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Serum 25-Hydroxyvitamin D Levels in Active Women of Middle and Advanced Age in a Rural Community in Japan

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ABSTRACT

There have been few epidemiologic studies on vitamin D status in Asians. The purpose of this study was to investigate the 25-hydroxyvitamin D (25[OH]D) levels in active women of middle and advanced age in Japan. We targeted 236 women who participated in an annual health check-up program in September 1997. Among them, 160 women were examined. Serum 25(OH)D_2 and 25(OH)D_3 levels were determined with high-performance liquid chromatography. In addition, the study included survey questions regarding age, body weight and height, occupation, use of skin protection, clinical and reproductive histories, and lifestyles. The average age was 65.6 y (SD = 8.3). The mean concentrations of 25(OH)D_2 and 25(OH)D_3 were 0.5 (SD = 3.2) nmol/L and 78.3 (SD = 17.8) nmol/L, respectively. None of the subjects showed hypovitaminosis D (25[OH]D <37.0 nmol/L). Concentrations of 25(OH)D_3 did not change with age ($r = -0.079$, $P = 0.32$), nor did other variables associated with 25(OH)D_3 concentrations except for "engaging in farming" ($P = 0.03$) in the occupational category. These findings indicate that 25(OH)D levels in active middle- and advanced-aged women in Japan have appropriate vitamin-D status. Studies to elucidate and assess the dietary intake of vitamin D in Japanese women can be of further benefit. *Nutrition* 1999; 15:870–873. ©Elsevier Science Inc. 1999

Key words: 25-hydroxyvitamin D, epidemiology, women, aged, Japan

INTRODUCTION

Nutritional status of vitamin D is replacing infantile rickets[1] as a main topic of interest in relation to bone health. As a risk factor for bone loss, hypovitaminosis D often secondary to hyperparathyroidism is a concern.[2,3]

Age-related decline of vitamin D reserves, low exposure to sun light, and low intake of vitamin D are major factors contributing to hypovitaminosis D.[4] Many investigators have pointed out that low levels of 25-hydroxyvitamin D (25[OH]D), a good nutritional indicator of vitamin D stores in the body, are prevalent in inpatients[5,6] and in institutionalized elderly patients.[7,8] The prevalence of hypovitaminosis D has been reported to be greater than 35% in such high-risk populations. Even in independent-living elderly populations, the prevalence has been reported to be 6–16%.[9–11]

Most of the epidemiologic studies on vitamin D nutrition concern northern Europe and North America, which are high-risk areas for hypovitaminosis D in northern latitudes. Elderly people, however, seem to be at substantial risk for hypovitaminosis D regardless of geographic location.[12] Therefore, we investigated 25(OH)D levels in elderly women in Japan, where no epidemiologic study has ever been conducted and, consequently, the 25(OH)D levels are unknown. In addition, studying Japanese populations was of particular interest because of the following three reasons. First, although the latitude of Japan is generally more southern than that of Western countries, vitamin D intake by Japanese is considered low because vitamin D fortification is not done. Second, very few studies on vitamin D status have been conducted in Asians. Third, the incidence of osteoporotic fracture is much lower in Asian countries than in white populations in Europe and North America.[13]

The purpose of this study was to investigate the 25(OH)D levels, prevalence of hypovitaminosis D, and correlates of 25(OH)D concentrations in the prevention of bone loss and to

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target active women of middle and advanced age in a rural community in Japan.

SUBJECTS AND METHODS

Population

We targeted active middle- and advanced-aged women who participated in an annual health check-up program in a rural community in Toyosaka City, Niigata, Japan. Toyosaka is located at a latitude of 37°54′ north. The health check-up program, sponsored by the city, was intended for adults aged 40 y and older. Two hundred thirty-six women in the community attended the health check-up examination on September 1 and 2, 1997. Of the 236 women, 173 (73.3%) agreed to take part in the study. Thirteen subjects who had diseases or conditions that could affect vitamin D metabolism were excluded: 3 with current liver disease, 8 taking multivitamin tablets, 1 undergoing treatment for osteoporosis, and 1 with current leukemia. Accordingly, 160 women were included for the analysis. This study was conducted under the guidelines of the Ethical Committee of the Niigata University School of Medicine. Written informed consent was obtained from all of the subjects.

25(OH)D Measurement

Blood specimens were drawn from subjects who arbitrarily came for the examination. The amount of time since their last meal was noted. Blood samples were centrifuged for serum within the same day and stored at −80°C until the 25(OH)D measurement was performed. Serum 25(OH)D_2 and 25(OH)D_3 were analyzed with the two-step method by high-performance liquid chromatography.[14] Interassay coefficients of variation were 5.8% for 25(OH)D_2 and 6.5% for 25(OH)D_3. Standard compound of 25(OH)D_2 was purchased from Tetrionics (Madison, WI, USA), and standard 25(OH)D_3 was a gift from F. Hoffmann-La Roche Ltd. (Basel, Switzerland).

Other Information

Body height and weight were measured to the nearest 1.0 mm and 0.1 kg, respectively. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2). Age, occupation, clinical and reproductive history, and lifestyle information were surveyed in interviews by trained public health nurses. Occupational status was coded as follows: farming (outdoor work) as 1, and other (indoor work) as 0 in terms of sunlight exposure. A complete medical history was obtained; a history of resection of any part of the gastrointestinal tract (GI resection) was noted. Subjects were asked whether they used any skin protection in the sunlight (skin protection) such as covering their skin against direct sunlight and applying sunscreen. Alcohol consumption and smoking habits were also determined.

Statistical Analysis

Differences between two mean values and among three or more mean values were evaluated with Student's *t* test and one-way analysis of variance, respectively. Pearson's product moment correlation coefficients were calculated for the linear relation between two variables. A *P* value less than 0.05 was considered statistically significant. Multiple linear regression analysis with a stepwise method was used to find correlates of 25(OH)D concentrations. Candidates for independent variables were age, age of menopause, BMI, occupation, use of skin protection, and history of GI resection. A P value <0.05 was set in performing stepwise methods of multivariate analysis to detect correlates of 25(OH)D for the summer months. An SAS statistical package[15] was used for the computation.

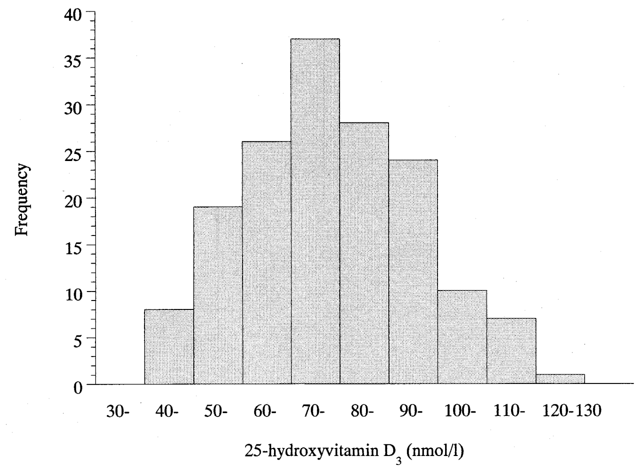

FIG. 1. Frequency distribution of 25-hydroxyvitamin D_3. The distribution is considered to be approximately normal.

RESULTS

The subjects' age ranged from 42 to 84 y, with a mean age of 65.6 (SD = 8.3), and 93.7% of the subjects were postmenopausal women. Their mean BMI was 23.5 (SD = 3.2) kg/m^2. Seventy (43.8%) of 160 women identified themselves as engaging in farming. The proportions of current smokers and drinkers were 0.6% and 16.5%, respectively. Seven women (4.5%) had a history of GI resection. Using some skin protection in the sunlight was reported by 64.6% of the subjects.

The mean concentrations of 25(OH)D_2 and 25(OH)D_3 were 0.5 (SD = 3.2) nmol/L and 78.3 (SD = 17.8) nmol/L, respectively. Because serum 25(OH)D_2 levels in the subjects were sufficiently small compared with those of 25(OH)D_3, the following analyses focus on 25(OH)D_3 levels. The frequency distribution of 25(OH)D_3 is shown in Figure 1. The distribution is approximately normal, with a minimum value of 42.7 nmol/L. No subject had a 25(OH)D_3 concentration less than 37.0 nmol/L, which is generally considered hypovitaminosis D.[6]

The mean 25(OH)D_3 concentration for each age group is shown in Figure 2. In the majority of subjects 50–79-y-old, 25(OH)D_3 levels tended to decrease with age, but the tendency was not statistically significant ($P = 0.21$). No correlation was found between age and 25(OH)D_3 concentration ($r = -0.079$, $P = 0.32$).

Univariate regression analysis showed that serum 25(OH)D_3 levels were significantly associated with outdoor work ($P = 0.018$) and GI resection ($P = 0.034$). However, serum 25(OH)D_3 levels were independent of the last meal time ($P = 0.84$). The summary of multiple regression analysis with the stepwise method for the dependent variable 25(OH)D_3 is presented in Table I. In the multivariate analysis, only outdoor work showed the $P < 0.05$ level as an independent variable. *P* values of GI resection and skin protection fell between 0.05 and 0.15. No other variables were used in the regression model.

DISCUSSION

The mean 25(OH)D_3 concentration was 78.3 (SD = 17.8) nmol/L in these women. Previous studies, conducted in female populations of similar age groups during summer, have reported 25(OH)D levels, 35.0–78.0 nmol/L from northern Europe,[10,16,17] 44.0–82.0 nmol/L from the USA,[9,18–20] and 75.0 nmol/L from a Caribbean island.[21] In comparison with these reports, our results

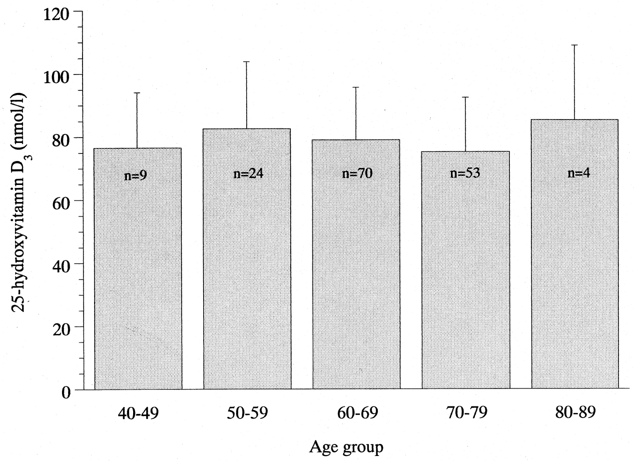

FIG. 2. Mean values with SD of serum 25-hydroxyvitamin D_3 concentrations by age group. No statistically significant differences in 25-hydroxyvitamin D_3 concentrations were found across age groups.

TABLE I.

SUMMARY OF MULTIPLE REGRESSION ANALYSIS WITH THE STEPWISE METHOD FOR THE DEPENDENT VARIABLE 25-HYDROXYVITAMIN D_3 (NMOL/L)

Independent variable (yes, 1; no, 0)	Parameter estimate	SE	*P*
Outdoor work	6.15	2.88	0.028
GI resection*	−11.69	6.70	0.083
Skin protection†	4.41	2.88	0.128

* Having a history of resection of any part of gastrointestinal (GI) tract.
† Skin protection against sunlight, e.g., covering their skin against direct rays from the sun and applying sunscreen.

seem relatively high. The 25(OH)D concentration during summer seems independent of latitude because a high value of 78.0 nmol/L has been reported from Finland,[17] and a low value of 44.0 nmol/L has been reported from New Mexico (USA).[9] We believe that other factors, such as length of time of outdoor activity and amount of vitamin D intake, may contribute to the regional differences.

The 25(OH)D level of the Japanese women in this study appeared to be acceptable for the following reasons. First, the female subjects under study are considered active in relation to sunlight exposure. Forty-four percent of the women identified themselves as regularly engaging in farming. In addition, 38% told us that they were involved in farm work for a short time each day; thus, they were considered to have received a large exposure of sunlight. Vitamin D intake is another important contributor to 25(OH)D concentration.[22] Our finding that gastrointestinal tract resection influenced 25(OH)D concentration may support this fact. Although detailed dietary assessment was not included in this study, our preliminary food-frequency interview showed that 47% of the subjects frequently ate fish, which contains large amounts of vitamin D_3 (data not shown). Thus, we speculate that Japanese may receive appropriate vitamin D intake even though vitamin D fortification is not allowed in this country. Because no nutritional studies for vitamin D intake have been conducted in Japan, further research is needed.

Our research has suggested that there may be a racial component in the production of vitamin D_3 in the skin because of the negative association between skin pigmentation and vitamin D_3 production.[23] Black people have been shown to have lower 25(OH)D_3 concentrations than white people.[24,25] In this context, dark-skinned Japanese are more disadvantaged than their white-skinned counterparts, with regard to vitamin D_3 synthesis in the skin. However, these questions are beyond the scope of this study.

That 25(OH)D levels decline with age has been well documented[7,11,21,26] and has been supported experimentally by studies demonstrating that the elderly had more than a two-fold decreased capacity for their skin to produce both previtamin D_3,[27] a precursor of 25(OH)D_3 in the skin, and 25(OH)D_3[28] in comparison with the young. In contrast, our study failed to observe such association. Only the study by Sherman et al.,[29] which targeted healthy and highly-motivated adults in Baltimore (USA), is in agreement with our results. They concluded that the excellent vitamin D status in the elderly was attributable to the following three factors: (a) extreme healthiness by means of the study's strict exclusion criteria, (b) high educational and socioeconomic status of the subjects, and (c) substantial sunlight availability. In the present population, the third factor is common. In addition, dietary factors may be slightly influential. We conclude that active lifestyles and resultant abundant exposure to sunlight can maintain adequate 25(OH)D levels even in the elderly.

The Japanese are an interesting population in terms of bone health. The incidence of osteoporotic fracture is much lower in Japan than in European and North American countries.[30] Researchers have estimated that the incidence of hip fracture in Japan is one-fifth to one-half of that in the United States.[13,31] This seems somewhat paradoxical considering the lower calcium intake of the Japanese population. Factors explaining the paradox, such as genetic predisposition, bone or body size, and Japanese lifestyle, has been hypothesized, but definite conclusions have not been drawn. From our data, we feel that the low prevalence of osteomalacia due to high vitamin D levels in the Japanese population may be one of the contributory factors.

SUMMARY

The 25(OH)D levels in active women of middle and advanced age in Japan have appropriate vitamin D status. Moreover, age-related decline of vitamin D status could be prevented with active lifestyles and sufficient sunlight exposure, even in the elderly. Further studies should be conducted to assess the dietary intake of vitamin D in the Japanese population and to compare these findings with those from Western countries.

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