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Vitamin D Insufficiency among Free-Living Healthy Young Adults

Vin Tangpricha, MD, Elizabeth N. Pearce, MD, Tai C. Chen, PhD, and Michael F. Holick, PhD, MD

Vitamin D, Skin & Bone Research Laboratory, Section of Endocrinology, Diabetes & Nutrition, Department of Medicine, Boston University School of Medicine, Boston, Massachusetts.

Abstract

Long-term vitamin D insufficiency can cause secondary hyperparathyroidism and osteomalacia (1). In addition, there is increasing evidence that vitamin D may protect against common cancers, such as cancer of the colon (2–4), prostate (5), and breast (6). Young adults aged 17 to 35 years drink inadequate amounts of milk (7) and are concerned about exposure to the sun because of the fear of developing skin cancer (8,9), which increases the risk of vitamin D insufficiency (10). We sought to examine the prevalence of vitamin D insufficiency in a group of free-living healthy young adults, consisting of mostly health care professionals, in Boston, Massachusetts.

SUBJECTS AND METHODS

We recruited hospital employees, attending physicians, house staff physicians, medical students, and hospital visitors during our vitamin D awareness screening program at Boston University Medical Center during March and April, 1999 (end of winter) and September and October 1999 (end of summer). Subjects were excluded if they had a history of intestinal malabsorption. Subjects were divided into four age groups: 18 to 29 years, 30 to 39 years, 40 to 49 years, and ≥ 50 years. Study participants gave written informed consent.

A questionnaire was administered to assess the intake of foods and supplements containing vitamin D. Approximately 5 mL of blood was drawn for determination of 25-hydroxyvitamin D and intact parathyroid hormone levels.

Analysis of 25-Hydroxyvitamin D and Parathyroid Hormone Levels

The serum assay for 25-hydroxyvitamin D (D_2 and D_3) was performed according to the method of Chen et al. (11). The limit of detection was 5 ng/mL, and values below the limit of detection were assigned 5 ng/mL. The assay has an intra-assay coefficient of variation of 8% and an inter-assay coefficient of 12%. Parathyroid hormone level was determined using a chemiluminescence assay kit (Nichols Institute Diagnostics, San Juan Capistrano, California). This assay has both intra- and inter-assay coefficients of variation of 6%.

Statistical Analysis

We used the unpaired Student *t* test to compare mean 25-hydroxyvitamin D and intact parathyroid hormone levels between groups. Results are presented as means $\pm$ SD. Chi-

squared tests were used to calculate differences in proportion of vitamin D insufficiency, which was defined as a 25-hydroxyvitamin D level ≤ 20 ng/mL (12). *P* values < 0.05 were considered statistically significant. Microsoft Excel (Seattle, Washington) and Epi-Info (Atlanta, Georgia) programs were used for all statistical calculations.

RESULTS

Baseline Characteristics

One hundred sixty-five subjects were enrolled at the end of winter and 142 subjects were enrolled at the end of summer, of whom 61% were women ($n = 186$) and 60% were white ($n = 185$).

Dietary History

Most subjects drank milk: 64% ($n = 91$) in the end-of-summer group and 58% ($n = 96$) in the end-of-winter group. An average of 1.6 ± 1.0 glasses of milk was drunk per day. There was no statistical difference between the age groups in the percentage of subjects who drank milk. In addition, 40% ($n = 123$) of subjects reported taking daily multivitamin supplements during the summer and winter months. There was no statistical difference in multivitamin use between the age groups.

25-Hydroxyvitamin D and Parathyroid Hormone Levels

Parathyroid hormone levels were inversely correlated with 25-hydroxyvitamin D levels ($r = 0.40$, $P < 0.001$; Figure 1). There was significant seasonal variation in the 25-hydroxyvitamin D levels for all subjects between the winter and summer: 35 ± 10 ng/mL at the end of summer, compared with 30 ± 10 ng/mL at the end of winter ($P < 0.01$). Parathyroid hormone levels were significantly higher (44 ± 20 pg/mL) at the end of winter, compared with at the end of summer (34 ± 20 pg/mL, $P < 0.01$). Overall, vitamin D insufficiency was more common at the end of winter (30%; $n = 49$) than at the end of summer (11%; $n = 16$).

Seasonal variation in 25-hydroxyvitamin D levels was most significant in subjects aged 18 to 29 years (Figure 2). Serum 25-hydroxyvitamin D concentration increased 30% (28 ± 10 ng/mL to 36 ± 10 ng/mL) from the end of winter to the end of summer in this age group, 3% (31 ± 10 ng/mL to 32 ± 10 ng/mL) in subjects aged 30 to 39 years, 12% (27 ± 10 ng/mL to 30 ± 10 ng/mL) in those aged 40 to 49 years, and 5% (35 ± 10 ng/mL to 37 ± 10 ng/mL) in subjects aged ≥ 50 years.

Vitamin D insufficiency was more prevalent in all age groups during the winter. The oldest group was least likely to have vitamin D insufficiency during the summer (4%; 1/26) and winter (16%; 6/37), compared with all other groups during the summer (10%; 7/69) and winter (30%; 21/69; Figure 3).

25-Hydroxyvitamin D Levels and Milk and Multivitamin Intake

There was no difference in serum 25-hydroxyvitamin D levels between subjects who drank and did not drink milk. During the summer, levels were 35 ± 10 ng/mL for those who drank milk versus 33 ± 10 ng/mL for those who did not ($P = 0.30$).

Subjects who took a multivitamin had 30% higher (37 ng/mL vs. 29 ng/mL) serum 25-hydroxyvitamin D concentrations than did those who did not ($P < 0.01$). Those who took multivitamins during the winter had higher 25-hydroxyvitamin D levels (35 ± 20 ng/mL vs. 27 ± 20 ng/mL, $P = 0.0002$) at the end of winter. Likewise, subjects who took a multivitamin during the summer had 23% higher 25-hydroxyvitamin D concentrations at the

end of summer (39 ± 10 ng/mL) compared with those who did not take a multivitamin (32 ± 10 ng/mL; $P = 0.0002$).

The prevalence of vitamin D insufficiency was higher in subjects who did not take a multivitamin supplement. At the end of winter, the prevalence of vitamin D insufficiency in those who took a multivitamin supplement was 11% (7/65) versus 42% (42/100) in those who did not take a multivitamin. At the end of the summer, the prevalence of vitamin D insufficiency in those who took a multivitamin supplement was 5% (3/58) versus 15% (13/84) in those who did not take a multivitamin.

DISCUSSION

The majority of elderly patients in the United States and Europe have vitamin D insufficiency (13–15). Little is known about the prevalence of vitamin D insufficiency in healthy young adults. We observed that 36% of young adults aged 18 to 29 years had vitamin D deficiency at the end of winter. They had 20% lower 25-hydroxyvitamin D levels than in the oldest group during this period and demonstrated the most seasonal variation in 25-hydroxyvitamin D levels.

Dietary intake of milk was not associated with higher circulating levels of 25-hydroxyvitamin D. This is not unexpected since the vitamin D content in milk is highly variable (16). Furthermore, even if the milk contained 400 IU of vitamin D per quart, 1.6 glasses of milk would be equal to 160 IU of vitamin D, which is below the recommended daily intake of 200 IU for this age group. In comparison, we found that daily intake of a multivitamin containing 400 IU of vitamin D was associated with higher 25-hydroxyvitamin D levels.

The high prevalence of vitamin D deficiency in young adults may be explained by their lower consumption of vitamin D–containing foods, such as fortified cereals and oily fish (17). Seasonal variation in sunlight exposure, however, is the most likely explanation, especially during the winter. There was a weak, albeit positive association between hours spent outdoors during the summer and 25-hydroxyvitamin D levels ($r = 0.20$, $P = 0.001$). During the winter, the sunlight is incapable of producing vitamin D₃ in the skin at latitude 42°N, where Boston is located (18). Most of the subjects in the youngest age group were students who were most likely to be indoors attending classes during the daylight hours in the fall and spring, and outdoors during the summer vacation months. This would account for the differences in 25-hydroxyvitamin D levels during the winter and summer in this group.

We conclude that young adults aged 18 to 29 years have an equal to greater risk of vitamin D insufficiency than do older adults, especially during the winter. Prevention of vitamin D insufficiency in young adults is easily accomplished by encouraging increased vitamin D intake through multivitamin supplementation, especially if they are not getting exposure to sunlight during the spring, summer, and fall, or have increased skin pigmentation, which interferes with the cutaneous production of vitamin D (19).

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Figure 1.
The relation between 25-hydroxyvitamin D and parathyroid hormone levels. Serum levels of 25-hydroxyvitamin D were inversely correlated with parathyroid hormone levels ($r = 0.40$, $P < 0.001$).

Figure 2.

Seasonal variation in 25-hydroxyvitamin D levels by age group. Means are presented with error bars representing the SD. Subjects in the end-of-summer groups had higher 25-hydroxyvitamin D levels. The dashed horizontal line represents the minimum level of 25-hydroxyvitamin D considered to be vitamin D sufficient (12). There was a significant difference in the mean serum 25-hydroxyvitamin D levels in the 18- to 29-year-old group when comparing the end-of-winter with the end-of-summer groups ($P < 0.01$).

Figure 3.

Percentage of subjects in the four age groups who were vitamin D deficient (25-hydroxy vitamin D level ≤ 20 ng/mL) at the end of winter and at the end of summer. There was a significant difference in the proportion of subjects with vitamin D insufficiency between the end-of-winter and end-of-summer groups ($P < 0.05$).