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Despite mandatory fortification of staple foods, vitamin D intakes of Canadian children and adults are inadequate☆

Hassanali Vatanparast*, Mona S. Calvo, Timothy J. Green, Susan J. Whiting

College of Pharmacy and Nutrition, University of Saskatchewan, 110 Science Place, Saskatoon, SK, Canada S7N 5C9

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ABSTRACT

Vitamin D is largely obtained through sun-induced skin synthesis and less from dietary sources, but during Canadian winters, skin synthesis is non-existent. The objective of this study was to estimate vitamin D intakes in Canadians from food sources. Data used in this study included food intakes of Canadians reported in the 2004 Canadian Community Health Survey Cycle 2.2 (CCHS 2.2), a nationally representative sample of 34,789 persons over the age of 1 year. The mean ± SD dietary intake of vitamin D from food of Canadians was 5.8 ± 0.1 μg/day, with males 9–18 years having the highest mean intakes (7.5 ± 0.2 μg/day) and females 51–70 years having the lowest intakes (5.2 ± 0.3 μg/day). Males in all age groups had higher intakes than females and White Canadians had higher vitamin D intakes than Non-Whites in most age sex groups. Milk products contributed 49% of dietary vitamin D followed by meat and meat-alternatives (31.1%). The majority of Canadians consume less than current recommended intake of vitamin D from food. Consideration should be given to strategies to improve vitamin D intake of Canadians by increasing both the amount of vitamin D added to foods and range of foods eligible for fortification.

1. Introduction

The prevalence of severe vitamin D deficiency leading to rickets in children is low in Canada relative to other countries; however, it is not yet eradicated even though milk consumption has not declined in Canadian children and fortification of milk and milk substitutes with vitamin D is required [1,2]. Also of growing public health concern is that vitamin D insufficiency, i.e., vitamin D status not severe enough to cause rickets or osteomalacia in adults, increases the risk of osteoporotic fracture [3–5]. Further, low vitamin D status has also been significantly associated with a number of non-skeletal outcomes such as increased fall incidence, poor dental health, and increased risk of Types 1 and II diabetes, other autoimmune disorders, as well as certain types of cancer [6,7]. Further, studies report that vitamin D supplementation in elderly reduces the risk of fall [8–9]. There is a very high prevalence of vitamin D insufficiency, particularly during the winter, in the general otherwise healthy Canadian population [10–12].

Vitamin D is synthesized in the skin through the action of ultra-violet light or is obtained from dietary sources. In Canada, during the winter, skin synthesis of vitamin D is severely limited or non-existent and thus the population is reliant on dietary sources [10,13]. This is concerning because the population does not frequently consume the few foods that are naturally high in vitamin D such as fatty fish. Further, the number of foods in Canada that are fortified with vitamin D is limited mainly to milk and margarine which are mandatory [14]. Other food sources include meats, fortified fruit juice, and eggs.

Given the widening spectrum of diseases associated with vitamin D inadequacy, the high prevalence of suboptimal status, and our reliance on dietary sources of this vitamin, we estimated national vitamin D intakes from food in the 2004 Canadian Community Health Survey Cycle 2.2 (CCHS 2.2). We also compared vitamin D intakes with current dietary guidelines for vitamin D intake: 15 μg/day for those greater than 70 years, 10 μg/day for those 50–70 years, and 5 μg/day for the rest of the population [15]. As American national surveys show that vitamin D intake is markedly lower in Non-Hispanic Blacks (NHB) and Mexican American adults than Non-Hispanic Whites (NHW) [16], we compared vitamin D intake of Caucasian Canadians to the vitamin D intake of other Canadians. The vitamin D intake from food was examined according to income, education, food security status and chronic disease conditions. Finally, we determined vitamin D intakes of Canadians from the main food groups.

2. Methods

The 2004 Canadian Community Health Survey Cycle 2.2 (CCHS 2.2) was designed to collect nationally representative information about food and nutrient intakes of Canadians. This cross-sectional

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* Corresponding author. Tel.: +1 306 966 5831; fax: +1 306 966 6377.
E-mail address: vatan.h@usask.ca (H. Vatanparast).

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survey did not include people living in institutions, in the territories, individuals living in aboriginal reserves and crown lands and some remote areas, members of the regular Canadian Forces as well as residents of Canadian Forces bases—military or civilian. The CCHS survey design, recruitment procedures and details of methodology have been reported in detail elsewhere [17,18]. The Cultural/racial origin of participants was initially categorized in 13 groups. We made a derived variable summarizing this into two categories, Caucasian and Other (all other ethnic groups).

Dietary data were collected from each participant during a face-to-face interview using a computer-assisted 24-h recall from 35,107 participants between January to December 2004. A second recall was collected 3–10 days later from a subset of about 30% of participants (n = 10,786). Response rates were 76.5 and 72.8%, respectively. We used the modified version of SIDE-IML provided by Statistics Canada to obtain adjusted values for vitamin D intake (thus estimates of usual intake) and consequently the percentage of populations meeting the recommended value of vitamin D from food. We report the mean vitamin D intake values using the initial 24-h recall as this allowed us to collapse the 15 age/sex groups into nine. The nutrient content of the diets were calculated using several sources: the Canadian Nutrient File; a recipe database; and a survey foods database, containing foods or local foods not in the other databases, which includes vitamin D found in meats [17,18].

Sampling weights were used in all analyses to obtain unbiased estimates of population quantities. The bootstrap method was used to estimate standard errors, coefficients of variation and confidence intervals [18]. We derived dietary vitamin D intake from food groupings [18], using data from the initial 24-h recall. Means and standard errors were calculated for each age, sex, and ethnic group. The difference in vitamin D intake from food was evaluated between groups by comparing 95% confidence intervals. No overlap in 95% confidence intervals was considered significant difference (p < 0.05) [18].

3. Results

Dietary intakes of vitamin D by age, sex, and race are given in Table 1. The mean ± SEM dietary intake of Canadians was 6.2 ± 0.1 μg/day, with males 9–18 years having the highest mean intakes (7.3 ± 0.1 μg/day) and females 51–70 years having the lowest intakes (5.1 ± 0.3 μg/day). Males in all age groups under 70 years had higher intakes than females in the corresponding age group (p < 0.05). The only ethnic difference was seen for Caucasian Canadian males 9–18 years having a higher vitamin D intakes than 9–18 years Other Canadian males. However, there were many sex differences in intake for females. In comparing intakes to current adequate intake (AI) for dietary vitamin D intake by sex and age, more than 60% of children aged 1–8 years met their AI value (5 μg/day) for vitamin D from foods. From age 9–30 years, the percent of males who met their AI (5 μg/day) from foods is more than for females. While 20% of males aged 51–70 years met their AI value (10 μg/day) from foods, only 8% of females did. In the age group over 70 years, less than 5% of males and females met their AI for vitamin D (15 μg/day) from foods.

When we evaluated vitamin D intake from food considering socio-economic factors, there was no significant difference in vitamin D intake between low and middle/high income groups (5.8 ± 0.3 μg/day vs. 5.8 ± 0.1 μg/day, respectively). Vitamin D intake did not differ by education. Canadians without secondary education had similar vitamin D intake from food (6.1 ± 0.2 μg/day) than those who had postsecondary degrees (5.7 ± 0.2 μg/day). Food security was the only factor which influenced vitamin D intake from food. Canadians categorized as either with moderate or severe hunger were combined as one group (comprising 2.35% of the population). Their vitamin D intake from food was significantly lower than food secure individuals (4.7 ± 0.4 μg/day vs. 5.9 ± 0.1 μg/day respectively, p < 0.05). Individuals reporting chronic conditions had similar vitamin D intake from food compared to apparently healthy people (5.9 ± 0.2 μg/day vs. 5.8 ± 0.1 μg/day).

Milk products were the main source of vitamin D contributing to 49.1% of dietary vitamin D intake, followed by meat and meat-alternatives (31.1%), other foods (11.8%), grain products (5.5%) and vegetable and fruit (2.4%). Milk products contributed approximately 2.9 μg/day vitamin D for all age/gender groups, with males aged 9–18 years having the highest contribution (4.7 μg/day) and females 19–50 years the lowest contribution (2.0 μg/day). The contribution of milk products and meat and meat-alternatives as the main contributors of dietary vitamin D intake varies by age. While milk products contribute 75% of dietary vitamin D intake in children

Table 1
Daily intake of vitamin D (μg) from food by ethnicity in the 2004 Canadian Community Health Survey.[a]

Sex	Age, year	Caucasian Canadians Mean ± SEM (n) Median (25%, 75%)	Other Canadians Mean ± SEM (n) Median (25%, 75%)	All Canadians Mean ± SEM (n) Median (25%, 75%)
Male + female	1–8	6.2 ± 0.1 (5027) 5.8 (4.2, 7.7)	6.2 ± 0.2 (628) 5.3 (3.8, 7.4)	6.2 ± 0.1 (5655) 5.6 (4.1, 7.5)
Male	9–18	7.5 ± 0.2 (3969)[x] 6.9 (4.9, 9.4)	6.4 ± 0.4 (567) 6.8 (4.9, 9.9)	7.3 ± 0.1 (4536) 6.9 (4.9, 9.4)
	19–50	6.0 ± 0.2 (4077) 5.7 (4.0, 7.9)	5.1 ± 0.4 (573) 5.7 (4.3, 7.5)	5.8 ± 0.2 (4650) 5.7 (4.0,7.8)
	51–70	7.0 ± 0.5 (2454) 5.5 (3.7, 8.4)	7.4 ± 1.5 (276) 5.6 (4.1, 7.8)	7.0 ± 0.4 (2730) 5.6 (3.7, 8.3)
	>70	6.7 ± 0.4 (1476) 5.3 (3.8, 8.0)	7.0 ± 2.0 (129) 6.5 (4.4, 8.0)	6.7 ± 0.4 (1605) 5.3 (3.9, 8.0)
Females	9–18	5.5 ± 0.1 (3843) 5.0 (3.7, 6.9)	5.0 ± 0.3 (563) 4.9 (3.5, 6.5)	5.4 ± 0.1[z] (4406) 5.0 (3.7, 6.8)
	19–50	5.2 ± 0.2 (4435) 3.6 (1.8, 6.2)	4.5 ± 0.4 (583) 2.9 (1.5, 5.2)	5.1 ± 0.2[z] (5018) 3.5 (1.7,6.0)
	51–70	5.2 ± 0.3 (3027) 4.5 (3.2, 6.7)	3.7 ± 0.3 (385) 4.6 (3.2, 6.0)	5.1 ± 0.3[z] (3412) 4.5 (3.2, 6.6)
	>70	5.7 ± 0.7 (2555) 4.6 (3.3, 0.5)	10.7 ± 2.4 (222) 3.6 (2.9, 5.5)	6.1 ± 0.7 (2777) 4.4 (3.2,6.4)

[a] Intake values (μg/day) are from the initial 24-h recall and presented mean ± standard error of mean, median (25 and 75 percentiles). Independent Student's t-test was used to compare mean intake of vitamin D across race and sex groups.

[x] Significant difference in vitamin D intake from food between Caucasian Canadians and Non-Caucasian Canadians (p < 0.05).

[z] Significant sex difference (respective age group) in vitamin D intake from food (p < 0.05).

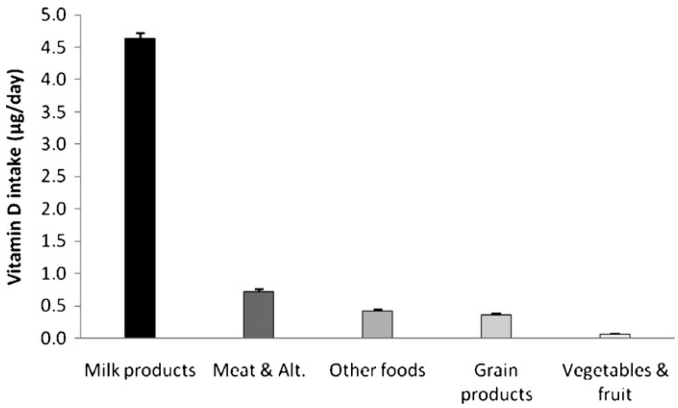

Fig. 1. Vitamin D intake (mean ± SEM, µg/day) of Canadian children age 1–8 years.

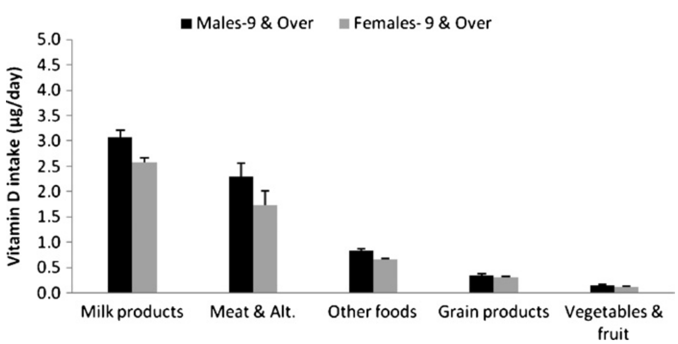

Fig. 2. Vitamin D intake (mean ± SEM, µg/day) of Canadians from food groups in males and females age 9 and over.

aged 1–8 years (Fig. 1), their contribution decreased by age in individuals over age 9 years and that from meat and meat-alternatives increased (Fig. 2).

4. Discussion

Here we report low vitamin D intakes in a nationally representative group of Canadians. While mean intakes exceeded the recommended intake for ages 1–50 years, a substantial proportion have lower than recommended intakes. Most experts indicate that these dietary guideline values set in 1997 are not high enough to maintain appropriate vitamin D status [19]. Vitamin D intakes were highest in males 9–18 years and lowest in females 51–70 years. Our findings of inadequate vitamin D intakes are consistent with reports of low circulating 25 hydroxyvitamin D concentrations, the best indicator of vitamin D status, among Canadians. Rucker et al. [11] reported that 34% of older Calgary residents (n = 188; ~64 years) had suboptimal 25 hydroxyvitamin D concentrations (<40 nmol/L), at least once during the year. Similarly, Vieth et al. [10] reported that each month from December to April 20–28% of young White women (n = 702) had a low 25 hydroxyvitamin D concentrations (<40 nmol/L). Finally, Roth et al. [12] reported that 40% of children (n = 90; 2–16 years) had 25 hydroxyvitamin D concentrations <40 nmol/L.

In examining food groups, as expected, milk products were the main source of dietary vitamin D of Canadians, especially children under 9 years of age. Milk fortification is mandatory in Canada at 2 µg/per 100 mL [14] which is twice the quantity of milk fortification in the USA or Sweden. While we did not find significant differences between Caucasian and Other Canadians, it may be that the Other group is very diverse. One small study has found that young adult Canadians with darker skin also have lower vitamin D intakes and lower status, when measured in winter [19].

Our finding that dietary vitamin D intake from food did not differ by socio-economic factors (e.g. education, income) indicates that food sources of vitamin D, particularly milk, are widely available except to those with moderate to severe food insecurity. However, our findings demonstrate a clear and compelling need to increase the intake of vitamin D intake from food in Canada. It is unlikely that people will change dietary patterns to increase vitamin D intake, i.e., consume more oily fish. Increased consumption of other sources such as liver, eggs and fortified margarine are not consistent with current healthy eating guidelines due to their high cholesterol and/or trans fat content. Encouraging increased consumption of fortified milk is the option recognized in the recent version of Canada's Food Guide [16]. However, this option will not allow persons over 50 years to achieve their recommended intakes, which compelled Health Canada to recommend vitamin D supplementation [16]. An alternative consideration is to increase the range of food categories that can lawfully be fortified with vitamin D in Canada, similar to the U.S. vitamin D fortification policy. Canada would need to take action to avoid the problems of poor commitment to voluntary vitamin D fortification of a wider range of foods that is observed with food manufacturers in the U.S. [14].

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