Vitamin D Nutritional Status of Women Living on a Solitary Island in Japan: A Population-Based Study

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Abstract

Objective: Serum 25-hydroxyvitamin D [25(OH)D] is a vitamin D metabolite and a good indicator of vitamin D nutritional status. Low 25(OH)D levels accelerate age-related bone loss in women. The aim of this study was to assess 25(OH)D levels using population-based samples from women in a community in Japan.

Subjects and Methods: Of all 187 adult women living on a solitary island (Niigata, Japan), 150 (80.2%) were enrolled in a cross-sectional study in early June 1998. After excluding 6 subjects who were undergoing treatment for osteoporosis, 144 female subjects were analyzed. Serum 25(OH)D₂ and 25(OH)D₃ were determined by high-performance liquid chromatography. The sum of 25(OH)D₂ and 25(OH)D₃ was calculated, yielding 25(OH)D, for which a concentration of less than 30 nmol/L was defined as vitamin D insufficiency. Demographic data such as age, height, weight, and body mass index (BMI) were also recorded.

Results: The average age of the subjects was 61.3 years (SD 12.8), ranging from 21 to 87. The average concentrations of 25(OH)D₂ and 25(OH)D₃ were 0.5 nmol/L (SD 3.2) and 64.6 nmol/L (SD 17.6), respectively. The number of subjects with 25(OH)D concentration less than 30 nmol/L was 4 of 149 (2.7%). Serum 25(OH)D concentrations were not significantly correlated with age ($r=-0.065$, $p=0.441$) or BMI ($r=0.086$, $p=0.310$).

Conclusion: The present population-based study confirms adequate levels of 25(OH)D and low prevalence of vitamin D insufficiency in Japanese women. Further research should be directed toward clarifying which dietary factors determine vitamin D nutrition.

Key words: epidemiology, 25-hydroxyvitamin D, Japanese, population-based study, women

Introduction

Vitamin D insufficiency is a current topic worldwide because it accelerates age-related bone loss in elderly women and is common in elderly people¹⁾. Serum 25-hydroxyvitamin D [25(OH)D], which is the most stable vitamin D metabolite synthesized in the liver, is known to be an index of vitamin D nutritional status²⁾, and a 25(OH)D concentration of less than 30 nmol/L is often defined as vitamin D insufficiency^{3,4)}. Using this cutoff value, the prevalence of vitamin D insufficiency in France was recently documented to be nearly half of the healthy elderly women who were studied⁵⁾.

For Japan, Nakamura et al^{6,7)} recently reported adequate levels of 25(OH)D. Average 25(OH)D concentrations in elderly women were 78.8 nmol/L in summer and 59.9 nmol/L in winter, among the highest levels ever reported. They also reported that the prevalence of vitamin D insufficiency was zero in summer⁶⁾ and 4.6% in winter⁷⁾. However, those studies were not population-based, and thus selection bias may have occurred.

We had an opportunity to conduct a health examination on a solitary island, Awashima, where most people are more or less involved in fishery. The annual health check examination targets all residents of the island. The aim of this study was to assess 25(OH)D levels in a population-based sample of a Japanese community. Studying women of this community would provide further information about 25(OH)D levels in Japan.

Subjects and Methods

Adult women living on Awashima Island were investigated.

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Awashima Island is a small, solitary island situated at latitude 38°26-29' N and longitude 139°13-16' E in the Japan Sea, about 36 km off the coast of Murakami City, Niigata, Japan. Awashima Island had an adult (over 20 years old) female population of 187 during the investigation period. Of 187 women, 150 (80.2%) participated in the annual health check examination, including blood tests, sponsored by the local government in early June 1998. No subjects showed a liver or renal disorder, which can affect vitamin D metabolism. But, 6 subjects were undergoing treatment for osteoporosis and they were excluded, so a total of 144 subjects were analyzed. Informed consent was taken from all subjects. This study was conducted under the guidelines of the Ethics Committee of Niigata University School of Medicine.

Non-fasting blood samples were drawn from the subjects. After the serum was centrifuged, it was refrigerated at -80 °C until biochemical analysis. Serum 25(OH)D₂ and 25(OH)D₃ were determined by high-performance liquid chromatography[®]. 25(OH)D₂ is derived from vegetable foods, and 25(OH)D₃ exogenously from animal food and endogenously from photochemical production in the skin. The inter-assay CV values of 25(OH)D₂ and 25(OH)D₃ were 3.4% and 4.1%, respectively. Demographic data such as age, height, and weight were also recorded. Body mass index (BMI, kg/m²) was calculated as weight (kg) divided by the square of height (m²).

Mean and standard deviation (SD) of parameters were calculated to characterize the population. Pearson's product moment correlation coefficient was used to evaluate a correlation between 25(OH)D levels and other continuous variables. Student's t-test was used for the comparison of mean values between two groups. A p-value less than 0.05 was considered to be statistically significant.

Results

The average age of the subjects was 61.3 years (SD 12.8), ranging from 21 to 87. Average height, weight, and BMI were 148.1 cm (SD 7.5), 53.0 kg (SD 7.9), and 24.1 kg/m² (SD 2.7), respectively. While more than half of the adult men on the island were engaged in fishery, most adult women were basically housewives. Of all subjects, 61.1% identified themselves as a housewife or a person without any occupation, 18.1% engaged in farming or fishery, 7.7% had a professional or clerical job, 4.9% were storekeepers, and the remaining 7.3% engaged in other work. Data on whether subjects engaged in indoor (including housewives and persons without occupation) or outdoor work were available for 140 subjects (4 unknown). One hundred and seven subjects (76.4%) were classified as having indoor work and 33 (23.6%) as having outdoor work.

The average concentrations of 25(OH)D₂ and 25(OH)D₃ were 0.5 nmol/L (SD 3.2) and 64.6 nmol/L (SD 17.6), respectively. 25(OH)D₂ concentrations were sufficiently small so the sum of 25(OH)D₂ and 25(OH)D₃ was calculated as 25(OH)D, which was used in the following analyses. The frequency distribution of 25(OH)D is shown in Fig. 1. The distribution is approximately normal with a mean value of 65.1 nmol/L (SD 18.0). The number of subjects with 25(OH)D concentration less than 30 nmol/L was 4 of 149 (2.7%).

Serum 25(OH)D concentrations are plotted against age in Fig. 2. 25(OH)D concentrations were not correlated significantly with age ($r=-0.065$, $p=0.441$), or with BMI ($r=0.086$, $p=0.310$).

Fig. 1 Frequency distribution of serum 25-hydroxyvitamin D [25(OH)D] concentrations in Japanese women in June. The average value was 65.1 nmol/L. The proportion of subjects with 25(OH)D concentration less than 30 nmol/L was 4/149 (2.7%).

Fig. 2 Scatterplots of serum 25-hydroxyvitamin D [25(OH)D] concentrations versus age. 25(OH)D concentrations were not correlated significantly with age ($r=-0.065$, $p=0.441$).

There was no significant difference in 25(OH)D concentration between subjects with indoor and outdoor work ($p=0.333$).

Discussion

A seasonal factor, ultraviolet (UV) radiation, needs to be considered when evaluating the 25(OH)D levels of this study. June is the rainy season in Japan, and the average number of hours of sunshine per day in the week previous to that of data collection was as short as 3.8 (as recorded by the Niigata Local Meteorological Observatory), similar to the level in March and April. The average 25(OH)D concentration in this population, 65.0 nmol/L, lies between those reported for Japanese women in February and September, 59.9 and 78.8, respectively (Fig. 3)^{6,7)}. Fig. 3 shows the comparison of 25(OH)D levels between the present and previously published studies. The present 25(OH)D level is one of the highest ever reported.

Not only the mean value of 25(OH)D, but also the proportion of insufficient 25(OH)D levels, is of concern. The

concept of "vitamin D insufficiency" should be distinguished from "vitamin D deficiency⁴⁾". Vitamin D deficiency is defined as a very low level of vitamin D nutritional status (e.g., serum 25(OH)D concentration $\leq 20\text{nmol/L}$ ¹²⁾ which leads to rickets or osteomalacia¹¹⁾. By contrast, vitamin D insufficiency has been defined as a low level of vitamin D nutritional status which does not cause osteomalacia but which harmfully affects calcium homeostasis and bone metabolism⁴⁾. Mild hyperparathyroidism, suboptimal calcium absorption, and reduced bone mass are found in those with vitamin D insufficiency⁴⁾. Serum 25(OH)D concentration $\leq 30\text{nmol/L}$ ^{3,4)} was defined as vitamin D insufficiency in this study. Using this threshold, the proportion of vitamin D insufficiency in elderly Caucasian women in winter has been reported to be from 14 to 65%^{3-5, 14)}. The prevalence of vitamin D insufficiency seems to be independent of degrees of latitude. Very high prevalence ($>60\%$) was reported even in Lebanon (lat. 33.5°N), a sunny country¹⁵⁾. Interestingly, van der Wielen et al.³⁾ demonstrated that the prevalence of vitamin D insufficiency in European countries was inversely correlated with degrees of latitude. They concluded that attitudes toward sunlight exposure, such as outdoor activities and clothing, were more important factors than latitude³⁾. Therefore, the prevalence of vitamin D insufficiency of 2.7% in this study is low. In addition, Japanese have darker skin than Caucasians and thus are at a disadvantage with regard to vitamin D biosynthesis in the skin²⁾, and they do not use vitamin D supplements as do women in some European and North American countries.

The question is why these women had such good 25(OH)D levels. Lifestyles on the island may provide a clue. Most women were housewives and did not engage in outdoor work. However, fish consumption on the island, where fishery is the chief industry, is probably high, although meats, vegetables, and fruits are imported from the mainland along with many other daily necessities. Because fish is a major source of vitamin D in the Japanese diet¹⁶⁾, it is highly likely that fish consumption of the women of Awashima may play an important role in vitamin D nutritional status. We do not have these data, which should be pursued in future studies.

The lack of association between age and 25(OH)D levels in the present population-based study is noteworthy. It has generally been believed that 25(OH)D levels decrease with age due to

Fig. 3 Comparisons of 25(OH)D levels between present and previously published studies.

decreased capacity for vitamin D₃ production in the skin¹⁷⁾, and this has also been observed in studies of Japanese women^{6,7)}. Now we can say that an age-related decrease of 25(OH)D is inevitable in Japanese women, which can be reasonably explained by the hypothesis that exogenous sources of vitamin D help maintain adequate levels of 25(OH)D.

This epidemiologic study has one limitation. The population in this study represented women residing in rural regions, where lifestyles are different from those in urban regions of Japan. Rural diets may be more traditionally Japanese than urban areas, and consequently the amount of vitamin D intake may be different. People with traditional Japanese diets may consume more fish and may thus have a more adequate vitamin D nutritional status.

In summary, the present population-based epidemiologic study reports an adequate level of 25(OH)D and a low prevalence of vitamin D insufficiency in Japanese women. Further research should be directed toward clarifying those dietary factors which determine vitamin D nutrition. In addition, epidemiologic studies of vitamin D nutritional status should target high-risk populations of women with osteoporosis, including those with low levels of daily activity.

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