

Are National Vitamin D Guidelines Sufficient to Maintain Adequate Blood Levels in Children?

Daniel E. Roth, MD¹
Pat Martz, RD²
Rochelle Yeo, RD²

Connie Prosser, PhD³
Melissa Bell, RD²
Adrian B. Jones, MD¹

ABSTRACT

Background: Vitamin D insufficiency (defined as 25-hydroxyvitamin D [25(OH)D] concentrations <40 nmol/L) may be associated with subclinical adverse effects on bone mineralization. The current vitamin D status of children and adolescents in Canada has not been described. The purpose of this study was to describe the association between 25(OH)D serum concentration and dietary vitamin D intake, and other potential determinants of vitamin D status, among a sample of children and adolescents aged 2-16 years presenting to a pediatric emergency department in Edmonton, Alberta (latitude 52°N) at the end of winter.

Methods: In early April 2003, 90 patients between the ages of 2 and 16 years who presented to the pediatric emergency department in Edmonton volunteered to participate. All participants and/or parents or guardians completed questionnaires regarding potential risk factors for vitamin D insufficiency, detailed dietary assessments, and anthropometric measurements. Serum 25(OH)D concentrations were measured in 68 of 90 participants.

Results: The mean serum 25(OH)D concentration was 47.2 nmol/L (95% CI 43.8-50.8 nmol/L). 34% of participants had vitamin D insufficiency (<40 nmol/L) and 6% were deficient (<25 nmol/L). Boys and girls aged 9-16 years had a prevalence of insufficiency of 69% and 35% respectively, while boys and girls 2-8 years old had a prevalence of insufficiency of 22% and 8% respectively. Dietary vitamin D intake per kilogram body weight was the most important independent determinant of 25(OH)D concentration ($r = 0.446$, $p < 0.001$). Vitamin D intake, age and male sex best predicted insufficiency. No subject was insufficient if they had an intake >0.45 mcg/kg/day.

Interpretation: Vitamin D insufficiency may be common among children and adolescents at the beginning of spring. The risk may be highest among older children because vitamin D intake does not adequately rise in proportion with increases in body mass. Further studies are needed to assess whether Canadian dietary vitamin D recommendations should be changed.

MeSH terms: Vitamin D; nutrition disorders; Canada; child; adolescent; vitamin D deficiency

La traduction du résumé se trouve à la fin de l'article.

1. Department of Pediatrics and Child Health, Faculty of Medicine, University of Alberta, Edmonton, AB
2. Nutrition and Food Services, Capital Health Authority, Edmonton

3. Department of Laboratory Medicine and Pathology, Faculty of Medicine, University of Alberta
Correspondence and reprint requests: Dr. Adrian Jones, Division of Pediatric Gastroenterology and Nutrition, Department of Pediatrics and Child Health, 2C3.76 Walter C. Mackenzie Health Science Centre, Edmonton, AB T6G 2R7, Tel: 780-407-3339, Fax: 780-407-3507, E-mail: ajones@cha.ab.ca

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Nutritional vitamin D deficiency (serum 25-hydroxyvitamin D [25(OH)D] concentration less than 25 nmol/L) leads to impaired calcium absorption and inadequate bone mineralization that can manifest as rickets in children.¹ However, even in the absence of overt metabolic bone disease, a moderately decreased 25(OH)D concentration referred to as vitamin D insufficiency (VDI) is associated with subclinical impairment of bone mineral accretion² and acceleration of bone resorption.³ Since bone mineral content (BMC) is largely acquired before and during the pubertal growth spurt,⁴ and the peak bone mass attained shortly thereafter correlates with the risk of osteoporosis in later life,⁵ optimization of vitamin D status during childhood and adolescence may reduce the risk of adulthood osteopenia.

VDI is common among healthy Canadian adults^{6,7} and children at northern latitudes,⁸ yet the vitamin D status of children and adolescents in the general Canadian population is previously unreported. Furthermore, it is unknown whether the current recommended 'adequate intake' (AI) of vitamin D [5 mcg/day (200 IU/day) for infants, children, and adolescents⁹] prevents VDI.

The purpose of this study was to describe the vitamin D status, and its potential determinants, in a sample of children and adolescents aged 2-16 years presenting to a pediatric emergency department (ED) in Edmonton, Alberta at the end of winter.

METHODS

Patients aged 2-16 years who consecutively presented to the pediatric ED at the Stollery Children's Hospital in Edmonton, Alberta (latitude 52°N) during pre-specified study hours (usually 11 a.m. to 9 p.m.) from April 7-17, 2003 were invited to participate in this cross-sectional study. The Stollery is the pediatric referral centre for Edmonton, northern and central Alberta, parts of Northern Saskatchewan, the Northwest Territories, and Nunavut.

Patients were excluded if they were in an unstable condition (i.e., medical care could not be interrupted for study procedures), were nourished entirely by feeding tube, or left the ED before being approached for participation. Patients who did not wish to

TABLE 1

Participant Characteristics and Vitamin D Status-related Lifestyle and Dietary Factors

Characteristic	Participants with Measured 25(OH)D Concentration	Participants with Questionnaire and Anthropometric Data Only
N	68	22
Boys (%)	39 (57%)	14 (64%)
Girls (%)	29 (43%)	8 (36%)
Age, mean \pm SD (range)	9.1 \pm 4.5 (2.1-16.7)	9.1 \pm 5.0 (2.3-16.1)
Resides in Edmonton area	81% (54/67)	91% (20/22)
Ethnic Origin		
West/East European	60% (41/68)	82% (18/22)
First Nations (Canada)	19% (13/68)	5% (1/22)
Height z-score, mean \pm SD	0.35 \pm 1.42	0.41 \pm 1.67
Weight z-score, mean \pm SD	0.25 \pm 1.18	0.62 \pm 0.82
BMI z-score, mean \pm SD	0.099 \pm 1.29	0.46 \pm 1.42
Admitted to hospital this visit (%)	13% (9/68)	9% (2/22)
Socio-economic Factors		
Gross annual household income greater than \$60,000 CDN (%)	54% (36/67)	59% (13/22)
Median number of years (IQR) of secondary and post-secondary education completed by mother	4.0 (3.0-5.4) *	5.5 (3.0-8.0) *
Median number of years (IQR) of secondary and post-secondary education completed by father	3.0 (2.0-7.0)	5.0 (3.8-7.0)
Median number of children <18 years old (IQR) living in same household as participant	2.0 (2.0-3.0)	2.0 (1.0-2.25)
Lifestyle Factors		
Hours spent outdoors in a typical week during the past winter, median (IQR)	4.8 (2.5-10.5)	7.5 (4.8-11.3)
Hours spent outdoors in a typical week during the preceding summer, median (IQR)	20.0 (13.0-35.0)	28.0 (18.8-60.0)
>7 days in sunny southern location in past 6 months	3.0% (2/67)	9.1% (2/22)
Dietary Factors		
Days since 'typical eating routine', median (IQR)	1.0 (0.0-2.0)	2.0 (0.0-3.5)
Vegan or vegetarian (%)	1.5% (1/68)	0
Drinks cow's milk regularly (%)	94% (64/68)	96% (21/22)
Takes multivitamin regularly (%)	27% (18/68)	32% (7/22)
Drinks carbonated beverages at least once per week (%)	60% (41/68)	64% (14/22)
Eats saltwater fish at least once per week (%)	10% (7/68)	13% (3/22)
Daily Milk Intake (cups/day), median (IQR)	2.1 (0.9-3.6)	2.7 (1.6-4.5)
Proportion of Dietary Vitamin D Intake Derived from Milk (%)	62%	58%
Dietary Vitamin D Intake, median (IQR)		
Total - Typical 24-hour (mcg/day)	6.32 (2.91-13.0)	9.20 (4.55-13.78)
Total - FFQ (mcg/day)	8.97 (4.33-13.27)	11.28 (6.09-17.52)
By weight - Typical 24-hour (mcg/kg/day)	0.22 (0.08-0.38)	0.22 (0.12-0.58)
By weight - FFQ (mcg/kg/day)	0.29 (0.12-0.46)	0.33 (0.19 - 0.60)

IQR = interquartile range (25th-75th percentile), SD = standard deviation, BMI = body mass index, ED = emergency department

Differences between groups were not statistically significant ($p > 0.05$) unless otherwise indicated;

* Significant difference between medians by Mann-Whitney U test ($p = 0.029$)

provide a blood sample, or for whom specimen collection was unsuccessful, were invited to participate in the vitamin D intake study. The study was approved by the Human Research Ethics Board (HREB) of the University of Alberta Health Sciences Faculties, the Capital Health Authority, and the Caritas Health Group. The parent/guardian, and the participant where appropriate, provided informed consent.

The participant and/or parent completed a questionnaire relating to potential risk factors for VDI. Weight was measured using a digital scale, which was calibrated with a standard 20-kg weight prior to the study. Standing height was measured using a height chart on a wall in the ED.

Daily intake of vitamin D, preceding the onset of the acute illness for which the child presented to the ED, was estimated by two methods, in the following order: 1) semi-quantitative food frequency questionnaire (FFQ) to quantify the intake of vitamin D sources over a typical 7-day

period (this was *a priori* designated the reference method), and 2) 24-hour dietary recall, to determine the participant's intake during a typical weekday. Two of the investigators who are Registered Dietitians (RY and PM) conducted the dietary assessments. A standardized set of dishes aided the estimation of portion sizes.

Daily vitamin D intake was calculated manually and expressed as micrograms/day for each method. Vitamin D content in fortified food products (e.g., milk, margarine) was obtained from manufacturers' Canadian nutrition labels (40 IU = 1 microgram of vitamin D). For natural sources of vitamin D (e.g., ocean fish, eggs, liver), quantities were derived from a published dataset.¹⁰

A 1-2 mL venous blood specimen was processed in the hospital laboratory within 2 hours of collection. Serum was frozen at -20°C until batched analysis of the 25(OH)D serum concentration was performed with the Diasorin/Inctar kit

(Stillwater, MN, USA), according to the manufacturer's instructions (interassay coefficient of variation of 12% at 60 nmol/L).

Vitamin D status was defined according to the serum concentration of 25(OH)D, the most stable circulating vitamin D metabolite.¹¹ Vitamin D deficiency was defined as 25(OH)D < 25 nmol/L, and VDI was defined as 25(OH)D < 40 nmol/L. Height (cm), weight (kg), and body mass index (BMI; kg/m²) were standardized for age and sex, and expressed as z-scores based on US Centers for Disease Control and Prevention 2000 Growth Charts (Epi Info 2002 software program, CDC, Atlanta, GA).¹²

Normality of continuous variables was assessed by the Kolmogorov-Smirnov statistic. Means and standard deviations were calculated for normally-distributed variables; medians and interquartile ranges were calculated for non-normal distributions. Unpaired observations among sub-

TABLE II
Vitamin D Status and Dietary Vitamin D Intake Among 68 Participants with Measured Serum 25(OH)D Concentrations

	All Participants			Boys			Girls		
	Total	2-8 Years	9-16 Years	Total	2-8 Years	9-16 Years	Total	2-8 Years	9-16 Years
N	68	35	33	39	23	16	29	12	17
25(OH)D (nmol/L), mean	47.2	51.5 *	42.6 *	45.5	51.5 *	36.9 * †	49.5	51.6	48.0 †
SD	14.6	14.6	13.3	15.1	16.0	8.4	13.8	12.3	15.0
Range	12-89	23-89	12-75	19-89	23-89	19-48	12-75	25-67	12-75
Prevalence of Vitamin D Deficiency (<25 nmol/L)	4 (5.9%)	1 (2.9%)	3 (9.1%)	3 (7.7%)	1 (4.3%)	2 (12.5%)	1 (3.4%)	0	1 (5.9%)
Prevalence of Vitamin D Insufficiency (<40 nmol/L)	23 (34%)	6 (17%)	17 (52%)	16 (41%)	5 (22%)	11 (69%)	7 (24%)	1 (8.3%)	6 (35.3%)
Dietary Vitamin D Intake (mcg/day), median (IQR)									
FFQ	8.97 (4.33-13.27)	8.31 (4.57-10.43)	10.53 (3.51-14.94)	9.34 (3.94-14.16)	8.75 (4.57-10.33)	11.91 (2.99-15.73)	8.19 (4.84-13.06)	7.90 (4.65-13.70)	10.34 (4.84-13.06)
24-hour recall	6.33 (2.91-13.03)	5.80 (2.40-8.18)	9.8 (3.02-13.77)	6.38 (2.40-12.89)	6.30 (2.40-7.31)	9.89 (2.50-13.58)	5.34 (3.02-14.02)	5.55 (2.09-13.32)	5.34 (3.03-14.35)
Weight-adjusted Dietary Vitamin D Intake (mcg/kg/day), median (IQR)									
FFQ	0.29 (0.12-0.26)	0.43 (0.23-0.65)	0.22 (0.07-0.31)	0.32 (0.12-0.48)	0.43 (0.26-0.64)	0.21 (0.06-0.32)	0.22 (0.12-0.39)	0.41 (0.17-0.73)	0.22 (0.12-0.32)
24-hour recall	0.22 (0.08-0.38)	0.28 (0.10-0.60)	0.17 (0.07-0.26)	0.22 (0.08-0.38)	0.28 (0.11-0.50)	0.18 (0.08-0.25)	0.21 (0.07-0.42)	0.34 (0.08-0.77)	0.15 (0.06-0.28)
Vitamin D Intake <5 mcg/day (FFQ) median (IQR)	20 (29%)	9 (26%)	11 (33%)	13 (33%)	6 (26%)	7 (44%)	7 (24%)	3 (25%)	4 (24%)
Proportion of Vitamin D Intake from Milk (%), mean	2.1 (0.9-3.6)	2.28 (1.36-3.22)	1.80 (0.60-4.40)	2.40 (1.00-3.85)	2.43 (1.50-3.50)	1.48 (0.58-4.84)	1.80 (0.79-3.64)	1.51 (0.75-2.22)	2.06 (0.79-4.19)
	62	63	62	68	71	63	55	47	60

Note: Differences between sexes or age groups were not significant ($p > 0.05$), unless otherwise indicated.

* Significant difference between age groups ($p < 0.05$)

† Significant difference between sexes within age-group ($p < 0.01$)

‡ Significant difference between age groups ($p < 0.01$)

§ Significant difference between sexes within age-group ($p < 0.05$)

groups of participants were compared by the analysis of variance (ANOVA) or Mann-Whitney U test. Bivariate associations were assessed by the Spearman rank correlation coefficient (r) for continuous variables, and the Chi-square or Fisher's exact tests for categorical/dichotomous variables. Questionnaire responses and anthropometric measures were assessed as potential predictors of VDI (logistic regression) or 25(OH)D concentration (linear regression). Logistic regression models used a forward step-wise (likelihood-ratio) method including all variables with p values < 0.10 . Odds ratios (OR) were calculated to measure the association between each determinant and VDI. Linear regression models were created using a step-wise method including variables with p values < 0.10 , and log-transformed 25(OH)D was used as the dependent variable to correct for a right-skewed distribution. Standardized residuals were plotted against the standardized predicted values to confirm linearity and equality of variances. All reported confidence intervals (CI) are at 95% and all reported p -values are two-sided; a p -value < 0.05 was considered statistically significant. Analyses were conducted using SPSS v.10.0 (SPSS Corporation, Chicago, IL).

RESULTS

Of the 178 potential participants who presented to the ED during the recruitment periods, 68 (38%) had both serum 25(OH)D concentration and vitamin D intake assessed, a further 22 (12%) had questionnaire and anthropometric data only (blood collection was unsuccessful or refused), and 88 (49%) were excluded (82 refusals, 4 major trauma, 2 left the ED before they could be approached). The two groups of included patients were similar with respect to most survey items, although participants from whom a blood level was not obtained tended to have higher mean age-adjusted weight and BMI and a longer median duration of parental post-secondary education (Table I). Neither the mean age nor proportion of boys/girls in the group of 88 excluded patients differed significantly compared to the group of 68 patients for whom complete data were available (data not shown).

The mean serum 25(OH)D concentration was 47.2 nmol/L (95% CI 43.8-50.8 nmol/L). Four of 68 participants (5.9%) were vitamin D deficient. The prevalence of VDI was 34% (95% CI 23-46%), but there were significant differences among sex- and age-defined subgroups (Table II; Figure 1). Participants aged 9 to 16 were at a higher risk for VDI than those aged 2 to 8 (OR 5.1, 95% CI 1.7-15.6; $p = 0.004$). Significant inverse correlations between 25(OH)D concentration and age ($r = -0.422$, $p < 0.001$) or weight ($r = -0.409$, $p = 0.001$) were significant in boys but not in girls (Figure 2).

The FFQ usually gave a higher estimate of daily vitamin D intake than the 24-hour recall method (median difference 1.58 mcg/day, IQR 3.24), yet correlation between the methods was good ($r = 0.782$, $p < 0.001$). Absolute dietary vitamin D intake (by FFQ) remained flat across the ranges of age ($r = 0.082$, $p = 0.444$) and weight ($r = 0.151$, $p = 0.163$).

The association between 25(OH)D concentration and absolute vitamin D intake was weak (Table III). However, the

association between 25(OH)D concentration and weight-adjusted dietary vitamin D intake (mcg/kg) was moderate and statistically significant (Table III; Figure 3). All participants with a vitamin D intake >0.45 mcg/kg/day had a 25(OH)D serum concentration >40 nmol/L.

Of participants with daily vitamin D intakes of at least the AI (5 mcg/day)[by FFQ], 27.1% (13/48) had VDI. These results varied by age, given that 40.1% (9/22) of the older children (9-16 years) who consumed >5 mcg/day had VDI, compared to a VDI prevalence of 15.4% (4/26) among the younger children who exceeded the AI. In all age groups, fortified milk was the major source of vitamin D (Table II).

Neither 25(OH)D concentration nor VDI was associated with the following factors (data not shown): sex- and age-adjusted weight/height/BMI, ethnicity, latitude of residence, number of days since child's eating routine was "typical", soft drink consumption, fish consumption, time spent outdoors during a typical week during the past winter or previous summer, vacation to sunny southern location during the past winter, household income, mother or father's education level, ED diagnosis, or hospital admission from ED.

In multiple linear regression analysis, weight-adjusted vitamin D intake was the only significant independent predictor of 25(OH)D concentration, whether intake was estimated by FFQ ($\beta=0.446, p<0.001$) or 24-hour recall ($\beta=0.452, p<0.001$). The multiple logistic regression model that best predicted VDI included three variables: lower total daily dietary intake of vitamin D estimated by 24-hr recall method (OR 0.84, 95% CI 0.73-0.98, $p=0.026$), higher age (OR 1.43, 95% CI 1.17-1.75, $p<0.001$), and male sex (OR 5.90, 95% CI 1.23-28.29, $p=0.027$).

DISCUSSION

This study detected VDI in about one third of the children and adolescents presenting to a pediatric ED in Edmonton, Alberta at the beginning of spring. VDI was expected to be common for several reasons: 1) cutaneous vitamin D synthesis is negligible from October to March in Edmonton;¹³ 2) current public health campaigns discourage children's exposure to

TABLE III
Dietary Measures as Potential Predictors of Vitamin D Status

Dietary Measure	25(OH)D Concentration Spearman rank coefficient, r	Vitamin D Insufficiency OR (95% CI)
Total Daily Vitamin D Intake (mcg) by FFQ	0.258, p=0.034	0.92 (0.83-1.01)
Total Daily Vitamin D Intake (mcg) by 24-hour Recall	0.280, p=0.021	0.92 (0.83-1.02)
Daily Vitamin D Intake per Kilogram Body Weight (mcg/kg) by FFQ	0.446, p<0.001	0.01 (0.00-0.23)
Daily Vitamin D Intake per Kilogram Body Weight (mcg/kg) by 24-hour Recall	0.452, p<0.001	0.01 (0.00-0.29)
Total Daily Milk Intake (cups)	0.113, p=0.360	0.98 (0.76-1.26)
Daily Milk Intake per Kilogram Body Weight (cups/kg)	0.328, p=0.007	0.001 (0.00-4.48)
Routine Multivitamin Use	N/A	0.17 (0.04-0.83)

N/A = not applicable because predictor variable is dichotomous
Strength of association with the 25(OH)D serum concentration is expressed by Spearman rank correlation (r), and strength of association with vitamin D insufficiency [25(OH)D<40 nmol/L] is expressed as odds ratio (OR) and 95% confidence interval (95% CI).

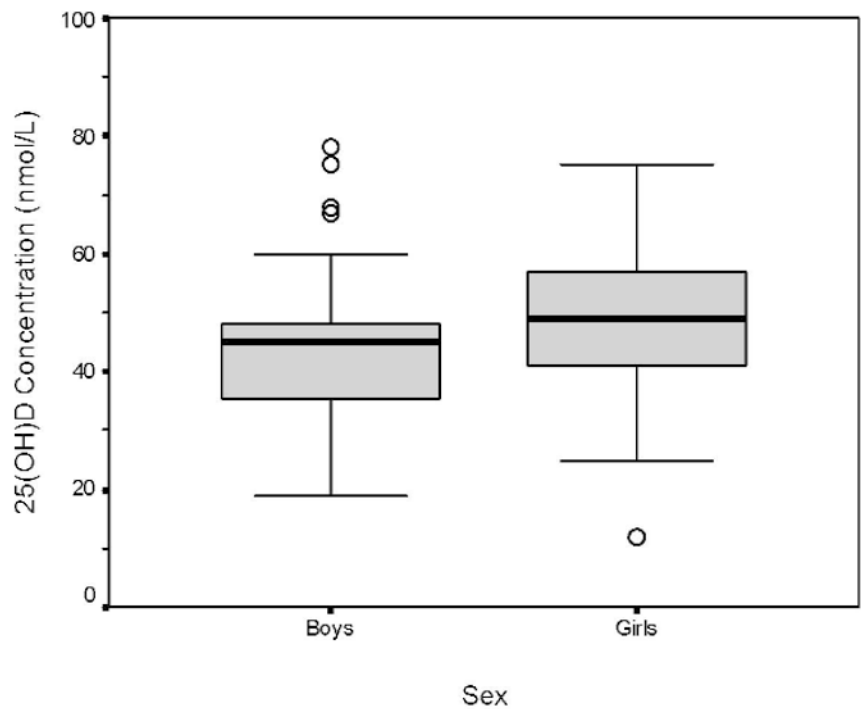


Figure 1. Distribution of serum 25(OH)D concentrations among 68 participants, separated by sex

The box represents the interquartile range which contains 50% of the values. The whiskers extend from the box to the highest and lowest values, excluding outliers which are represented as clear circles. The line through each box indicates the median.

sunlight;¹⁴ 3) per capita milk consumption (the major fortified source of vitamin D in Canada) is decreasing;¹⁵ 4) North American children and adolescents are tending to replace milk with soft drinks;¹⁶ and 5) federal legislation limits the types of food products that can be fortified with vitamin D.¹⁷

Dietary vitamin D intake correlated with serum 25(OH)D levels, which is consistent with wintertime pediatric studies at northern latitudes in Europe¹⁸ and the US.¹⁹ We found that the serum 25(OH)D concen-

tration was best predicted by weight-adjusted vitamin D intake, suggesting that the complex relationship between weight (and/or age) and vitamin D status is important. We found that older participants (particularly boys) were at a higher risk of VDI, even among those who consumed the AI. We postulate that dietary vitamin D intake does not adequately increase in proportion with body mass through childhood and adolescence. Lower mean 25(OH)D concentrations at higher ages were also reported among children in

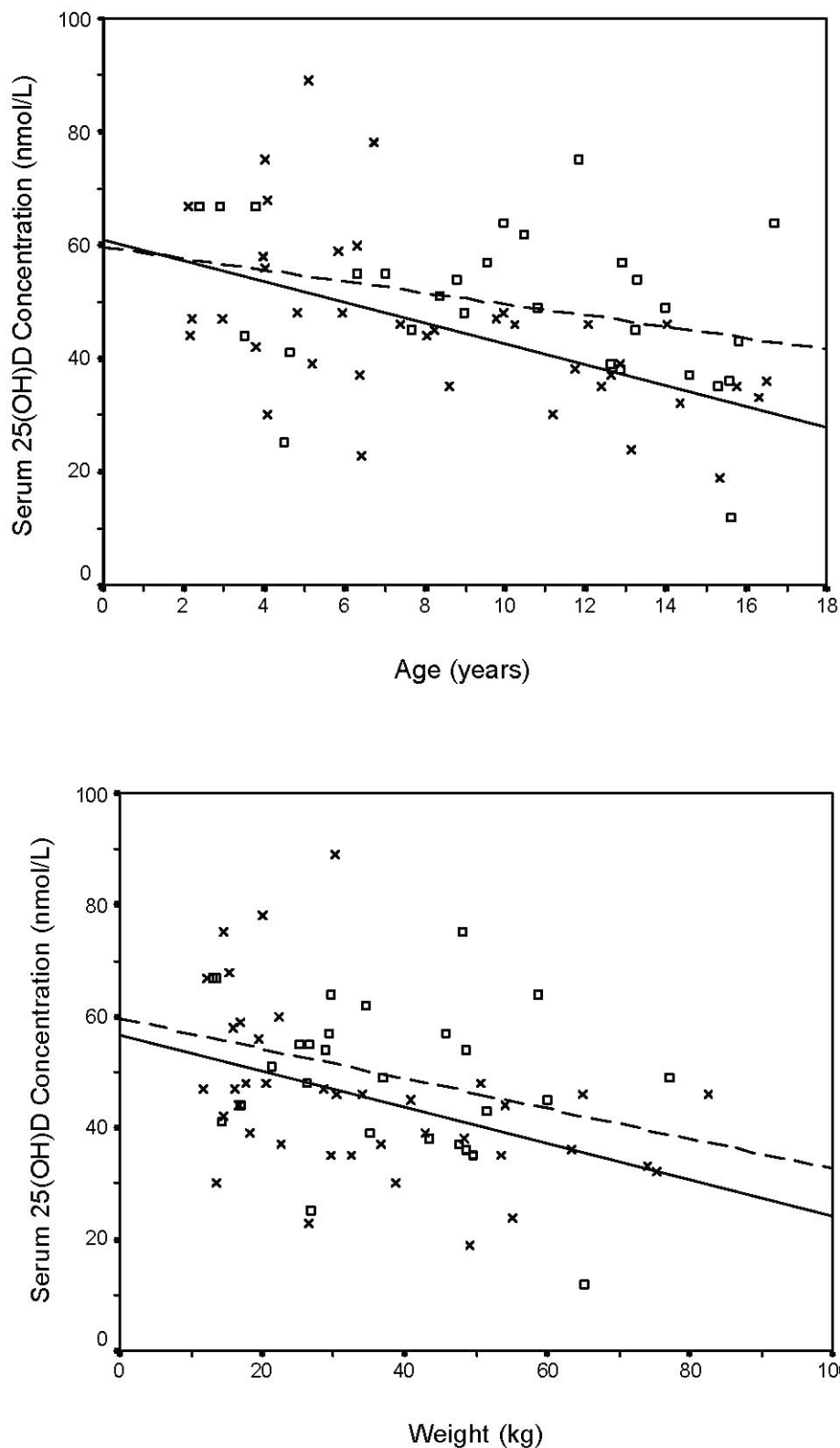


Figure 2. The relationship between serum 25(OH)D concentration and (a) age, or (b) weight

The fit lines demonstrate similar negative linear associations between 25(OH)D level and either age or weight, that are non-significant among girls (cases marked by clear boxes; fit line - - -; age: $r=-0.316$, $p=0.094$; weight: $r=-0.362$, $p=0.058$) but significant among boys (cases marked by 'x'; fit line —; age: $r=-0.540$, $p<0.001$; weight: $r=-0.487$, $p=0.002$).

a Finnish study.²⁰ An inverse relationship between Tanner stage* and vitamin D status was found among Swiss adolescent boys but not girls,²¹ consistent with our findings. Vitamin D occurs in very few foods in the typical Canadian diet, so it is not surprising that vitamin D intake is not proportional to total caloric intake. Age may be a surrogate marker for weight in our analysis, yet there are age-related factors unrelated to body mass that may lead to a relative decrease in vitamin D consumption as the child grows (e.g., increasing soft drink intake that replaces milk¹⁶). Furthermore, non-dietary factors clearly influence vitamin D status; for example, one 16-year-old girl had negligible vitamin D intake but used an indoor tanning bed for approximately 15 minutes per week, and had a serum 25(OH)D level of 64 nmol/L (see Figure 1).²²

The public health significance of our findings depends on an evidence-based definition of VDI in pediatrics, which remains controversial.²³ Relative hyperparathyroidism secondary to VDI has been suggested by wintertime elevations in intact parathyroid hormone (iPTH) levels that paralleled declines in 25(OH)D levels among French adolescent boys, such that when 25(OH)D fell below 30 nmol/L, iPTH concentrations increased rapidly to levels above the normal range (>5.9 pmol/L).²⁴ Among adolescent girls in Finland, there was an inverse relationship between iPTH and 25(OH)D level,¹⁸ and subjects with 25(OH)D <40 nmol/L had significantly decreased forearm BMD. A longitudinal study of Finnish girls aged 9-15 years found that baseline 25(OH)D concentration significantly correlated with the change in BMD at the lumbar spine and femoral neck after three years, and no participant with a 25(OH)D concentration greater than 50 nmol/L had a net loss of lumbar spine BMD.² These studies collectively suggest that VDI compromises bone mineral accretion during pubertal growth.

A potential limitation of our study is that the participants were not community-dwellers but were recruited in an ED. However, neither discharge diagnosis nor hospital admission status was a determinant of the vitamin D status, and none of

* A standard staging of pubertal changes, from 1 (prepubertal) to 5 (fully mature).

the 90 participants reported a chronic illness (e.g., hepatic failure) or medication use (e.g., anti-convulsant) that decreases 25(OH)D levels. The average of fewer than two days since the participants' last 'typical' day of eating was negligible relative to the half-life of 25(OH)D of approximately 3 weeks. A second potential limitation of the study is the widely-acknowledged inaccuracy of dietary histories.²⁵ Moreover, milk is known to have variable amounts of vitamin D.^{26,27} Differences between the estimates from the FFQ and 24-hour recall were common, likely because non-milk vitamin D sources (e.g., fish), if present, were typically consumed on a weekly basis, not daily. Nonetheless, the two dietary measures correlated well and intakes were consistent with a previous Alberta study.²⁸ Notably, all participants with intakes greater than 0.45 mcg/kg/day had 25(OH)D serum concentrations above 40 nmol/L. This is remarkably consistent with the findings of Vieth et al. (2001) who showed that a vitamin D3 intake of at least 25 mcg/day ensured 25(OH)D concentrations greater than 40 nmol/L in healthy Canadian adults²⁹ (i.e., 0.45 mcg/kg/day for an average adult weighing 70 kg is approximately 30 mcg/day).

In conclusion, pediatric VDI may be common in Canada and may not be prevented by current vitamin D recommendations, particularly among adolescents. Vitamin D deficiency, which was not rare in this sample (5.9%), represents the 'tip of the iceberg' of a much broader public health issue. VDI in adolescence is a potential long-term public health concern because vitamin D status may affect bone mineral accrual during pubertal growth. Suboptimal vitamin D status may also be linked to risks of type I diabetes,³⁰ multiple sclerosis,³¹ insulin resistance,³² infectious diseases such as tuberculosis³³ and childhood pneumonia,³⁴ and cancer.³⁵ Further studies are needed to assess whether Canadian vitamin D recommendations should be changed.

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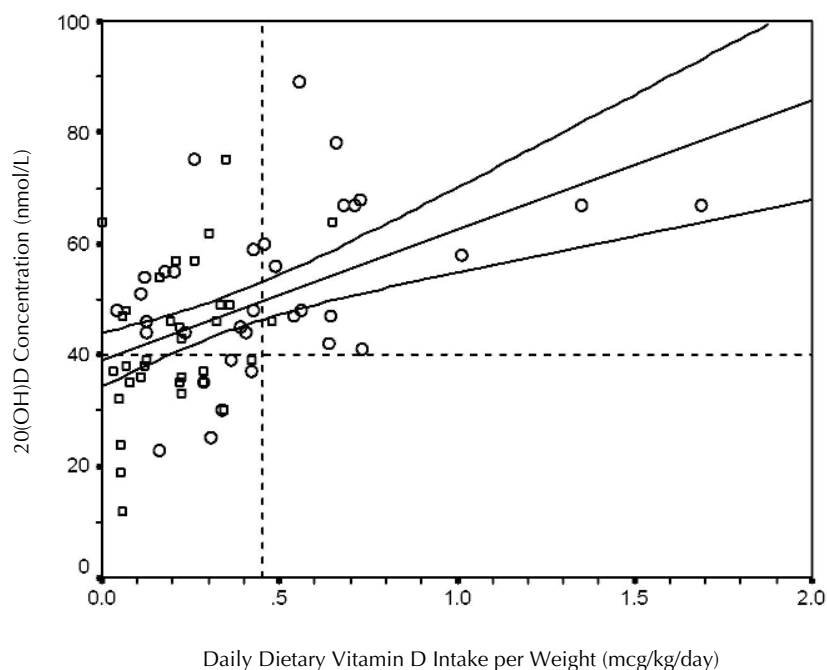


Figure 3. The relationship between 25(OH)D concentration and daily dietary vitamin D intake per kilogram body weight (FFQ method). Boxes represent older children (9-16 years) and circles represent younger children (2-8 years). The fit line, with 95% confidence intervals shown, demonstrates a significant positive linear relationship overall ($r=0.446$, $p<0.001$). Removing the three outliers (intake >1.0 mcg/kg/d) marginally reduces the magnitude of the association ($r=0.382$, $p=0.002$). Vertical and horizontal reference lines (- - -) show that there were no participants with intake greater than 0.45 mcg/kg/day who had vitamin D insufficiency (as defined by 25(OH)D concentration <40 nmol/L). Only 2 older children had intakes greater than this threshold. Calculations using the 24-hour recall method produced analogous results and are therefore not shown.

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RÉSUMÉ

Contexte : L'insuffisance en vitamine D (définie dans cette étude comme les concentrations de 25-hydroxyvitamine D [25(OH)D] inférieures à 40 nmol/L) peut être associée à des effets subcliniques indésirables sur la minéralisation osseuse. Comme le statut actuel en vitamine D des enfants et des adolescents au Canada n'a pas encore été décrit, nous avons cherché à déterminer l'association entre la concentration sérique en 25(OH)D et l'apport en vitamine D dans l'alimentation, ainsi que d'autres déterminants possibles du statut en vitamine D, au sein d'un échantillon d'enfants et d'adolescents de 2 à 16 ans s'étant présentés au service d'urgences pédiatriques d'Edmonton (Alberta) (latitude 52°N) à la fin de l'hiver.

Méthode : Quatre-vingt-dix patients âgés de 2 à 16 ans s'étant présentés au service d'urgences pédiatriques d'Edmonton au début d'avril 2003 ont participé bénévolement à l'étude. Tous les participants et/ou leurs parents ou tuteurs ont rempli des questionnaires portant sur les facteurs de risque d'insuffisance en vitamine D et se sont soumis à des évaluations approfondies de leur alimentation et à des mesures anthropométriques. Les concentrations sériques en 25(OH)D ont été mesurées chez 68 des 90 participants.

Résultats : La concentration sérique moyenne en 25(OH)D était de 47,2 nmol/L (IC de 95 % = 43,8-50,8 nmol/L). Trente-quatre p. cent des participants avaient une insuffisance en vitamine D (<40 nmol/L), et 6 % étaient carencés (<25 nmol/L). Les garçons et les filles de 9 à 16 ans affichaient des taux d'insuffisance de 69 % et de 35 % respectivement, contre 22 % et 8 % respectivement pour les garçons et les filles de 2 à 8 ans. L'apport alimentaire en vitamine D par kilogramme de poids était le principal déterminant indépendant de la concentration en 25(OH)D ($r=0,446$, $p<0,001$). L'apport en vitamine D, l'âge et le sexe masculin étaient les meilleurs prédicteurs d'insuffisance. Aucun sujet ayant un apport supérieur à 0,45 mcg/kg/jour n'a été considéré comme présentant une insuffisance.

Interprétation : L'insuffisance en vitamine D pourrait être commune chez les enfants et les adolescents au début du printemps. Les enfants pourraient présenter le risque le plus élevé, car leur apport en vitamine D n'augmente pas suffisamment en proportion de la croissance de leur masse corporelle. D'autres études sont nécessaires pour déterminer s'il faut modifier les recommandations canadiennes concernant l'apport alimentaire en vitamine D.

Coming Events / Activités à venir

To be assured of publication in the next issue, announcements should be received by **November 15, 2005** and valid as of **December 31, 2005**. Announcements received after **November 15, 2005** will be inserted as time and space permit.

Pour être publiés dans le prochain numéro, les avis doivent parvenir à la rédaction avant le **15 novembre 2005** et être valables à compter du **31 décembre 2005**. Les avis reçus après le **15 novembre 2005** seront insérés si le temps et l'espace le permettent.

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