Vitamins & Minerals

Insufficient Vitamin D Intake and Low Vitamin D Status in Men Over 80 Y of Age: Intervention is Required to Meet Dietary Targets in Long-Term Care Facilities

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Abstract

Description: Vitamin D is important to bone health. This study examined vitamin D intake and status in institutionalized elderly men in relation to biomarkers of bone metabolism and functional indicators.

Materials and Methods: Elderly male veterans were studied in Phase I (n=40) for 16 weeks (April, June, August 2008) and Phase II (n=30) for another 16 weeks (October and December 2008 and February 2009) for dietary vitamin D using 5 day menu selection (Phase I) and using 3×3-d weighed food records (Phase II). Anthropometric data, Mini-Mental State Evaluation (MMSE) scores and sun exposure were collected. Functional capacity was assessed using the Frail Elderly Functional Assessment Tool (FEFA) and handgrip strength. Biochemistry included serum 25-hydroxyvitamin D (25(OH)D), parathyroid hormone (PTH), osteocalcin (OC) and C-terminal telopeptides of Type 1 collagen (CTX). Mixed model ANOVA and Pearson correlation analyses were used.

Results: Participants were relatively healthy (Age: 85 ± 3 years (Mean ± SD), BMI: 26.1 ± 4.3 kg/m^2, MMSE: 25 ± 5, FEFA: 13 ± 8, grip strength: 22 ± 8 kg). Sixty-six percent (280 ± 120 IU) of the planned dietary vitamin D was consumed. Vitamin D came mainly from fortified milk and meal supplements and 33% took pill supplements (400-800 IU/d). Serum 25(OH)D concentration rose by summer (Phase I: 60.9 ± 24.4, 68.2 ± 24.6 and 76.1 ± 22.4 nmol/L, respectively) and declined thereafter (Phase II: 57.7 ± 24.1, 62.9 ± 30.7 and 61.3 ± 29.2 nmol/L). PTH was lower in spring compared to late summer through winter whereas CTX and OC did not change. Serum 25(OH)D was correlated to BMI, but not to indicators of functional status.

Conclusions: In long-term care, vitamin D from foods and supplements fails to meet recommendations of 800 IU (20 μg) for those over 70 y.

Keywords: Vitamin D intake; 25-hydroxyvitamin D; Men; Long-term care

Introduction

Aging is associated with reduced bone health, reduced mobility and increased need for help in accomplishing activities of daily living [1]. Vitamin D is considered an important nutrient for its role in bone health with well known consequences of deficiency leading to osteomalacia and osteoporosis in the elderly [2]. It is predicted that in 2025, more than 20% of Canadians will be over the age of 65 y [1]. These statistics are very similar to other countries. For example, by 2040, 21% of the population will be aged 65 years or older in the United States [3] and will represent 36.1% of the population in Japan [4].

For most people, values of 25-hydroxyvitamin D (25(OH)D) above 50 nmol/L are sufficient to maintain bone health [5]. However, low vitamin D status demarked by circulating 25(OH)D below 50 nmol/L has been reported in community dwelling [6-9] and institutionalized elderly [10-12]. In the community, a wide range of values have been reported. A large cohort study looking at bone health in American men reported blood levels of 25(OH)D to be 62.5 ± 19.8 nmol/L with 2.9% below the deficiency cut-off of 30 nmol/L [13]. The Canadian Health Measures Survey reported that men over the age of 70 years presented with 25(OH)D values of 71 ± 27.5 nmol/L with 10% of them below 37.5 nmol/L [14]. More recently, elderly men living in the community in Australia were reported to have levels of 25(OH)D as low as 42 nmol/L [15]. Less is known about those in institutions. In long-term care facilities where 25(OH)D was assessed, values ranging from 26 to 40 nmol/L were seen despite a supervised environment. Low status may be ascribed to vitamin D intakes below recommendations [10,11,16-20], in some cases as low as 120 IU/d. Such intakes are exceptionally low in view of the newly updated recommendations by Institute of Medicine

(IOM) Dietary Reference Intakes (DRI) for Calcium and Vitamin D [5]. The IOM modified the recommendation from an Adequate Intake (AI) to now include Estimated Average Requirements (EAR) and Recommended Dietary Allowances (RDA). For adults of >70 years, a daily EAR of 400 IU (10 μg) and RDA of 800 IU (20 μg) were set in comparison to the previous AI of 600 IU (15 μg).

Vitamin D intake and serum 25(OH)D levels have been reported to be both below dietary and status targets in institutionalized elderly populations of women and men. This deserves further attention since better 25(OH)D status has been associated with better leg strength and function [21], grip strength [22], general physical activity and daily living activity [23,24]. Furthermore, low serum concentration of 25(OH)D has been identified as a risk factor for long-term care facility admission [25]. Moreover, bone turnover is a constant physiological phenomenon and although aging is associated with higher resorption than formation, vitamin D should be provided in sufficient amounts to ensure normal parathyroid hormone (PTH) concentrations and reduce associated morbidity and mortality risks [26,27]. Nonetheless,

information specifically regarding very old males (aged 80+) is scarce and impacts on biomarkers of bone metabolism are not as well studied.

The primary objective of this 1 year prospective cohort study was to evaluate vitamin D intake and 25 (OH) D concentrations in a long-term care population of elderly male veterans (aged 80+y) across all seasons. Our secondary objective was to track changes in biomarkers of bone metabolism including PTH, osteocalcin (OC) and C-terminal telopeptides of Type 1 collagen (CTX) over the year as well as changes in Frail Elderly Functional Assessment (FEFA) and the Mini-mental State (MMSE) tool scores in association with vitamin D status. It was hypothesized that all participants would present with low serum 25(OH)D (<50 nmol/L) regardless of sampling time, that total intake of vitamin D would be below recommendations and that 25(OH)D concentration would be significantly related to functional tests of daily living.

Materials and Methods

This prospective observational cohort study was conducted in elderly males living at Ste. Anne's Hospital, a long-term care facility (Veterans Affairs Canada, Montreal, QC; 46°N). Phase I took place from spring to summer (16 weeks; n=40) whereas Phase II captured the fall to winter period (16 weeks) for 30 of the 40 original participants. Of the 10 participants who did not continue in Phase II, 4 died, 3 had a significant cognitive decline and the other 3 did not wish to participate. In view of the study objectives, all veterans over the age of 70 years were eligible including those with stable chronic diseases, receiving oral and enteral feeding modes. There were 8 exclusion criteria: 1) end-stage (i.e., prognosis of less than 4 months) conditions and palliative care, 2) end-stage renal disease due to altered vitamin D metabolism, 3) use of vitamin D analogues, 4) end-stage liver disease, 5) untreated hyperparathyroidism, 6) active cancers, 7) metabolic bone diseases except for osteoporosis and osteomalacia and, 8) any acute condition that would exclude any oral intake of food. The completion of the 3 month study phase or, change in clinical status preventing continuance in the study was considered the end-point (Figure 1). The study was approved by the Institutional Review Board of the Faculty of Medicine of McGill University and Ste. Anne's Hospital Scientific Board. Consent forms stated voluntary participation, right to withdraw at any time without consequences and respect of privacy. Competency to consent was validated via medical records or confirmed with the treating physician. When competent, the patient signed the consent form for himself. If participant was unfit to consent, the legal representative (mandatory, curator or tutor) signed, as per required by Article 21 of Quebec Civil Code.

Participants were measured for weight using a standard balance, calibrated yearly at the hospital. Height was obtained from the military medical chart and confirmed using knee-height measuring calliper (Seca 207 model, Seca Corp, MD, US) using algorithms adjusted for age and sex calculations, then body mass index (BMI; kg/m²) was calculated. A nurse met with participants to complete a MMSE at baseline (unless the medical chart had a MMSE score dated less than 3 months prior to the study) and at the end of each phase of the study. The FEFA scores were obtained at midway and final assessments. Handgrip strength (Hydraulic hand dynamometer, Jamar®) was performed at midway and final assessments of Phase II (Fall-Winter). Subjects were instructed to squeeze the handle as hard as they could and were encouraged for 20 second each trial. The maximum reading of each trial was recorded. Measurements were done in triplicates, using the non dominant arm and average values were used. The time used to read and record the data (approximately 15 sec.) was used as a rest period.

In both segments of the study, fasted blood samples were obtained every 8 weeks, between 0630 and 0730 h. Routine biochemistry were immediately measured at the hospital using Vitros 250E (Ortho Clinical Diagnostics, Johnson & Johnson, version 250) and Symex XT-2000i (Sysmex, version XT-2000i/XT-1880i) auto analyzers. This laboratory participates in the ISO (Norm 15189–Medical Laboratories) quality assurance program. Sample aliquots were stored at–80°C until further testing at McGill. Serum total 25(OH)D, PTH, OC was measured using chemiluminescent immunoassays (Liaison; DiaSorin, Minnesota) and serum CTX by colorimetric immunoassay (IDS Inc, Arizona). This laboratory participates in the DEQAS (Vitamin D External Quality Assessment Scheme) program and consistently reports results within 25% of the ALTM (All-Laboratory Trimmed Mean). Controls were in range with specifications of each assay. Intra-assay variability ranges were 0.1%-8.1% for 25(OH)D, 0.18%-12.4% for PTH, 0% -5.8% for OC and 0%-14.8% for CTX. Inter-assay variability ranges were 5.3%-15.8% for 25(OH)D, 1%-7.7% for PTH and 1.8%-7.3% for OC.

Main food sources of vitamin D were examined in Phase I using 5 days of hospital menus at each time point, for all participants. In Phase II, actual food intake was assessed using weighed food records for 3 non consecutive days, including a weekend day, in October, December and February. All foods were weighed before being served and leftover weights were deducted to obtain actual intake. For Phase II, a database including all detailed recipes cooked in the Production Center of the Hospital was used to determine nutritional composition. The Canadian Nutrient File 2007b and menu management software ProMenu was used to generate nutrient intakes to reflect the period of study. Nutritional values of market foods were included to complete the missing nutritional values of certain items. Intakes were compared to the various DRI values.

Statistical analyses

Continuous variables were expressed as means ± SD or median (range), if non-normally distributed. Categorical variables were expressed as n (%). All data were checked for normality using D'Agostino & Pearson omnibus normality test; when normality criteria were not met, data were log transformed or a nonparametric test was used. Levene's test was used to determine homogeneity of variances. The relationships among time and vitamin D intake with 25(OH)

Figure 1: Recruitment for Phase I and Phase II.
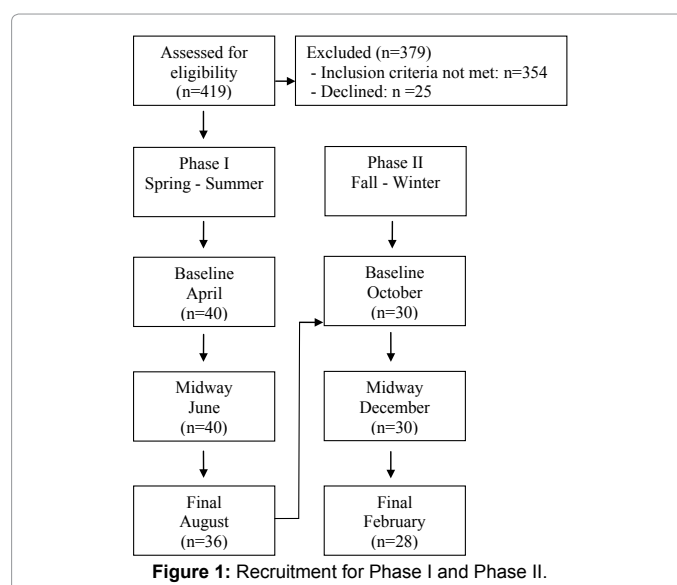
D, PTH, OC and CTX were assessed using a mixed model ANOVA, controlling for random effect of age. Tukey-Kramer was used as post hoc test. Relationships between 25(OH)D and other measures were tested using Pearson correlation analyses. Statistical significance was set at $p \leq 0.05$, and all p values presented are 2 tailed. Data were analyzed using Statistical Analysis System, version 9.2, statistical software (SAS Institute Inc., Cary, N.C.).

Results

In general, the participants were of healthy body weight for age, in good mental status and had routine serum biochemistry within the normal range (Tables 1 and 2). Thirty-three percent of participants were receiving a supplement containing vitamin D (n=6 received 400 IU/d, n=2 received 600 IU/d and n=2 received 800 IU/d). Sunlight exposure was minimal for most participants due to limited outdoor activities or because hats, long sleeves and pants were worn regularly. From April to August, 73% (29) of participants were able to go outside for an average period of 41 min per day (Range: 2-180 min /d). Thirteen participants were less than 15 min. outdoors every day. Eighty percent (80%) wore hats, 53% wore long sleeves and 75% wore long pants. Although ultraviolet beta (UVB) radiation is minimal in the fall to winter months, sunlight exposure was observed. During that period, only 21.4% participants went outdoors, and all of them wore hats, long sleeves and long pants.

In Phase I, the analysis of the foods identified as the main sources of vitamin D provided on the hospital tray (average of 3×5 days of proposed menus) revealed a mean dietary vitamin D of 240 ± 160 IU/d. In Phase II, the nutrient intake was obtained via average weight of all foods of 9 days of intake (3 days at baseline, 3 days at midway and 3 days at final assessments) using detailed recipes. No difference was seen among days, therefore the mean of 9 days of intake was used (Table 3). The diet was well balanced for macronutrients. The vitamin D content of all foods served was 440 ± 200 IU/d, however, only 66% of that was consumed. At the time of the study, the recommendation for vitamin D was an AI set at 600 IU revealing that the assessed menu could not met these recommendations with food and meal supplements alone. In Phase II, actual intakes were compared to DRI values; only 1 participant (3%) exceeded the AI of 600 IU with food and meal supplements alone in October, December and February. Similarly, when comparing to the 2011 revised DRIs, only 1 participant (3%) reached the new 800 IU/d RDA value with food alone (February only). Three participants (10%) met the EAR of 400 IU in October and December whereas 4 participants (14%) met the EAR in February with food and meal supplements alone. The main sources of dietary vitamin D (52%) were fortified milk, enriched meal supplements and milk-based soups and margarine.

	Phase I (n=40)		Phase II (n=30)	
	Mean*	SD	Mean*	SD
Age, y	85.2	3.2	84.9	3.6
Weight, kg	76.0	12.7	74.7	13.2
BMI, kg/m²	26.1	4.1	26.0	4.3
MMSE (/30)	23.0	7.0	24.0	3.0
FEFA (/55)	13.0	8.0	13.0	8.0
Number of prescriptions**	11.0	5.0	11.0	5.0
Handgrip (kg)	N/A		10.0	3.6

*Stable over time, within phases.
**Including vitamin tablet supplements.
FEFA: Frail Elderly Functional Assessment; MMSE: Mini Mental State Evaluation; N/A: not assessed.

Table 1: Characteristics of participants (Mean ± standard deviation).

	Normal Range[1]	Phase I (n=40)		Phase II (n=30)	
		Mean*	SD	Mean*	SD
Glucose (nmol/L)	4.1 - 5.9	5.2	1.1	5.2	0.9
Albumin (g/L)	35 - 50	35	4	36	4
Phosphate (mmol/L)	0.81 - 1.45	1.14	0.17	1.20	0.16
Total calcium (mmol/L)	2.10 - 2.55	2.27	0.09	2.23	0.08
Ionized calcium (mmol/L)	0.95 - 1.15	1.04	0.05	1.03	0.04
Total cholesterol (mmol/L)**	0 - 6.2	4.1	0.9	4.3	0.8
Triglycerides (mmol/L)**	0 - 2.26	1.58	0.70	1.59	0.81

[1]References values of Ste-Anne's Hospital Laboratory.
*Stable over time, within each phase;
**Total cholesterol and Triglycerides were only obtained at baseline and final assessments in Phase I and in Phase II.

Table 2: Serum biochemistry of participants.

Intake per day	DRI[1]	Provided on Tray		Consumed	
		Mean	SD	Mean	SD
Energy, kcal	3067[2]	2522	547	1744	351
Protein, g (%Energy)	56 (10-35%)	102	23 (16%)	69	16 (15%)
CHO, g (%Energy)	130 (45-65%)	333	76 (51%)	233	56 (51%)
Fiber, g	30 g*	22	8	14	6
Fat, g (%Energy)	--- (20-35%)	90	24 (31%)	62	15 (31%)
Vitamin D, IU[4]	800 IU[3]	440	200	280	120
Calcium, mg	1200 mg[3]	1488	632	1013	424
Phosphorus, mg	700 mg	1837	569	1255	376
Sodium, mg	1200 mg*	3936	939	2512	653
Potassium, mg	4700 mg*	4010	969	2643	736

[1]Values are RDA; when followed by (*) values represent Adequate Intake (AI).
[2] Estimated Energy Requirement (EER): For males, subtract 10 kcal/d for each year above 19.
[3] New DRI values (IOM, 2011): RDA: Vitamin D, 800 IU and Calcium, 1200 mg; EAR: Vitamin D, 400 IU and Calcium, 1000 mg.
[4] Does not include pill supplement.

Table 3: Average daily intake in elderly living in long-term care facility (Phase II - 9 days; Mean ± SD).

In Phase II, only 33% of participants were receiving vitamin D from tablets to enhance their exogenous intake, providing an average additional 530 ± 160 IU/d. Pill supplement dosages ranged from 400 IU/d to 800 IU/d. When considering actual food-derived vitamin D intakes and the additional intake of vitamin D from pill supplementation, 27% (8/30) of participants met the AI of 600 IU/d in October and December whereas 24% (7/29) met the AI in February. With the revised IOM values, 40% (12/30) of participants met the EAR value at every time point. The RDA was met by 13% (4/30) of participants and by 10% (3/30) in October and February.

In Phase I of this prospective study, mean serum 25(OH)D concentrations were above 50 nmol/L in April, June and August (Table 4) for this elderly institutionalized population. The proportion of participants presenting with 25(OH)D concentrations above 50 nmol/L increased from 72.5% in April to 77.5% in June and 88.9% in August. In April, 10% of the participants were deficient (<30 nmol/L). However, in June and August no participant was deficient (Figure 2). In Phase II, the proportions of participants presenting with 25 (OH)D concentrations above 50 nmol/L were 60.0% in October, 65.5% in December and 67.9% in February. Deficiency was observed in 10.0%, 10.3% and 17.9% of the population in October, December and February, respectively.

Biomarkers of bone metabolism over a year are shown in Table 4. In the months of April, June and August, mean 25(OH)D, PTH and OC concentrations were within their respective normal ranges. During the fall to winter segment of the study PTH levels were

	Normal Range		Serum 25(OH)D* (> 50 nmol/L)		Serum 1-84 PTH (1.1 – 7.5 pmol/L)		Serum OC (2.4 – 7.9 nmol/L)		Serum CTX (ng/L) ----	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
	Month	n	Phase I							
Baseline	April	40	60.9[ac]	24.4	6.4[a]	3.3	5.1	2.8	941	533
Midway	June	40	68.2[a]	24.6	7.4[ad]	6.6	4.6	2.2	915	529
Final	August	36	76.1[b]	22.4	7.5[b]	3.2	5.2	3.2	828	419
			n			Phase II				
Baseline	October	30	57.7[c]	24.1	7.9[bd]	3.2	5.0	2.8	834	379
Midway	December	29	62.9[ac]	30.7	10.4[cd]	4.6	4.8	3.3	899	458
Final	February	28	61.3[c]	29.2	8.4[b]	3.7	5.2	3.0	920	593

Means followed by different superscript lowercase letters, within columns, differ ($P<.05$), mixed model ANOVA, controlling for random effect of age and using Tukey-Kramer adjustment for multiple comparisons. Values were log transformed for statistical analyses, but are presented in original units.
* Minimal ultraviolet beta radiation in the fall to winter period.
25(OH)D: 25-hydroxyvitamin D; PTH: parathyroid hormone; OC: osteocalcin; CTX: C-terminal telopeptides of Type 1 collagen.

Table 4: Biomarkers of bone metabolism in elderly veterans living in long-term care facility (Mean ± SD).
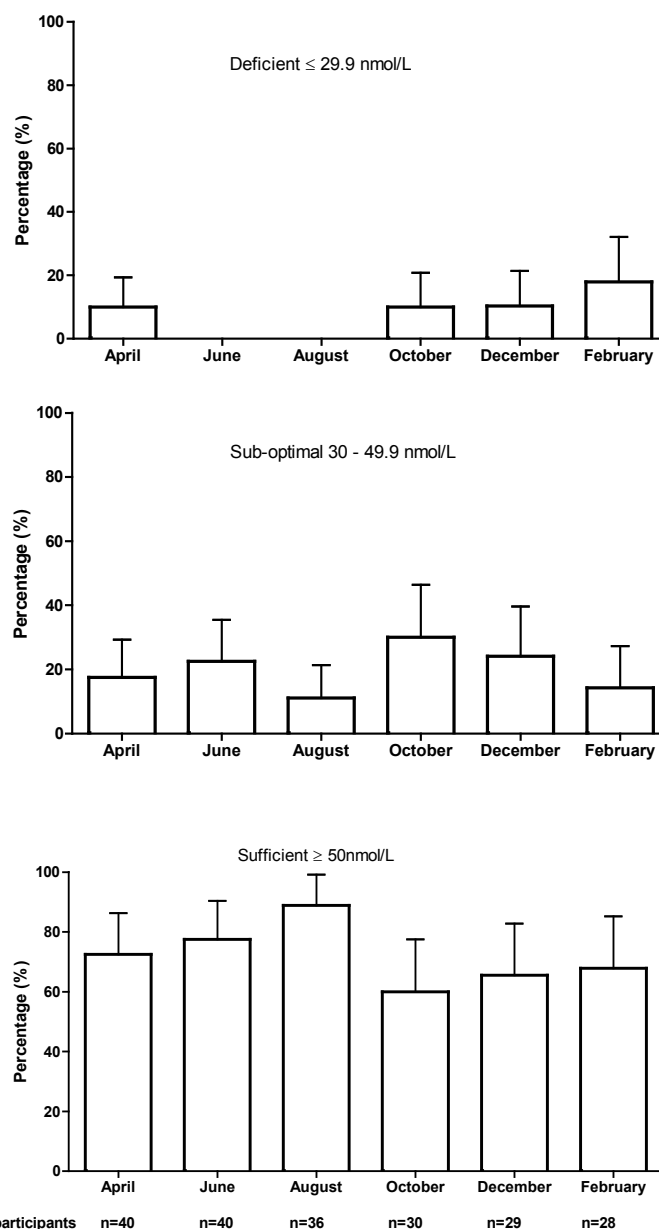

Figure 2: Proportion (%, CI 95%) of participants according to 25(OH)D status during 1 year follow-up.

indicative of secondary hyperparathyroidism. Although 25(OH)D and PTH concentrations fluctuated over time, CTX and OC did not show significant changes throughout this 1 year follow up study, reflecting a lack of change in bone turnover during the year.

In Phase I, PTH and OC demonstrated a positive correlation (Pearson r=0.32; p=0.044) only in April whereas 25(OH)D was negatively correlated to PTH (Pearson r=-0.398 p=0.016) in the month of August. Body mass index was correlated with 25(OH)D concentrations in April (Pearson r=-0.32; p=0.019). No other relationships were observed in this phase.

In the fall to winter period (Phase II), where 25(OH)D was at its minimal value, 25(OH)D was negatively correlated with PTH in October, December and February (Pearson r=-0.584; p=0.001, Pearson r=-0.519; p=0.004 and Pearson r=-0.440; p=0.019 respectively). CTX was positively correlated to OC at all 3 time points assessed in Phase II (Pearson r=0.546; p=0.002, Pearson r=0.523; p=0.004 and Pearson r=0.636; p=0.001, respectively). Correlations between 25(OH)D and biomarkers of bone health and function in February, when vitamin D status is dependent on exogenous sources, are presented in Figure 3. No other relationships were observed among bone biomarkers.

No correlations were seen between serum 25(OH)D concentration and handgrip strength, neither MMSE nor FEFA scores. However, the FEFA scores were negatively correlated to the handgrip strength (Pearson r =-0.43; p=0.034) in February demonstrating that handgrip strength is a reflection of functional mobility and the upper body strength is required for adequate daily activity.

Vitamin D intake in Phase II was positively correlated to energy intake, protein, calcium, phosphorus and potassium intakes (p<0.010), but was not correlated to 25(OH)D concentrations.

Discussion

This study was carried out in an elderly cohort of males living in a long-term care facility of Montreal (QC, Canada; 46°N). Despite their advanced aged, the biological markers revealed a healthy population presenting with normal values for glucose, albumin, phosphate, total and ionized calcium as well as for total cholesterol and triglycerides. Participants maintained BMI, cognitive and functional status and number of medications taken over the year of study. The average serum concentrations of 25(OH)D were relatively good during the summer months in this elderly cohort when compared to the targets (25(OH)D >50 nmol/L) recently set by the IOM [5]. Only 34.5% and 32.1% were below 50 nmol/L of 25(OH)D in December and February when 25(OH)D is dependent on exogenous sources alone. These observations concur with other reports in nursing home facilities [10-12]. However, this report is the first to provide a yearly profile of 25 (OH) D status in institutionalized elderly men over 80 y as well as rigorous dietary assessment. Despite limited direct exposure to UVB, a small seasonal effect was observed in June and August where no participant presented 25(OH)D values below 30 nmol/L as observed in other studies of elderly [7,9,12].

Although Canada's Food Guide (Health Canada) suggests that 400 IU (10 µg) of vitamin D be taken as a supplement by individuals>50 y,

r= - 0.41 p=0.030

r= 0.13 p=0.523

r= 0.20 p=0.323

r= 0.30 p=0.124
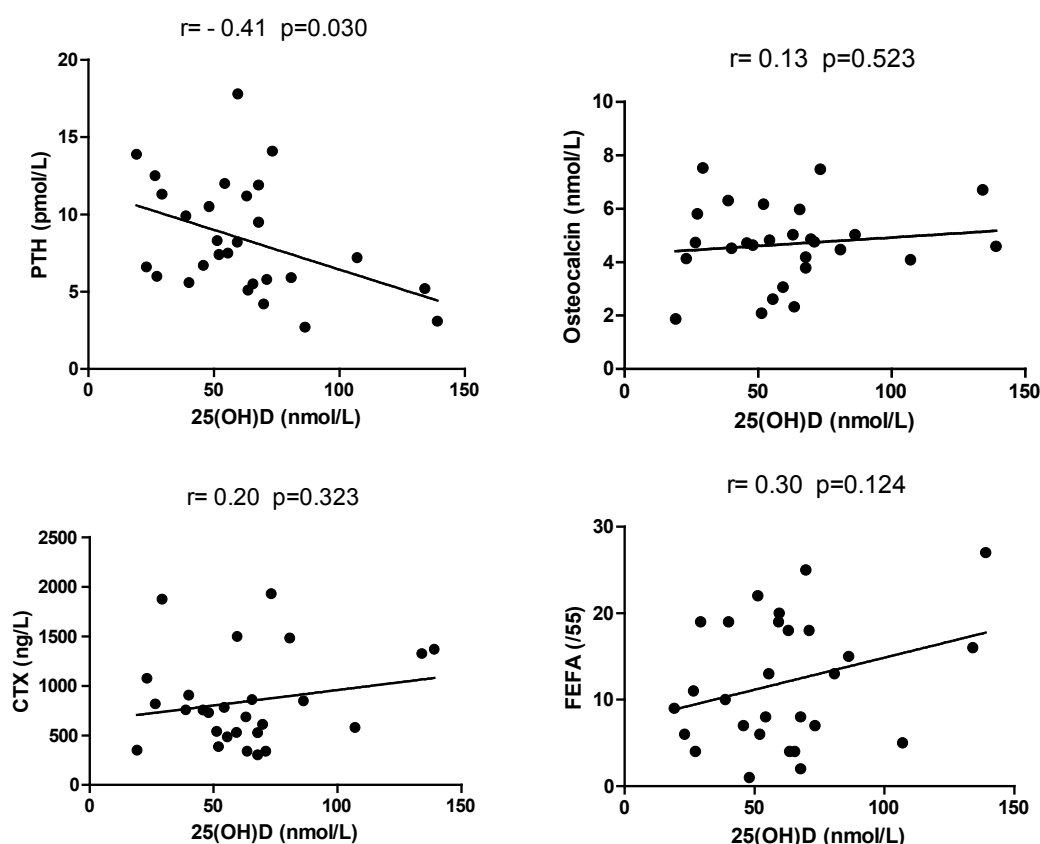
Values were log transformed for statistical analyses for 25(OH)D, PTH, OC and CTX, but are presented in original units.

Figure 3: Linear regression between 25(OH)D and PTH, OC, CTX and FEFA in February, when vitamin D status is dependent on exogenous sources.

only 33% of participants were receiving supplements at the time of the study. Thus the majority of vitamin D intake was from diet. In Phase II, nutritional intake over time was stable and confirms the presence of a routine regarding food preferences. These results complement previous observations revealing low average intake of vitamin D in the elderly living in a Canadian long-term care facility [10,16,19,28], but provides new knowledge regarding food sources and status of vitamin D across a year. The main sources of vitamin D for this cohort were fortified milk, meal supplements and vitamin from tablets. Only one participant met the AI value of 600 IU, which prevailed at the time of the study, with food and meal supplements alone. With the new DRI values, 10 to 14% of participants reached the EAR with food and meal supplements. However, the actual intake from food was sufficient to meet the RDA for one participant in the month of December only.

The implications of not meeting recommended intakes of vitamin D extend beyond vitamin D status alone. In this study, PTH was elevated often throughout the course of the study but was only significantly elevated during the early winter segment of the study. As in the younger adult, PTH is known to increase with declining 25(OH)D status [29]. However, hyperparathyroidism is also associated with higher morbidity and mortality in the elderly [26,27,30]. OC and CTX did not significantly change over time in this group. This aligns with the modest changes in PTH and that the values were on average elevated for the majority of the year.

Other possible functional indicators of vitamin D status were explored in this study such as handgrip strength and function in daily living tasks. Contrary to previous observations in community-dwelling seniors with vitamin D deficiency, the FEFA [23] did not associate well with vitamin D intake or vitamin D status. It is possible that the 25(OH)D concentrations observed in our cohort were above a threshold for influencing functionality. Vitamin D status above 50 nmol/L compared to lower status positively associates with physical performance, handgrip strength in community dwelling elderly [31] as well as with functional capacity [23]. However, it is negatively associated with frailty [32]. Dose response studies are required to clarify this association and determine if a threshold exists as related to optimal performance [5].

Although this study is a comprehensive look at vitamin D nutrition in elderly men living in a long-term care facility, the fact that it is entirely composed of elderly veterans and is of small sample size might hinder the extrapolation of our results to other elderly. It is also possible that participants ate more since they were aware that meal intake was documented, therefore increasing vitamin D intake. However, the similar BMI in both study phases and only 66% of vitamin D consumed suggests this was not the situation.

In summary, this study provided detailed data on food intake, vitamin D status and bone biomarkers for relatively healthy, well monitored, very old male veterans living in a long-term care facility over a year. This study underscores the importance of not only planning intakes to meet needs, but to observe actual food intakes since only 66% of the food was consumed. In this advanced aged population, vitamin D intake was positively correlated with vitamin D status during winter months. The main contributors of vitamin D in the diet of this long-term care facility were vitamin D fortified milk and meal supplements and tablet supplements. The newly published DRI values for vitamin D in the healthy population above 70 y have changed from an AI value of 600 IU (15 µg) to a EAR of 400 IU (10 µg) and RDA of 800 IU (20 µg) [5]. Reaching these recommendations with foods or meal supplements alone will be a challenge in the institutionalized elderly.

This study adds to the mounting evidence of insufficient intake of vitamin D by food and meal supplements alone as well as 25(OH)D concentration values below 30 nmol/L for up to 18% of this population in the winter months. Although vitamin D status was sufficient for a majority of participants, PTH was elevated and above the normal range in the fall and winter months suggesting that higher intakes could be beneficial. Future research should thus provide information including data on calcium and bone metabolism in elderly individuals living in long-term care facilities within higher vitamin D status ranges. Vitamin D dose-response studies in the elderly population should also provide information to reduce the knowledge gap in elderly males with regard to benefits of achieving vitamin D recommendations on health outcomes other than bone health.

Acknowledgments

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