Calcium and Vitamin D Intakes
In an Adult Canadian Population

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Abstract

Purpose: Calcium and vitamin D intakes from food and supplements were estimated in Canadian men and women.

Methods: Calcium intakes from both diet and supplements and vitamin D intakes from fortified milk and supplements were estimated using cross-sectional data from 9423 randomly selected subjects aged 25 years or older, who were participating in a longitudinal study on osteoporosis. Subjects completed an abbreviated food frequency questionnaire administered by a trained interviewer between July 1995 and December 1997.

Results: The mean (standard deviation) daily intake for calcium was estimated to be 1038 (614) mg for women and 904 (583) mg for men; for vitamin D, mean intakes were 5.6 (5.9) µg and 4.8 (5.5) µg for women and men, respectively.

Conclusions: Mean intakes for calcium and vitamin D in men and women under age 51 were close to the adequate daily intake levels. Older adults, however, may be at risk of deficiency.
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Résumé

Objectif. Les apports en calcium et vitamine D provenant de l'alimentation et des suppléments ont été évalués chez des Canadiens et Canadiennes.

Méthodes. Les apports en calcium provenant tant de l'alimentation que des suppléments et les apports en vitamine D provenant du lait enrichi et des suppléments ont été estimés à l'aide de données transversales de 9423 sujets de 25 ans ou plus choisis au hasard, qui participaient à une étude longitudinale sur l'ostéoporose. Entre juillet 1995 et décembre 1997, les sujets ont rempli un questionnaire abrégé de fréquence alimentaire administré par un intervieweur entraîné.

Résultats. L'apport quotidien moyen (écart type) de calcium a été estimé à 1038 (614) mg chez les femmes et à 904 (583) mg chez les hommes; pour la vitamine D, les apports moyens se chiffraient à 5,6 (5,9) µg et 4,8 (5,5) µg respectivement pour les femmes et les hommes.

Conclusions. Les apports moyens en calcium et en vitamine D chez les hommes et les femmes de moins de 51 ans étaient proches des apports quotidiens suffisants. Cependant, les adultes plus âgés peuvent se trouver à risque de carence.
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INTRODUCTION

Calcium and vitamin D are essential nutrients for increasing peak bone mass and for minimizing age-related bone loss, and for thereby decreasing the risk of osteoporosis and low-trauma fractures (1,2). In the past few years, there has also been interest in the role that vitamin D can play in reducing the risk of chronic diseases, such as some forms of cancer, autoimmune diseases, infectious diseases, and cardiovascular disease (2). In the late 1980s,

both calcium and vitamin D were recognized as necessary to reduce the risk of hip fractures. Chapuy et al.'s clinical trial of calcium and vitamin D versus double placebo showed reductions in both hip and non-vertebral fractures (3). The authors thus concluded that supplementation with vitamin D_3 and calcium reduces the risk of hip fractures and other non-vertebral fractures among elderly women. In the Nurses' Health Study, a prospective study (18 years of follow-up) of postmenopausal women, a lower risk of hip fracture was observed among women with higher calcium intake accompanied by higher vitamin D intakes (4). In 2000, Heaney (1) reviewed 139 papers published since 1975, in which the relationship between calcium intake and bone health was described. Of the 52 randomized, controlled trials, all but two showed better bone balance, greater bone gain during growth, reduced bone loss in the elderly, or reduced fracture risk at higher intakes. In the 86 observational studies, 65 (over 75%) showed a positive association between calcium intake and bone mass, while 17 (20%) showed no effect.

A cohort of 9423 men and women was recruited for the study.

Calcium must be consumed from an exogenous source, whereas vitamin D, a key component in the stimulation of intestinal calcium absorption, can be synthesized by the body through exposure to the sun's ultraviolet (UV) rays. Season, geographic location, age, use of sunscreens and clothing to block UV light, and skin pigmentation all influence the cutaneous production of vitamin D (1,5,6). Alternatively, vitamin D in the form of vitamin D_3 or as the plant-derived form vitamin D_2 (ergocalciferol) may be absorbed from the diet. The main natural food source of vitamin D is fatty fish, such as salmon and mackerel, and liver oils, such as cod-liver oil (7). In Canada, milk and margarine are fortified with vitamin D.

The Standing Committee on the Scientific Evaluation of Dietary Reference Intakes (DRIs) (8) reported an Adequate Intake (AI) level of 5 µg/day (200 IU/day) for vitamin D in men and women aged 19 to 50 years; the level is 10 µg/day (400 IU/day) for men and women aged 51 to 70 years, and 15 µg/day (600 IU/day) for men and women older than 70. The committee recommended that AI levels for calcium be set at 1000 mg/day for men and women aged 19 to 50 years, and at 1200 mg/day for those 51 years or older.

PURPOSE

In 1997 to 1998, Gray-Donald et al. (9) studied a sample of 1544 Canadian respondents aged 18 to 65 years, for which they provided data on calcium but not on vitamin D intake because of gaps in the nutrient composition file at that time. There is an important gap in the knowledge about calcium and vitamin D intakes in older populations, and of vitamin D intakes in Canadian adults. In this study we estimated calcium and vitamin D intake from specific foods and the contribution of supplements to total intake in Canadian adults.

METHODS

We used data from the Canadian Multicentre Osteoporosis Study (CaMos), a longitudinal observational study including a random sample of 9423 men and women aged 25 and over who had been recruited in nine cities across Canada, to estimate calcium and vitamin D intakes. Further details on the rationale and methods for CaMos have been reported previously (10). These intakes are compared with the reference values for dietary nutrient intakes for the healthy population in Canada and the United States; these reference intakes are set to maximize peak bone mass during growth and to minimize bone loss after the peak has been reached (1). This comparison, therefore, will provide an indication of the population subgroups that may need to be targeted for programs aimed at improving bone health through improved nutrition.

Data collection

The sampling frame used for CaMos was a list of randomly selected non-institutionalized residential telephone subscribers residing within a 50-km radius in each of nine study centres within Canada (Vancouver, Calgary, Saskatoon, Toronto, Hamilton, Kingston, Quebec City, Halifax, and St. John's). More women than men were recruited because the sample size calculations were based on accurately estimating the prevalence of fractures, which was believed to be higher in women. Ethics approval was obtained in each of the nine centres and in the coordinating centre in Montreal. Signed informed consent was obtained from all study participants. A cohort of 9423 men and women was recruited for the study between July 1995 and September 1997.

Information on dietary calcium intake was obtained from an interviewer-administered, abbreviated semi-quantitative food frequency questionnaire (FFQ). Interviewers were provided with food models to assist participants in estimating the portion size of each food. The semi-quantitative FFQ included only the foods considered to be excellent sources of calcium. The study instrument was not validated in the population for which it was used; however, sufficiently high agreement between FFQs or food record methods and 24-hour recalls has been demonstrated repeatedly, and so assessing dietary calcium intake or determining adequacy of intake is possible using FFQs (11-14). Nevertheless, there is some underestimation because low levels of calcium are present in other foods as well.

All foods listed in the abbreviated FFQ were classified into four groups based on the type of food: milk to drink (milk on cereal, milk in tea and coffee), milk products (milk desserts, cheese, yogourt, ice cream, cream soups), other foods (canned salmon, broccoli, dark leafy greens, dried peas or beans, whole wheat bread, white bread, tofu), and supplements. Vitamin D intake was estimated according to use of supplements and fluid milk fortification only. An estimate of calcium and vitamin D intake

Table 1
Participant characteristics: baseline means and medians, by gender

	Women (n=6539)		Men (n=2884)	
Variable	**Mean (SD)**	**Median (IQR)**	**Mean (SD)**	**Median (IQR)**
Age	63.1 (12.8)	65 (55, 72)	59.9 (14.5)	62 (50, 71)
Weight (kg)	68.6 (13.9)	67 (59.0, 76.4)	81.5 (14.1)	80 (72.0, 89.0)
Body mass index (kg/m^2)	26.9 (5.2)	26.3 (23.2, 29.7)	27.0 (4.1)	26.6 (24.3, 29.2)
Calcium from milk (mg/day)	397 (362)	304 (136, 565)	429 (425)	311 (145, 576)
Calcium from milk products (mg/day)	279 (250)	226 (112, 370)	259 (247)	204 (96, 336)
Calcium from other foods (mg/day)	114 (86)	96 (66, 141)	133 (114)	113 (74, 165)
Calcium from supplements and medications (mg/day)	248 (402)	0 (0, 440)	83 (237)	0 (0, 0)
Total calcium (mg/day)	1038 (614)	930 (589, 1360)	904 (583)	774 (507, 1155)
Vitamin D from supplements (µg/day)	2.9 (5.0)	0 (0, 5.0)	1.8 (4.2)	0 (0, 0)
Vitamin D from milk (µg/day)	2.7 (2.9)	1.8 (0.4, 3.8)	3.0 (3.5)	2.1 (0.5, 3.9)
Total vitamin D from milk and supplements (µg/day)	5.6 (5.9)	3.2 (1.1, 9.4)	4.8 (5.5)	2.6 (0.8, 7.5)

IQR=interquartile range; n=number; SD=standard deviation

from non-food sources was obtained from the current use of vitamin and mineral supplements. The interviewer recorded this information from the supplement bottles that participants brought to the interview.

A central office was responsible for entering the questionnaire data into an electronic database. Blinded repeat data entry was conducted, and the error rate was found to be less than 1%.

The calcium content of the foods listed in the abbreviated FFQ was calculated from dietary data collected at the recruitment interview, using the 1997 Canadian Nutrient File data included in Food Processor II (version 5.03, ESHA Research, Salem, OR, 1992).

Statistical analyses

Means, standard deviation (SD), and medians with interquartile ranges were calculated. Estimates of the mean calcium intake (SD) in milligrams per day from all sources and mean contribution from milk, milk and milk products, other foods, and supplements were stratified by gender and age (men and women aged 25 to 50, 51 to 70, or older than 70) and by centre (Calgary, Halifax, Hamilton, Kingston, Quebec City, Saskatoon, St. John's, Toronto, or Vancouver). Similarly, estimates of the mean vitamin D intakes (SD) in micrograms per day from fluid milk and from supplements were stratified by gender, age, and centre. SAS (version 9.1 for Windows, SAS, Cary, NC, 2002-2003) was used for the analyses.

RESULTS

The vast majority of female and male participants identified themselves as being white: 6263 (95.8%) women and 2683 (93.0%) men. Women's mean age was slightly higher than men's (Table 1). Mean age was comparable across centres. Mean body mass index was similar for both women and men.

The distributions of calcium and vitamin D intakes were asymmetrical, and so medians and interquartile ranges are also reported. Mean calcium and vitamin D intakes were similar for women and men. The proportion of men using dietary supplements was lower than that of women for calcium (22.6% versus 43.7%) and for vitamin D (19.7% versus 32.4%).

We examined the total calcium intake in each of the nine centres. Among women, the centre with the highest reported mean total calcium intake (SD) was Saskatoon, with 1218 (636) mg/day, a finding that was mostly owing to a higher contribution from calcium supplements on average. Quebec City had the lowest mean total calcium intake at 895 (546) mg/day because of a lower intake of milk and supplements. For men, the centre with the highest mean calcium intake was Calgary, with 1034 (616) mg/day. The centres with the lowest mean calcium intakes were Quebec City with 795 (542) mg/day and Toronto with 779 (554) mg/day.

Vitamin D intake was calculated from reported use of dietary supplements and from the fortification of milk (2.5 µg per 250 mL of fluid milk). We excluded 94 women and 11 men who reported using vitamin D supplements exceeding 25 µg/day, because we considered these to be therapeutic levels and we were interested in reporting average supplement use. In women, the highest mean vitamin D intake was reported in Saskatoon, with 7.3 (6.4) µg/day, while the centres with the lowest reported intakes

Table 2
Mean and median calcium and vitamin D intake, by age group and gender

	Calcium in mg/day[a]				Vitamin D in µg/day[b]			
	Women		Men		Women		Men	
Age group (years)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
	n=1068		n=754		n=1068		n=743	
25-50	961 (581)	840 (552, 1236)	918 (610)	771 (522, 1168)	4.6 (5.2)	2.6 (0.5, 7.1)	4.6 (5.6)	2.6 (0.7, 6.3)
	n=3508		n=1380		n=3493		n=1371	
51-70	1063 (631)	949 (602, 1374)	908 (581)	783 (508, 1155)	5.7 (6.1)	3.6 (1.1, 10.0)	4.8 (5.3)	2.7 (0.8, 7.5)
	n=1963		n=750		n=1956		n=744	
>70	1035 (598)	944 (588, 1388)	884 (557)	762 (488, 1138)	5.8 (6.0)	3.6 (1.3, 10.0)	5.0 (5.7)	2.7 (1.1, 7.5)

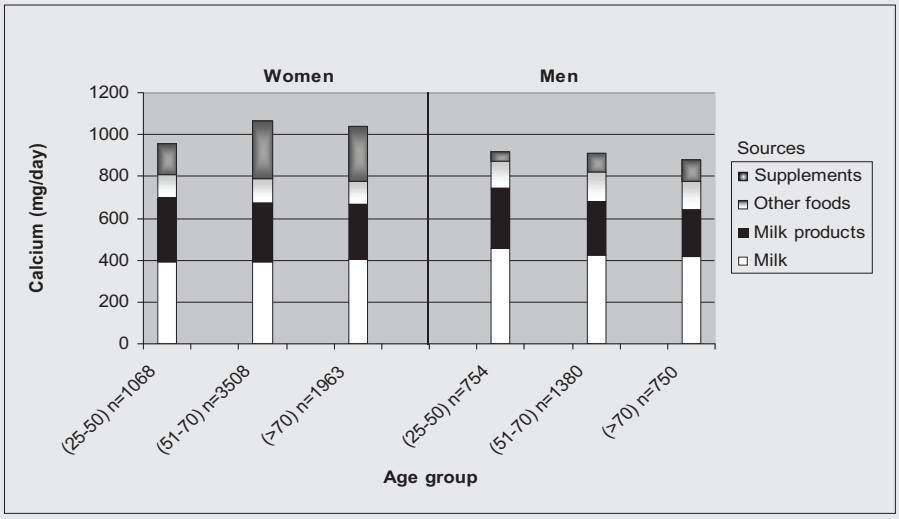
IQR=interquartile range; n=number; SD=standard deviation
[a]Calcium Adequate Intakes for men and women: age 25-50, 1000 mg/day; age 51-70, 1200 mg/day; age >70, 1200 mg/day
[b]Vitamin D Adequate Intakes for men and women: age 25-50, 5 µg/day; age 51-70, 10 µg/day; age >70, 15 µg/day

were Quebec City, with 4.2 (5.0) µg/day, and St. John's, with 4.7 (5.3) µg/day. The highest mean vitamin D intake for men was in Saskatoon, at 6.0 (5.8) µg/day, while the lowest reported mean vitamin D intake was in Quebec City, St. John's, and Toronto, at the level of 3.4 (4.4), 4.2 (5.4), and 4.5 (5.8) µg/day, respectively.

In Table 2, the mean and median calcium and vitamin D intakes by age- and sex-specific groups are presented for comparison with the DRIs. Men and women in the 51 to 70 and the over 70 age groups had a mean daily calcium intake below the 1200 mg/day recommended intake. Younger women and men aged 25 to 50 were closer to the recommendation. Similarly, both women and men aged 25 to 50 had reported mean vitamin D intakes close to the AI, but intakes were well below the AI levels in the two older age groups.

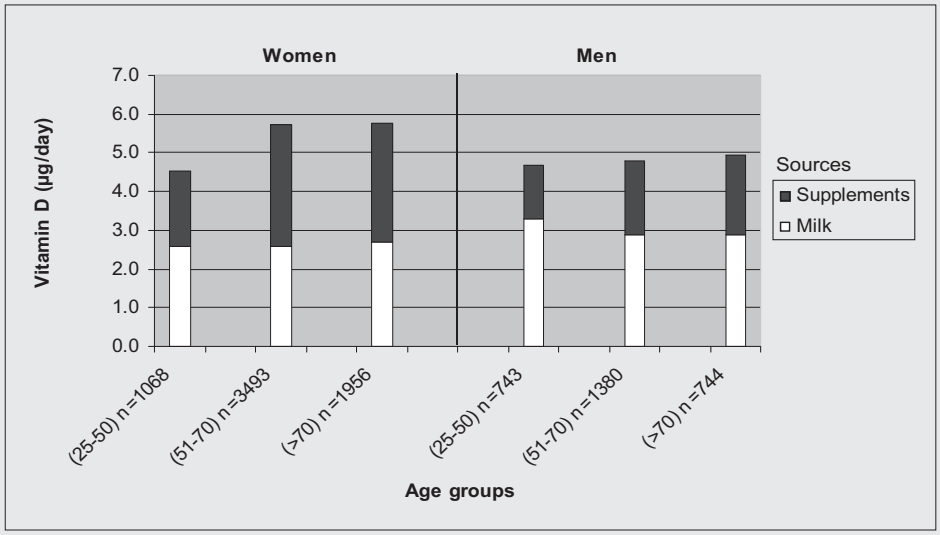
Figure 1 gives a breakdown of the sources of calcium by age group. The higher total calcium intake in women over age 50 was attributable to higher intakes of supplements.

Figure 1
Mean calcium intake and sources for women and men, by age group



n=number

Figure 2
Mean vitamin D intake and sources for women and men, by age group



n=number

We observed higher intakes of vitamin D in the older age group of women (Figure 2), while in men intake was stable across age groups. The difference between the intakes in men and women was attributed to a greater use of vitamin D supplements in women, although women consumed less milk than men did.

DISCUSSION

Younger versus older groups

For younger age groups, mean calcium and vitamin D intakes were close to the AI levels for both women and men. As requirements increase for the older age groups, their needs are more difficult to meet through diet alone and the use of supplements may be required. Several studies from other countries (9,15-19) have also shown that women over age 50 are at increased risk of failing to meet the recommended daily intake for calcium.

Our results confirm the Health Canada recommendation (20) that people over age 50 need a vitamin D supplement, particularly as it is not advisable or possible to rely on UV light to maintain adequate vitamin D status. The mean (SD) daily intakes for vitamin D, as reported in CaMos, were below the AI for both women and men over age 50 and are lower than those reported by Moore et al. (21). Data from the third National Health and Nutrition Examination Survey (NHANES III), in which a 24-hour dietary recall was used to assess nutrient intake, indicate that the usual mean vitamin D intake was reported to be 8.37 (14.2) µg/day from food and supplements in women and 8.11 (9.0) µg/day in men (21). The lower vitamin D intake in this study—mean intake of 5.6 (5.9) µg/day for women and 4.8 (5.5) µg/day for men—may be explained to a small degree by the failure to record consumption of fatty fish, margarine, and egg yolk intake.

We further compared our results with those of NHANES III for non-Hispanic whites, by stratifying the CaMos data into two age groups (25 to 50 and 51 or older), as was done in a subsequent study by Moore et al. (22). In our Canadian study, a higher intake of vitamin D from fortified milk was reported by both genders and age groups, with the exception of men 51 and older, who reported similar intakes. In NHANES II, vitamin D intake from supplements was found to be higher for both age groups and genders. Fewer investigators have examined mean vitamin D intake in men (16,21,23), but those who have also found that mean intakes were below the AI after age 50.

Study limitations

The limitations of this study need to be considered. Self-reported food intake can be unreliable and difficult to validate because of day-to-day fluctuations in intake and intake-related bias associated with a tendency to overestimate low intakes of healthy foods and underestimate high intakes of unhealthy foods (24). In our study, we attempted to reduce measurement errors due to inaccurate estimates of portion sizes by using food models and by having an interviewer administer the questionnaire, rather than permitting participants to complete the questionnaire on their own.

The frequency of consumption of calcium-rich foods (milk, milk products, and other calcium-rich foods) was captured by our instrument, but calcium-poor foods were not included. If these foods are eaten often or in large amounts, they will increase the total dietary intake of calcium. In 1996, Canada Food Stats indicated that dairy products represented 71% of the daily per capita calcium available from the Canadian food supply, while other foods (cereals, eggs, fish, meat and poultry, fruits and vegetables, nuts, oils and fats, and sugars and syrups) supplied the

remaining 29% (25). Calcium intake estimates therefore probably would have been greater had a more exhaustive list of foods been included.

Comparing CaMos mean calcium intakes (excluding vitamin and mineral supplements) with those recently released by Health Canada from the Canadian Community Health Survey (CCHS) (26), we found similar mean values for women: 790 mg/day versus 793 mg/day; values were slightly lower for men at 821 mg/day versus 931 mg/day. The nutritional data in CCHS were collected from a representative Canadian sample of 18,820 participants over age 19, using a 24-hour dietary recall. A comparison between CaMos and CCHS on the use of vitamin and mineral supplements is not possible as these data are not currently available in the CCHS data tables, but both studies indicate that calcium intake from food alone appears to be below AI levels in Canadians over age 50.

In our estimation of vitamin D from milk, we have presumed that there is little variation in the content of vitamin D in milk. Several studies have revealed that the amount of vitamin D actually present in the milk supply in Canada and the United States is variable (27,28). However, this should not affect overall averages, assuming that variations are about the assumed mean values.

Although we used the 1997 DRIs to determine adequacy of calcium and vitamin D intakes, our data were collected between 1995 and 1997 when recommended intakes for calcium in adults over age 19 were lower (700 mg/day for women and 800 mg/day for men) (29). The previous Recommended Nutrient Intake for vitamin D was 2.5 µg/day (100 IU) and 5.0 µg/day (200 IU) for women and men aged 19 to 49 and aged 50 and over, respectively (29). Therefore, mean calcium and vitamin D intakes were adequate according to the 1990 guidelines. The situation today may have improved further because more calcium-fortified items (e.g., fortified juices, plant beverages, fluid milk with additional calcium) are now available.

The response rate for CaMos was 42%. This is not surprising because we were asking healthy subjects to spend much time in hospitals over a five-year period. Most nonparticipants likely declined participation for reasons far removed from their food intake. In addition, the issue of non-response bias was addressed in detail with other outcomes in our data; for example, for osteoporosis prevalence we found little evidence for bias (30). Thus it might be reasonable to expect little bias for intakes.

The importance of food choices

Our results suggest how Canadian food choices affect the ability to meet calcium and vitamin D recommended intakes. The message aimed at menopausal women (aged 50 to 70) to meet their calcium requirements appears to have been heard and understood, as 57% of women aged 51 to 70 reported taking a calcium supplement; the proportion was 11% in the 25 to 50 age group and 32% in the group over age 70. In women, the average consumption of milk for all age groups was approximately 300 mL (360 mg of calcium). This concentrated source of calcium provides about 40% of total calcium intake in women and in the two older groups of men. In men, the daily serving of milk rises slightly above 300 mL. Women and men over age 50 are falling short of meeting their calcium needs.

Milk is the only food included in our study to quantify vitamin D from the diet. On average, women in the youngest age group were receiving 60% of their daily vitamin D intake from milk, while women in the two older groups were receiving 45% from milk. In men over age 25, milk provided an average of 65% of the daily vitamin D intake. Those over age 50 appear to be having difficulty meeting their vitamin D requirements.

RELEVANCE TO PRACTICE

Our data suggest that adequate calcium intake is difficult to achieve over age 50, even though 25% of men and 46% of women are consuming supplements. For the same age group, our data supports the Health Canada recommendations that vitamin D supplements are needed to meet recommended intakes, particularly as UV light is insufficient to maintain adequate vitamin D status for at least half the year at Canadian latitudes (20). Consumption of good sources of calcium and vitamin D needs to be encouraged in the entire population. Examples of good sources are fortified milk and alternatives and at least two servings of fish a week.

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