Calcium intake levels in the United States: issues and considerations

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Calcium is a nutrient required for such essential functions as nerve conduction, muscle contraction and blood clotting. Maintenance of calcium within narrow serum and cellular levels is so important to critical biological functions that an elaborate control system has evolved for storage and release of calcium from the skeleton in response to need. Since calcium is the major mineral component of the skeleton, it also provides structural support to the body. Thus, adequate dietary intakes of calcium are critical to normal growth and development of the skeleton and teeth as well as essential physiologic functions.

During recent years calcium has received much attention, primarily because of its well-publicized relation to osteoporosis, a disabling disease which occurs late in life and more commonly affects women. Osteoporosis is characterized by low bone mass, with the internal structure of the bone eroded to the extent that even slight trauma will cause the bone to fracture easily. According to recent estimates obtained using World Health Organization (WHO) diagnostic criteria, in the United States approximately 4 million to 6 million older women and 1 million to 2 million older men have osteoporosis (Looker *et al*., 1997). Because life expectancy in the United States will soon average more than 80 years, it is anticipated that this disease will affect an even larger proportion of the United States population (Melton *et al*., 1992).

In 1994, the United States National Institutes of Health (NIH) sponsored a consensus conference on optimal calcium intake to consider in depth the levels of calcium intake that could be considered optimal not merely in terms of optimal growth, but in terms of disease prevention. The resulting consensus statement (United States National Institutes of Health, 1994) concluded that adequate calcium intake is critical to achieving optimal peak bone mass and modifies the rate of bone loss associated with ageing. The consensus panel recommended levels of calcium intakes for most age and gender subgroups even higher than the recommended dietary allowances (RDAs) used in the United States at that time (United States National Academy of Sciences, Food and Nutrition Board, 1989). More recently, the National Osteoporosis Foundation and several NIH institutes have urged the adoption of these higher dietary guidelines for calcium intake (Welton *et al*., 1995; Whiting and Wood, 1997).

This paper examines current dietary intakes of calcium by United States population groups in relation to the 1989 RDAs and the optimal calcium intake levels recommended at the 1994 Consensus Conference.[1] The objectives are to

REGULATING NUTRIENT CONTENT AND HEALTH CLAIMS ABOUT CALCIUM

The United States Food and Drug Administration (FDA) has played a part in making the public aware of the importance of adequate levels of calcium intake to delay the onset of this osteoporosis. In November 1990, the President of the United States signed into law the Nutrition Labeling and Education Act of 1990. This act mandated FDA to review available scientific information on ten nutrient-disease topic areas, including calcium and osteoporosis, and to issue regulations authorizing food manufacturers to make health claims on food packaging where appropriate. The calcium and osteoporosis health claim decision was based on the total publicly available scientific evidence and on significant scientific agreement among experts qualified by training and experience to evaluate the calcium and osteoporosis relationship. In January 1993 a regulation was finalized (United States FDA, 1993) which permits a health claim regarding calcium and osteoporosis on foods that contain at least 20 percent of the reference daily intake (RDI)[1] of calcium per standard serving (known as reference amount) if they also meet other conditions specified in the regulation. Other FDA regulations permit claims such as “good source of calcium” on foods that contain 10 to 19 percent of the RDI per reference amount and “high calcium” on foods that contain 20 percent or more.

[1] RDI is a reference standard developed by FDA for nutrition labelling purposes. The RDI for calcium is 1 000 mg.

[1] **Editor’s note:** After this paper was written the Food and Nutrition Board of the United States National Academy of Sciences proposed new recommendations for calcium in 1997 (see Table given by Heaney on page 7 of this issue).

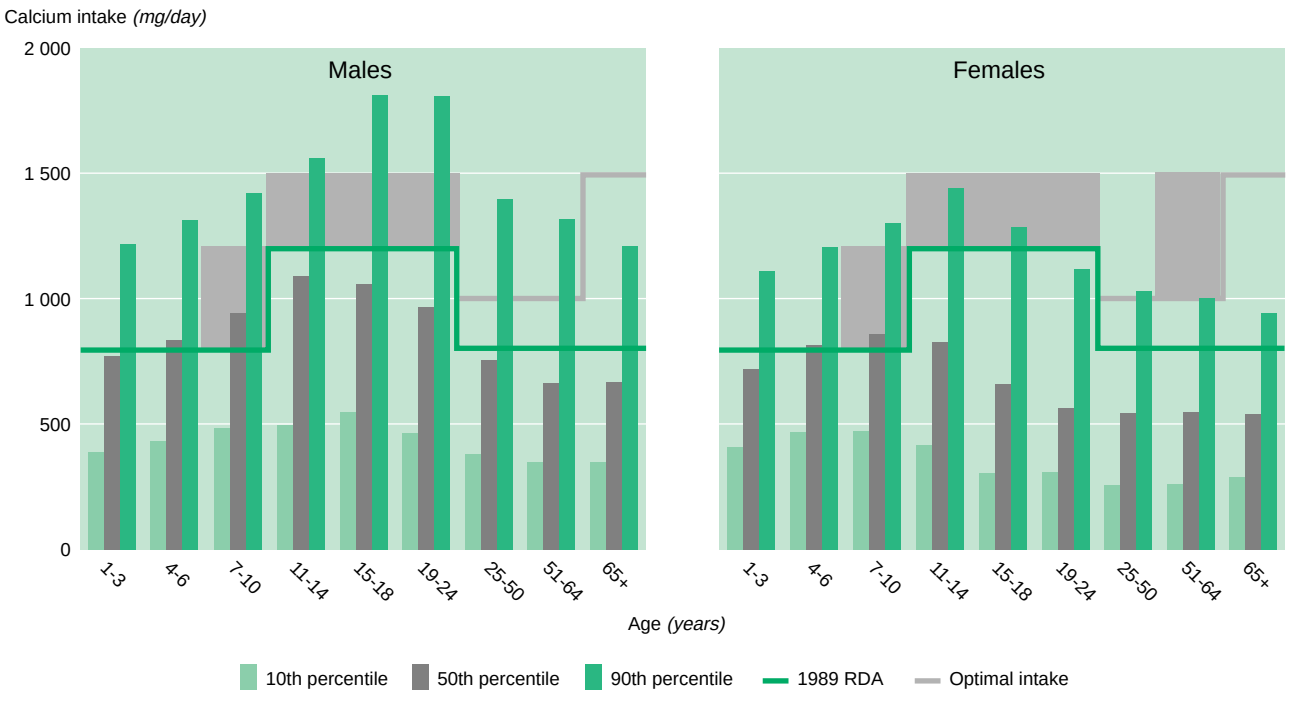
discuss some of the challenges that have been encountered in estimating calcium intake in the diverse United States population and to bring attention to several issues that need consideration in assessing nutrient intake status linked to a chronic disease in any population.

CURRENT DIETARY INTAKES OF CALCIUM IN THE UNITED STATES

Two large surveys conducted by the United States Federal Government provide nationally representative information on the kinds and amounts of foods consumed by the United States population: the Continuing Survey of Food Intakes by Individuals (CSFII), conducted by the United States Department of Agriculture (USDA), and the National Health and Nutrition Examination Survey (NHANES), conducted by the United States Department of Health and Human Services. Data from these surveys are used to estimate nutrient intakes by United States population groups. The two surveys usually show similar results. Because CSFII provides more extensive dietary intake data than NHANES (multiple-day versus one-day, respectively), CSFII is used here to estimate current dietary intakes of calcium by United States population groups. All dietary intake estimates are based on three-day dietary intake data for persons one year of age or older. All estimates were weighted by the weighting factors provided in the survey database to represent United States population estimates.

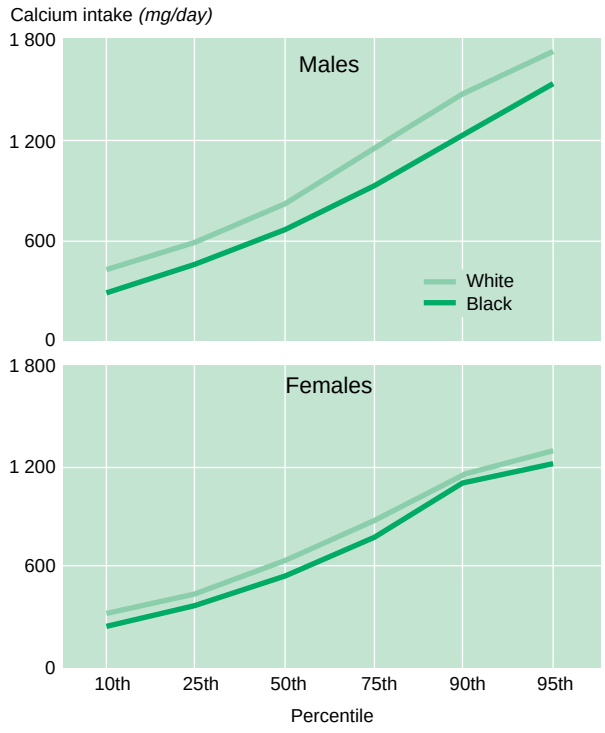
Intakes by age and gender group

Estimates of calcium intakes among males and females (divided into nine age groups and presented at the 10th, 50th and 90th percentiles) are compared with the 1989 RDAs and optimal intakes in Figure 1. The median intakes of boys and girls under 11 years of age essentially met the 1989 RDAs. Median intakes of women, particularly adolescent girls and young women, were far short of the 1989 RDAs. In contrast, median intakes of men were much closer to the 1989 RDA, ranging from 80 to 95 percent of the RDA. For all age groups and both males and females, except for women between the ages of 19 and 24 years, the 90th percentile intakes exceeded the RDA. However, a much smaller percentage of people of both genders in all age groups met the recommended optimal calcium intake level. With the exception of young children, median intakes of all age groups (both male and female) were lower than the recommended level and even the 90th percentile intakes of most adult women were short of the recommended level.



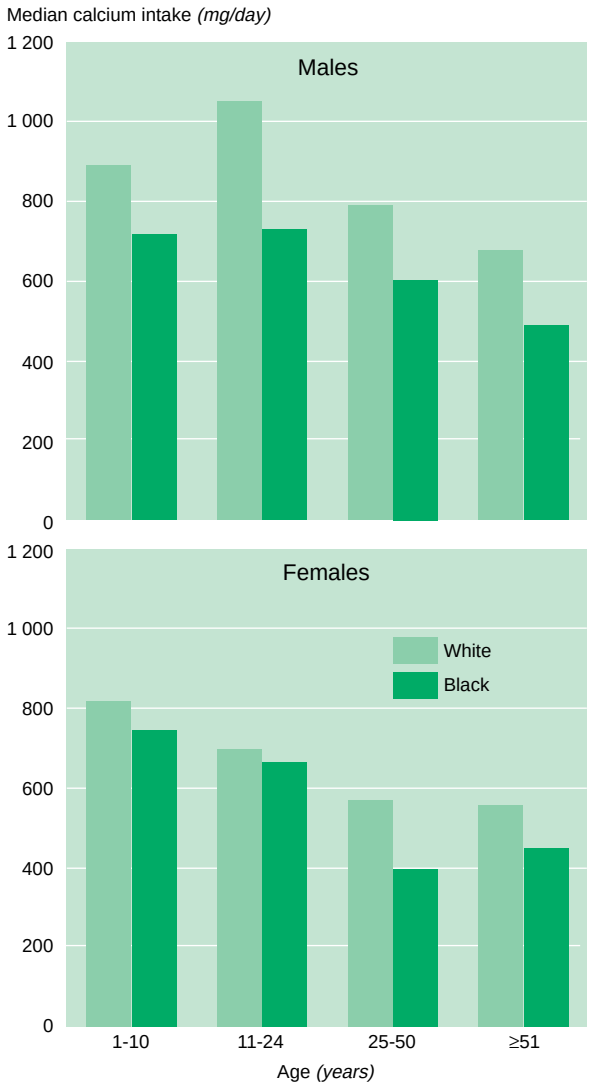
Source: Data from 1989-1991 CSFII.
Note: RDA = Recommended dietary allowances; Optimal intake = Calcium intake recommended at the 1994 optimal calcium intake consensus conference. Optimal intakes for young children are the same as RDAs. Optimal intakes for most age groups are given as a range and presented as an area.

1
Average daily intakes of calcium in the United States by age and gender (10th, 50th and 90th percentiles)



Source: Data from 1989-1991 CSFII.

2
Selected percentile average daily intakes of calcium in the United States by race and gender (excludes Hispanics)



Source: Data from 1989-1991 CSFII.

3
Median average daily intakes of calcium in the United States by race, age and gender (excludes Hispanics)

Intakes by race

For both men and women, blacks consumed less calcium than whites at all percentile levels; differences were greater for men than for women (Figure 2). For women, median intakes were lower for blacks than for whites in all age groups (Figure 3); racial differences in calcium intakes were particularly notable for women 25 years of age or older. In that age group the median intakes of black women corresponded to only about 70 to 80 percent of the median intakes of white women. The median calcium intakes of black women less than 25 years old were only slightly lower than those of white women. Similar age-related differences in median intakes were not observed in men; in all age groups, black men consumed only about 70 to 80 percent as much calcium as white men. The racial differences in calcium intakes reflect the generally lower consumption of milk and milk products by blacks (Federation of American Societies for Experimental Biology, 1995), which may be partially due to a higher prevalence of lactose intolerance among blacks.

Despite the lower calcium intakes of blacks, evidence from the third NHANES survey demonstrated significantly higher femoral density in black men and women than in whites (Looker *et al.*, 1995). There is also evidence of significantly lower hip fracture rates in blacks than in whites, particularly in women (Farmer *et al.*, 1984; Griffin *et al.*, 1992). The lower fracture rate has largely been attributed to higher peak bone mass in blacks. Racial differences in bone mass are apparent early in childhood (Luckey *et al.*, 1996; Gilsanz *et al.*, 1991), even with lower calcium intakes in black children. Other components of the diet that negatively affect bone accretion, such as inadequate protein intakes or high sodium intakes, do not appear to influence these racial differences.

Race and ethnicity are critical factors to consider in examining the adequacy of calcium intake and its specific disease association, osteoporosis. In the United States,

blacks represent a population subgroup for which genetic factors outweigh environmental influences such as diet. However, this racial difference is not necessarily universal and should be explored for each unique population.

Intakes by degree of urbanization

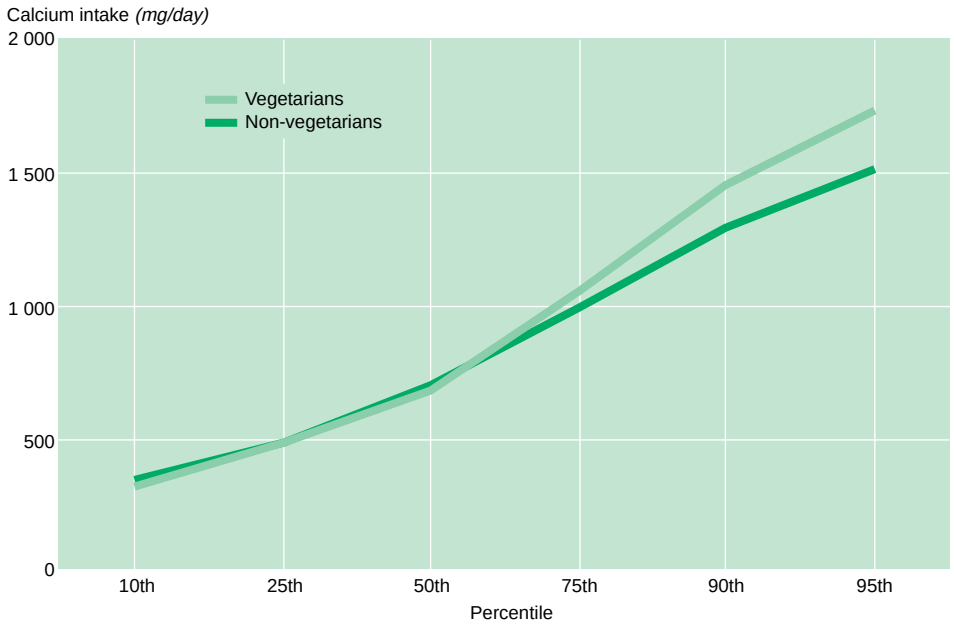
Examination of calcium intakes by degree of urbanization showed little difference among people living in city centres, suburban areas and non-metropolitan areas. This result is not surprising because in the United States, foods are shipped nationwide by large distributors. As a result, food availability is similar throughout the country, regardless of the degree of urbanization.

In developing countries calcium intakes might differ where the varieties and quantities of foods are more limited in less urbanized areas or where there is a large gap in income among people living in cities versus rural areas. Also, a possible lack of appropriate refrigeration in some rural areas of developing countries would limit the availability of the richest sources of calcium, fresh dairy foods.

Intakes of vegetarians versus non-vegetarians

USDA surveys conducted for all ages and for both males and females betweeen 1977 and 1995 show that the percentage of the United States population that is vegetarian, i.e. avoiding foods containing animal flesh, is increasing, particularly among women. It was thus of interest to analyse whether calcium intakes of vegetarians differ from those of non-vegetarians. The percentile distributions of calcium intakes among vegetarians versus non-vegetarians are shown in Figure 4. There was little difference between the two groups in the lower percentile values of intakes. For the upper percentiles, however, intakes among vegetarians were higher than those of non-vegetarians, reflecting the influence of lactovegetarians. In addition, the 1989-1991 CSFII showed that the use of vitamin and mineral supplements is more prevalent among vegetarians than among non-vegetarians (62 percent versus 38 percent, respectively). Not surprisingly, calcium intakes from supplements were higher for vegetarians than for non-vegetarians (Park *et al.*, 1997). Therefore, if calcium from supplements had been included in the calculations, the difference in intakes between the two groups would likely have been even greater.

Examination of food sources of calcium for the two groups showed that the major sources of calcium were similar for both groups: 51 to 52 percent of total calcium intakes were from milk and milk products and 25 to 27 percent from grain products. All other groups (meat, poultry and fish products; eggs and egg products; legumes, nuts and seeds; fruits and fruit products; vegetables and vegetable products; fats and oils; and sugars, sweets and beverages) contributed about 0.5 to 7.5 percent each for both vegetarians and non-vegetarians. Understandably, vegetarians obtained more calcium from legumes, nuts and seeds, fruits and fruit products and vegetables and vegetable products, whereas non-vegetarians



Source: Data from 1989-1991 CSFII.
Note: The 95th percentile value for vegetarians is potentially unreliable because of small sample size.

4
Selected percentile average daily intakes of calcium by vegetarians and non-vegetarians in the United States

obtained more calcium from meat, poultry and fish products.

The 1989-1991 CSFII also showed that vegetarians consumed about 10 g less protein per day than non-vegetarians, but that the majority of vegetarians consumed an amount equivalent to the RDA (0.8 g protein per kilogram desirable body weight for adults) or more, undoubtedly because of the wide availability in the United States of dairy products and foods of plant origin that are good sources of protein such as legumes, nuts, seeds and their products. In addition, vegetarians consumed on the average about 400 mg less sodium per day than non-vegetarians. Salt added at the table was not included in the estimates. However, the percentage of people who used salt at the table was lower for vegetarians than for non-vegetarians (50 percent versus 60 percent), which suggests that total sodium intakes including the amount used at the table would exhibit a greater difference between vegetarians and non-vegetarians. Although the differences are small, the combination of higher calcium, adequate protein and lower sodium intakes by vegetarians suggests that current dietary practices of United States vegetarians, particularly lactovegetarians, are conducive to optimal calcium absorption and retention. This may not necessarily be true for vegetarian dietary practices in other countries.

DIETARY VERSUS TOTAL CALCIUM INTAKES

The estimates of calcium intakes discussed above represent intakes from food only. They underestimate the true calcium intakes of the United States population for several reasons, as described below.

Underreporting of food intakes

Numerous studies suggest that individuals do not report their full energy intakes, i.e. food intakes, in self-reported food consumption surveys (Schoeller, 1990; Forbes, 1993). CSFII is a self-reported survey. The energy intakes reported in the 1989-1991 CSFII were substantially lower than the 1989 RDAs for energy (Crane *et al.*, 1995; Glinsmann and Park, 1995), which represent the average energy needs of individuals engaged in light to moderate physical activity with no safety margin. On the other hand, there is a prevalence of overweight in the United States; the third NHANES, conducted from 1988 to 1991, showed that 33 percent of adult men and women in the United States were overweight (Federation of American Societies for Experimental Biology, 1995). Underreporting of food intakes suggests that the calcium intakes estimated in the 1989-1991 CSFII are likely to be underestimates of the true dietary calcium intakes of the United States population.

Calcium-fortified foods

Since the authorization of nutrient content and health claims by the United States Food and Drug Administration (FDA) in 1993, many foods fortified with calcium at 10 percent of the reference daily intake (RDI) or more per serving have been introduced into the United States food supply. Informal market surveys in 1994 and 1996 showed an increasing availability of calcium-fortified foods (see Table). The majority of these products were introduced after the 1989-1991 CSFII; thus increased calcium intakes from the consumption of these fortified products were not reflected in the CSFII estimates.

Vitamin and mineral supplements

Many national surveys show that vitamin and mineral supplement use is widespread in the United States, with the proportion of users generally ranging from 35 to 40 percent of the population (Federation of American Societies for Experimental Biology, 1995). A National Health Interview Survey conducted in 1986 showed that about 20 percent of United States adults 18 years of age or older consumed supplements that contained calcium (Moss *et al.*, 1989). The same survey also showed that the potency of calcium-containing supplements varied widely (Park, Kim and Yetley, 1991). Although the median potency of products intended for consumption by adults was in a moderate range (150 to 300 mg per tablet), some products contained 600 mg or more of calcium per tablet.

Estimates of calcium intakes from the 1989-1991 CSFII do not include calcium from supplements. Using the frequency of supplement use estimated in the 1989-1991 CSFII, the median calcium potency of multinutrient supplements containing calcium and the daily dosage directions on

Examples of calcium-fortified foods commonly available in the United States[a]

Food	Amount of calcium *(mg/100 g)*
Milk	160-200
Meal replacements, milk-based	150-360
Meal replacements, fruit-based	70
Cottage cheese	170
Breakfast cereals, hot, dry	220-710
Breakfast cereals, ready to eat	270-830
Bread, light	330
Sweet bakery products	160-230
Cereal bars	540-870
Weight loss candy/bars	460-910
Apple sauce	160
Fruit juice	80-130
Fruit punch	60-130

[a] Based on an informal 1996 FDA market survey conducted in the Washington, DC metropolitan area, except for fruit punch. Some data on fruit punch came from the 1989-1991 CSFII.

single calcium supplements, it has been estimated that users of all types of supplements that contain calcium, i.e. both single and calcium-containing multinutrient supplements, would have consumed on the average about 300 mg of calcium per day from supplements.

Water

Water can be another source of calcium. The calcium content of ground and surface water used for human consumption in the United States varies widely. A two-phase survey conducted over 1989-1990 and 1991-1992 reported that the median calcium content in finished (i.e. treated for human consumption) ground and surface water ranged from 20 to 105 mg per litre and from 10 to 54 mg per litre, respectively (American Water Works Association, 1992). Estimates of calcium intakes from the 1989-1991 CSFII did not include calcium from drinking-water or water used to prepare food. As a result, calcium intake was underestimated, particularly for people who live in areas with hard water. For instance, in the midwestern United States calcium content of finished ground and surface water is typically as high as 100 and 50 mg per litre or higher, respectively (American Water Works Association, 1992).

Other sources of calcium

Drugs can also be a source of calcium. For example, some antacids (commonly used over-the-counter drugs in the United States) contain 200 to 400 mg of calcium per tablet or provide as much as 2 600 to 3 200 mg per recommended daily dosage. An analysis of data from NHANES III (unpublished) indicated that about 18 percent of United States adults 17 years of age or older use antacids in a form (tablet or capsule) that usually contains calcium.

Some prescription drugs also contain calcium, but their contributions to daily calcium intakes are likely to be minor because these medications are usually used on a short-term basis and the percentage of the population using prescription drugs containing calcium is likely to be small.

OTHER CONSIDERATIONS

Several other aspects of dietary practices should be considered in assessing calcium nutritional status.

Distribution of intakes

Studies frequently examine mean or median intakes but often fail to examine distributions of intakes within the group. People's food consumption patterns vary greatly, and as a consequence there is a wide variation in individual nutrient intake. For example, among 15- to 18-year-old girls, the lower 10 percent consumed about 300 mg or less of dietary calcium per day, while the upper 10 percent consumed more than 1 300 mg per day (Figure 1). Mean or median intakes alone are not sufficient to assess the adequacy or the safety of the calcium intakes of a population. In considering a change in public health policy, it is particularly important to examine distributions of intake to ensure that the change would favourably affect the target group (low-level consumers) while maintaining safe levels of intake for non-target groups such as upper-percentile consumers of calcium.

Nutrient interactions

Another safety aspect that should be kept in mind when fortification or supplementation programmes are under consideration is that no nutrient functions independently. The nature of the interactions with other nutrients must be defined. There is considerable evidence in experimental animals that excessive calcium intake can impair the nutritional status of other nutrients, especially magnesium, zinc and iron, but evidence in humans is not clear (Whiting and Wood, 1997). Some studies have reported deleterious effects of high calcium intakes on the nutritional status of these other minerals, while others have found no adverse effects. However, most of these clinical studies have been short term, and they have usually focused only on mineral availability or balance. More research, particularly in the form of long-term studies, is needed to determine any adverse effects of high calcium intakes on the status of other minerals in vulnerable populations.

The opposite consideration is that a number of dietary components can have an adverse impact on calcium. Western diets are typically high in protein and sodium. Low intakes of protein are associated with lower calcium absorption (Kerstetter, O'Brien and Insogna, 1997), while very high intakes of protein from animal sources are associated with higher rates of hip fracture (Abelow, Holoford and Insogna, 1992). High sodium intakes may increase the amount of calcium excreted in the urine and thereby increase the body's need for calcium (Massey and Whiting, 1996). Evaluation of protein and sodium intakes should be part of the assessment of calcium intakes in countries where protein or sodium intake are likely to be too low or excessive.

CONCLUSIONS

These efforts to estimate and evaluate calcium intakes among United States population groups illustrate a number of issues that need to be considered in evaluating national nutrition policy issues. These concerns are largely universal and should be emphasized when the intakes of any essential nutrient are estimated.

- Differences in intake among various racial and ethnic groups should be anticipated; however, they may reflect cultural preferences, as in the case of vegetarians, or genetic differences in tolerance or avoidance of specific foods such as dairy products.
- Care should be taken to resist overinterpreting the significance of estimates and their links to disease risks, and the results should be examined over the full distribution of intake, not merely in terms of means or medians.
- Surveys based on dietary recall or record reflect only the level of nutrient obtained from food. They do not account for other important sources such as vitamin and mineral supplement use, frequently used medications and drugs and water; nor do they account for the omnipresent underreporting of food intake or reflect current food fortification practices in the United States.
- Other aspects of the diet, notably those that facilitate efficient nutrient use or seriously hinder it, should be examined. Such factors as excessive sodium intake and inadequate protein intake, even with adequate intake of calcium, can have the same impact on calcium nutritional status as low calcium intake.
- Nutritional status of other nutrients could be impaired when they are consumed at low levels relative to calcium. This factor should be taken into account especially when policy decisions to raise dietary intake guidelines are being considered. ♦

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Summary/Résumé/Resumen

Calcium intake levels in the United States: issues and considerations

Increasing awareness of the importance of adequate calcium intake for the maintenance of bone, neuromuscular and cardiovascular health have stimulated recommendations to increase calcium intakes in the United States. Estimates of dietary calcium intakes of United States population groups have shown that the mean and median intakes of many age groups, particularly adolescent girls and adult women, are substantially lower than the 1989 recommended dietary allowances (RDAs) and the 1994 National Institutes of Health recommendations.

To increase public awareness of the importance of adequate calcium intakes, the United States Food and Drug Administration permits food manufacturers to make health claims regarding calcium and osteoporosis on food labels. Since such claims were authorized in 1993, many foods fortified with calcium, including products made from milk, cereals and fruits, have been introduced into the United States food supply. The consumption of fortified products, the use of calcium supplements and calcium from water (especially in hard-water areas) suggest that dietary surveys may underestimate calcium intakes in the United States.

A number of issues need to be considered in estimating the intakes of any essential nutrient and establishing nutrition policies. It is important to examine distributions of intake to ensure that a change in diet would benefit the target group while maintaining safe levels of intake for non-target groups. Designers of fortification or supplementation programmes should remember that no nutrient functions independently; the nature of interactions with other nutrients must be defined. Aspects of the diet that facilitate or seriously hinder efficient nutrient use should be examined. Nutrient intakes among various ethnic groups may reflect cultural preferences or genetic differences in tolerance of specific foods.

Apports en calcium aux Etats-Unis: questions et considérations

Aux Etats-Unis, on prend de plus en plus conscience de l'importance du calcium pour maintenir la santé des os et des systèmes neuromusculaire et cardiovasculaire, ce qui a conduit à l'adoption de recommandations visant à augmenter les apports calciques. Des estimations des apports alimentaires riches en calcium ont montré que les apports moyens et médians de nombreuses classes d'âge (particulièrement adolescentes et femmes) étaient nettement inférieurs aux apports alimentaires recommandés (AAR) de 1989 et aux apports préconisés par les instances nationales de la santé en 1994.

Afin de mieux informer les consommateurs des risques associés à une carence calcique, l'Office américain chargé de l'alimentation et des médicaments autorise les fabricants de produits alimentaires à attirer l'attention de la santé publique, par le biais de l'étiquetage, sur le lien existant entre ostéoporose et calcium. Depuis 1993 (année d'entrée en vigueur de cette autorisation), de nombreux aliments enrichis, y compris les produits laitiers, les céréales et les fruits, ont fait leur apparition sur le marché américain. La consommation de produits enrichis, l'utilisation de compléments en calcium et le calcium provenant de l'eau (en particulier dans les régions où l'eau est calcaire) donnent à penser que les enquêtes alimentaires sous-estiment les apports calciques aux Etats-Unis.

Un certain nombre de facteurs doivent être pris en compte lorsqu'on évalue l'apport de tout nutriment essentiel et qu'on institue des politiques de nutrition. Il est important de contrôler la répartition des apports pour s'assurer que le groupe ciblé puisse bénéficier du changement apporté à son alimentation tout en conservant un apport approprié aux groupes non ciblés. Les responsables de la conception des programmes d'enrichissement ou de complémentation devraient se rappeler du fait qu'aucun nutriment ne fonctionne indépendamment; la nature des interactions avec d'autres substances nutritives doit être définie. Les aspects de l'alimentation qui peuvent favoriser ou sérieusement entraver une meilleure utilisation d'un nutriment devraient être étudiés. Les apports nutritionnels peuvent refléter, chez divers groupes ethniques, des préférences culturelles ou des différences génétiques par rapport à la tolérance de certains aliments.

Niveles de la ingesta de calcio en los Estados Unidos: problemas y consideraciones

El reconocimiento cada vez mayor de la importancia de una ingesta suficiente de calcio para el mantenimiento del buen estado óseo, neuromuscular y cardiovascular ha alentado la formulación de recomendaciones sobre el incremento de dicha ingesta en los Estados Unidos. Las actuales ingestas media y mediana de calcio de muchos grupos de edad, en particular muchachas adolescentes y mujeres adultas, son considerablemente inferiores a los niveles dietéticos recomendados en 1989 y a las recomendaciones de los Institutos Nacionales de Salud de 1994.

Para sensibilizar al público sobre la importancia de una ingesta suficiente de calcio, la Administración de Alimentos y Medicamentos de los Estados Unidos ha autorizado a los fabricantes de alimentos a declarar las propiedades saludables del calcio para la osteoporosis. Desde que en 1993 se autorizó a declarar estas propiedades y el contenido de alimentos, se han introducido en el mercado alimentario de los Estados Unidos muchos alimentos enriquecidos con calcio. El enriquecimiento de productos a base de leche, cereales y frutas, la utilización de suplementos de calcio y el calcio contenido en el agua (especialmente en regiones donde el agua es dura) indican que es posible que en las encuestas alimentarias se subestime el nivel de la ingesta de calcio en los Estados Unidos.

Al estimar la ingesta de cualquier nutriente esencial y establecer políticas nutricionales es necesario tener en cuenta varias cuestiones. Es importante examinar la distribución de las ingestas para asegurarse de que un cambio en el régimen de alimentación beneficiaría al grupo destinatario, al tiempo que se mantendría un nivel de ingesta adecuado para los grupos restantes. Los encargados de formular programas de enriquecimiento o suplementación deben recordar que ningún nutriente actúa de modo independiente; es necesario definir la naturaleza de las interacciones con otros nutrientes. Han de examinarse los aspectos de la alimentación que facilitan un uso eficaz de los nutrientes o lo obstaculizan gravemente. Las discrepancias en las ingestas de nutrientes de diversos grupos étnicos pueden deberse a preferencias culturales o a diferencias genéticas en cuanto a la tolerancia a determinados alimentos. ◆