to promote calcium intake by serving calcium-rich foods and to urge that calcium be included in all nutrition education efforts within public schools.
- Government cafeterias should serve as models to promote optimal calcium intake by serving calcium-rich foods, labeling calcium content in single servings of those foods, and distributing brochures about the relationship between dietary calcium needs and good health to their customers.
- Address, within health care reform, the need for financial coverage of calcium supplements for those who cannot reach optimal calcium intake through foods alone, and for financial support for screening of target populations to identify individuals who are at high risk of fracture and who would be likely to benefit from increased calcium intake.

What Are the Recommendations for Future Research on Calcium Intake?

- Prospective longitudinal studies to investigate long-term effects of calcium intake on regional (e.g., spine, hip, forearm) changes in bone mass and on fracture incidence in postmenopausal women and in older men.
- Prospective longitudinal studies of adolescent girls and boys to investigate the long-term effects of different levels of calcium intake on the achievement of peak bone mass.
- Studies to determine optimal calcium intake in the decade before menopause and the potential role of declining estrogen levels during this time.
- Evaluation of the long-term effects of calcium intake on bone remodeling.
- Investigation of interactions between calcium supplementation and the absorption of other nutrients.
- Evaluation of dose–response relationships between calcium intake and estrogen replacement therapy.
- Determination of optimal calcium requirements in different ethnic populations.
- Evaluation of the effect of long-term calcium supplementation on the development or prevention of kidney stones.
- Studies on the effect of dietary calcium on bone mass and fracture incidence.
- Evaluation of the role of vitamin D metabolites in optimizing calcium balance.
- Development of a cost-effective means by which calcium-deficient individuals can be identified at all ages.
- Development of effective health-promoting programs to change population behavior with respect to calcium intakes that are tailored to specific age, sex, ethnic, socioeconomic status, and regional needs.
- Improved methods to achieve and maintain optimal dietary intake of calcium by both nutritional and supplemental means.

Conclusions

- A large percentage of Americans fail to meet currently recommended guidelines for optimal calcium intake.
- On the basis of the most current information available, optimal calcium intake is estimated to be 400 mg/day (birth–6 months) to 600 mg/day (6–12 months) in infants; 800 mg/day in young children (1–5 years) and 800–1,200 mg/day for older children (6–10 years); 1,200–1,500 mg/day for adolescents and young adults (11–24 years); 1,000 mg/day for women between 25 and 50 years; 1,200–1,500 mg/day for pregnant or lactating women; and 1,000 mg/day for postmenopausal women on estrogen replacement therapy and 1,500 mg/day for postmenopausal women not on estrogen therapy. Recommended daily intake for men is 1,000 mg/day (25–65 years). For all women and men over 65, daily intake is recommended to be 1,500 mg/day, although further research is needed in this age group. These guidelines are based on calcium from the diet *plus* any calcium taken in supplemental form.
- Adequate vitamin D is essential for optimal calcium absorption. Dietary constituents, hormones, drugs, age, and genetic factors influence the amount of calcium required for optimal skeletal health.
- Calcium intake, up to a total intake of 2,000 mg/day, appears to be safe in most individuals.
- The preferred source of calcium is through calcium-rich foods such as dairy products. Calcium-fortified foods and calcium supplements are other means by which optimal calcium intake can be reached in those who cannot meet this need by ingesting conventional foods.
- A unified public health strategy is needed to ensure optimal calcium intake in the American population.

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OPTIMAL CALCIUM INTAKE

A Continuing Medical Education Activity
Sponsored by the National Institutes of Health

OBJECTIVE

The objective of this NIH Consensus Statement is to inform the biomedical research and clinical practice communities of the results of the NIH Consensus Development Conference on Optimal Calcium Intake. The statement provides state-of-the-art information regarding optimal amounts of calcium intake, the best ways for attaining optimal calcium intake, and the risk factors associated with different levels of calcium intake, and it presents the conclusions and recommendations of the consensus panel regarding these issues. In addition, the statement identifies those areas of study that deserve further investigation. Upon completion of this educational activity, the reader should possess a clear working knowledge of the state-of-the-art regarding optimal calcium intake.

ACCREDITATION

The National Institutes of Health is accredited by the Accreditation Council for Continuing Medical Education to sponsor continuing medical education for physicians. The National Institutes of Health designates this continuing medical education activity for 1 credit hour in Category 1 of the Physician's Recognition Award of the American Medical Association.

EXPIRATION

This form must be completed and **postmarked by March 1, 1996**, for eligibility to receive continuing medical education credit for this continuing medical education activity.

INSTRUCTIONS

The consensus statement contains the correct answers to the following 14 questions. Select your answer to each question and write the corresponding letter in the answer space provided. Mail the completed test **no later than March 1, 1996,** to the address shown on the last page of this test. You will receive notification of your test results within 2 to 3 weeks. If you have successfully completed the test (10 or more correct), you will receive a certificate for 1 hour of CME credit along with your test results. Photocopies of this form are acceptable.

National Institutes Of Health
Continuing Medical Education

1. Optimal calcium intake refers to the levels of consumption that are necessary for an individual to:

   a) maximize peak bone mass
   b) maintain adult bone mass
   c) minimize bone loss in later years
   d) all of the above
   e) none of the above

   ANSWER:_____

2. The proportion of total body calcium that is found in bone is:

   a) 50 percent
   b) 75 percent
   c) 90 percent
   d) 99 percent

   ANSWER:_____

3. For which population group(s) did the NIH Consensus Development Panel recommend an optimal calcium intake level greater than the current Recommended Daily Allowance (RDA) for calcium? (Indicate all that are different)

   a) Infants 6 months through 1 year of age (RDA: 600mg)
   b) Middle-aged men and women (RDA: 800 mg)
   c) Postmenopausal women not taking estrogen (RDA: 800 mg)
   d) Men and women over the age of 65 years (RDA: 800 mg)

   ANSWER:_____

4. Peak bone mass is largely achieved by what age?

   a) 16 years
   b) 20 years
   c) 40 years
   d) 50 years

   ANSWER:_____

5. The calcium intake threshold for achieving optimal peak bone mass in adolescent and young adult women is approximately 1200 to 1500 mg of calcium per day. Population surveys of calcium intake revealed that women in these age groups (11 to 24 years) consume an average of:

   a) less than 500 mg per day
   b) less than 900 mg per day
   c) 1200 mg per day
   d) 1600 mg per day

   ANSWER:_____

6. The panel recommended two different levels of calcium intake for post-menopausal women depending upon whether or not they were taking estrogen replacement. The panel's recommendations were:

   With estrogen replacement/Without estrogen replacement

   a) 500 mg per day/1000 mg per day
   b) 800 mg per day/1200 mg per day
   c) 1000 mg per day/1500 mg per day
   d) 1500 mg per day/2000 mg per day

   ANSWER:_____

7. The panel recommended that elderly men and women (over age 65 years) consume 1500 mg of calcium per day because:

   a) 1,25 dihydroxyvitamin D production by the kidneys declines with age
   b) intestinal calcium absorption is reduced in the elderly
   c) bone mass continues to decrease with age
   d) all of the above
   e) none of the above

   ANSWER:_____

8. Indicate the statement(s) that is (are) true. The rapid loss of bone mass following immobilization: (You must indicate all that are correct.)

   a) is due to increased bone resorption and decreased bone formation
   b) is seen in patients placed on bed rest
   c) may occur in patients with para- and quadriplegia
   d) is best treated with increased levels of calcium intake

   ANSWER:_____

9. Indicate which factor(s) has (have) been found to reduce calcium absorption by the intestines. (You must indicate all that are correct.)

   a) diets high in sodium and animal protein
   b) diets high in oxalate, phytate, or wheat bran
   c) consumption of aluminum-containing antacids
   d) glucocorticoids

   ANSWER:_____

10. Which of the following is NOT a risk associated with increased calcium intake?

    a) Daily intake of calcium greater than 4000 mg per day may cause hypercalcemia, renal damage and ectopic calcium deposition.
    b) Increased intake of calcium clearly is associated with constipation.
    c) Some forms of calcium supplements decrease iron absorption.
    d) Calcium interferes with absorption of tetracycline antibiotics.

    ANSWER:_____

11. Based on currently available evidence, a range of calcium intake that appears to be safe for most people is up to:

    a) 1200 mg per day
    b) 1500 mg per day
    c) 2000 mg per day
    d) 3500 mg per day

    ANSWER:_____

12. Food sources with high bioavailability of calcium include all of the following EXCEPT:

    a) spinach
    b) broccoli
    c) canned fish
    d) nuts

    ANSWER:_____

13. Which of the following is a false statement regarding calcium supplements?

    a) Calcium carbonate absorption is improved when taken with certain foods in fasted individuals
    b) Calcium citrate requires gastric acid to be present for optimal absorption.
    c) For most individuals, absorption of calcium supplements is most efficient when they are taken between meals.
    d) Calcium suppelments are best absorbed when taken in doses of 500 mg or less.

    ANSWER:_____

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