Original Article

25(OH)D status and demographic and lifestyle determinants of 25(OH)D among Korean adults

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Purpose: Vitamin D deficiency is a global health problem that is associated with increased risks of major diseases. This study investigated the status of 25-hydroxyvitamin D [25(OH)D] and its demographic and lifestyle determinants among Korean adults. Methods: A total of 5,847 adults who had participated in the Korean National Health and Nutrition Examination Survey of 2008 (KNHANES) were included in the present study. Stepwise linear regression analysis was performed to determine the demographic and lifestyle determinants of 25(OH)D concentration. Results: The weighted prevalence (standard error) of 25(OH)D deficiency (<20 ng/mL) was 49.9 (2.1)% among the males and 67.4 (1.7)% among the females. Severe 25(OH)D deficiencies (<10 ng/mL) were found in 5.7 (0.8)% of the males and 11.1 (1.0)% of the females. These peaked in spring and winter. Only 12.2 (1.1)% of the males and 6.4 (0.6)% of the females exhibited 25(OH)D sufficiency (≥30 ng/mL). The correlates with higher 25(OH)D concentration for both genders included summer, fall (vs spring), the 60s age group (vs 20s), rural residence (vs urban), moderate and vigorous physical activity (vs sedentary), alcohol consumption, and multivitamin supplementation. Higher education and unmarried status were inversely associated with 25(OH)D concentration for both genders. The strongest predictors of 25(OH)D concentration were season and residential area. Conclusions: 25(OH)D deficiency is a prevalent condition in Korea. Understanding the determinants of 25(OH)D can facilitate identification of persons at risk of 25(OH)D deficiency.

Key Words: 25(OH)D, prevalence, determinants, lifestyle, Korean

INTRODUCTION

Vitamin D deficiency is a global health problem. Although its definition remains a matter of debate, vitamin D deficiency can cause growth retardation and skeletal abnormalities, and also increases the risks of hip fractures.[1] Additionally to its classical role in osteoporosis, vitamin D deficiency has been reported to be related to increased risks of many chronic diseases such as breast and colon cancer, cardiovascular disease, multiple sclerosis and autoimmune disease.[1] To reduce health risks associated with vitamin D deficiency, knowing the determinants of 25-hydroxyvitamin D [25(OH)D] concentration, which is a major circulating metabolite of vitamin D that reflects both dietary intake and endogenous synthesis, is critical.

There are many studies on 25(OH)D status determination among Caucasians, but only limited numbers among Korean adults.[2,3] Most of these studies, moreover, were small in scope, lacking in diversity of age, gender and geographic location, and thus could not accurately indicate the status of 25(OH)D among representative Koreans. Furthermore, there has been little focus on the demographic and lifestyle determinants of 25(OH)D. In response to these research lacunae, the present study investigated the status of 25(OH)D and its demographic and lifestyle determinants among a representative population of Korean adults using data from the Korean National Health and Nutrition Examination Survey 2008 (KNHANES).[4]

METHODS

Study population

The data used in the present study was obtained from KNHANES, which had been conducted by the Korean Ministry for Health and Welfare. That survey involved a population-based random sampling of 12,528 individuals across 200 national districts and 4,600 households. A total of 9,744 people participated in the Health Behavior Survey, the Health Examination Survey, or the Nutrition Survey. For the purposes of my analysis, those aged less than 20 years and who had no 25(OH)D-relevant data were excluded, leaving a total of 5,847 participants (2,481 males and 3,366 females).

Basic questionnaire and health examination

Height was measured using a stadiometer with the subject in the upright position and bare-footed, and body weight was measured on a balanced scale. BMI was calculated according to the formula BMI=body weight (kg)/height^2 (m^2). Blood pressure was measured using a mercury sphygmomanometer with the subject in the sitting

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position after a 5-min rest period. Three measurements were taken from all subjects, and the average of the last two measurements was used. Blood samples were collected in the morning after an overnight fast and then centrifuged, refrigerated and transferred to a national central laboratory in Seoul. Glucose was measured enzymatically on an automatic analyzer (Hitachi 7600). The 25(OH)D concentrations (ng/dL) were assayed with a radioimmunoassay kit (DiaSorin, Still Water, MN). The interassay coefficients of variation were 11.7%, 10.5%, 8.6% and 12.5% at 8.6, 22.7, 33.0 and 49.0 ng/mL, respectively. The vitamin D nutritional status was defined as "sufficiency" (≥30 ng/dL), "deficiency" (<20 ng/dL), or "severe deficiency" (<10 ng/mL).

Self-reported questionnaires were administered to determine the smoking status, alcohol intake, education level, physical activity level, previous and current diseases and multivitamin use. Dietary intake was assessed using a single 24-hour dietary recall method. The smoking status was categorized into two groups, non smokers and current smokers, the latter defined as those who smoke ≥5 packs and who currently smoke cigarettes. Alcohol consumption was categorized into two groups, drinkers and non drinkers, the latter defined as those who drink alcohol more than once per month. The educational level was categorized into three groups: <9 years, 9-12 years, and ≥12 years. Physical activity was categorized into four groups: sedentary, mild, moderate, and vigorous activity. Vigorous activity was defined as difficult and/or breathlessness-inducing exercise ≥3 times per week for at least 20 minutes. Moderate activity was defined as that undertaken ≥5 times per week and of ≥30 minutes duration that produces moderate extents of breathlessness and sweating. Mild activity was defined as walking ≥5 times per week for at least 30 minutes. Hypertension was defined as having a prescription for antihypertensive medication or systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg. Diabetes was defined as having a prescription for diabetes medication or a history of a previous diagnosis of diabetes or a fasting blood glucose level ≥126 mg/dL. Season was classified into four groups: spring (March, April, May), summer (June, July, August), fall (September, October, November), and winter (December, January, February). Marital status was categorized into two groups: married and unmarried. Residential area also was categorized into two groups: urban and rural. Calcium intake (mg/d) was estimated from the reported one-day recall, and this was categorized into quartiles. Multivitamin use was defined as intake of multivitamins for at least 2 weeks within one year, and this was categorized into two groups: yes and no.

Statistical analysis

All analyses excepting the stepwise regression analysis were performed using the KNHANES 2008 sample weights to account for the complex survey design and to provide unbiased estimates of the prevalence for the total Korean population. Prevalence estimates of 25(OH)D deficiency, severe deficiency and sufficiency were reported as percentages with 95% standard error (SE). Mean 25(OH)D concentrations and 95% confidence interval (CI) were estimated using linear regression. Estimated mean 25(OH)D concentrations were compared according to the characteristic of study participants using ANOVA analyses. Males and females were analyzed separately owing to the gender difference in 25(OH)D concentrations. Stepwise linear regression analysis was used to determine the association of the 25(OH)D concentration (continuous) with the possible determinants, which included sociodemographic characteristics (age, gender, education, residential area, marital status), the season in which the blood was drawn, BMI, physical activity, smoking status, alcohol intake, multivitamin supplementation, calcium intake, diabetes and hypertension. As the 25(OH)D data was not normally distributed, log-transformation was performed. However, the log-transformed and untransformed model results were similar; therefore, for interpretative convenience, the untransformed 25(OH)D data was used. A stepwise procedure allowing only variables that had a *p* value less than or equal to 0.10 for at least 1 category was employed. The statistical analyses were performed using SPSS (version 18.0, SPSS, Chicago, IL). A *p* value <0.05 was considered significant.

RESULTS

25(OH)D deficiency (<20 ng/mL) was found in 49.9 (SE, 2.1)% of the males and 67.4 (1.7)% of the females. In spring and winter, prevalence of 25(OH)D deficiency rose to more than 70% of males and more than 80% of females, which was 2 times higher for male and 1.5 times higher for female compared to that during summer and fall. Severe 25(OH)D deficiency (<10 ng/mL) was found in 5.7 (0.8)% of the males and 11.1 (1.0)% of the females. During spring, it rose to 12.6 (2.0)% among the males and 22.5 (2.4)% among the females, which levels, compared with the summer and fall, were more than 4 times higher in the case of the males, and 5 times higher in the case of the females. The prevalence of 25(OH)D sufficiency (≥30 ng/mL) was 12.2 (1.1)% among the males and 6.4 (0.6)% among the females; in spring and winter, it fell to around 3% for both genders (Figure 1). Subjects in their 20s showed the lowest 25(OH)D concentration (males: 17.8 ng/mL; females: 15.9 ng/mL) and the highest prevalence (males: 67.1%; females: 81.5%) of 25(OH)D deficiency (Figure 2). The prevalences of 25(OH)D deficiency and sufficiency decreased and increased, respectively, with increasing age (p_{trend}<0.0001) for both genders.

The summary data on the potential determinants of 25(OH)D concentration are listed in Table 1. The males had a significantly higher mean 25(OH)D concentration as compared with that of the females (20.7, 95% CI: 20.0-21.4 vs 17.8, 95% CI: 17.2-18.4 ng/mL, respectively; *p*<0.001). The 25(OH)D concentrations significantly varied according to the age group, season, residential area, education, marital status, physical activity, and presence of hypertension in both genders. Cigarette smoking and alcohol consumption in the males and BMI and vitamin supplementation in the females also significantly influenced the 25(OH)D concentrations (Table 1).

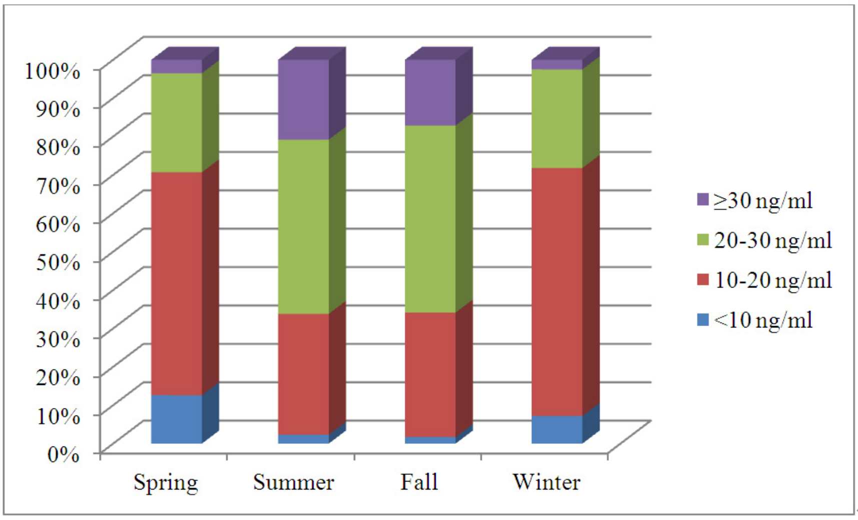
Table 2 lists the results from the stepwise regression models as stratified by gender. The determinants for the males and females slightly varied: summer, fall (vs spring), the 60s age group (vs the 20s age group), rural residence (vs urban), moderate and vigorous physical

Table 1. Estimated means of 25(OH)D concentration according to the characteristics of study participants

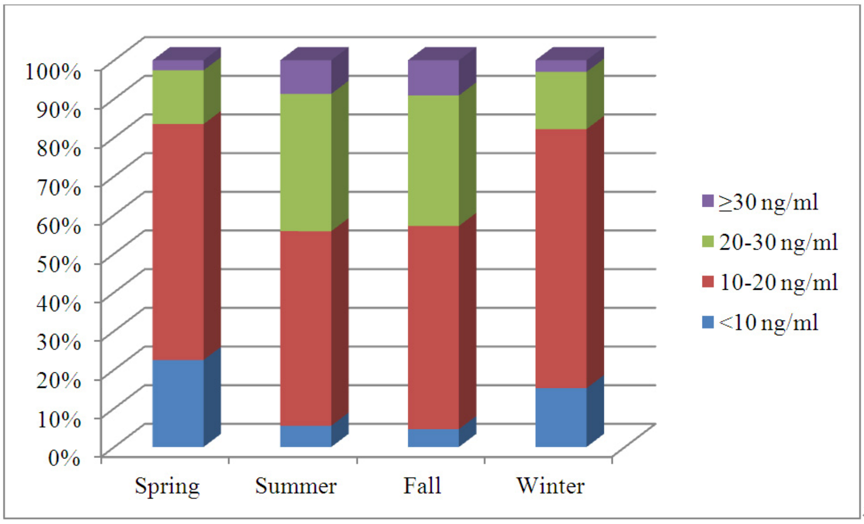
	Male			Female		
	Number of participants	Average (ng/mL)	95% CI	Number of participants	Average (ng/mL)	95% CI
Age, years	2481	43.3	42.4-44.3	3366	45.7	44.8-46.6
BMI, kg/m^2	2481	24.0	23.8-24.1	3365	23.1	22.9-23.2
25(OH)D, ng/mL	2481	20.7	20.0-21.4	3366	17.8	17.2-18.4
Calcium intake, mg/d	2003	542.0	524-560	3094	428.0	415-440
Age group*						
20-29	308 (12.4)	17.8	16.6-18.9	422 (12.5)	15.9	15.1-16.8
30-39	538 (21.7)	20.3	19.3-21.3	701 (20.8)	17.6	16.8-18.4
40-49	516 (20.8)	21.1	20.2-21.9	652 (19.4)	17.3	16.5-18.1
50-59	433 (17.5)	22.8	21.7-23.8	567 (16.8)	19.6	18.7-20.5
60-69	380 (15.3)	23.1	22.1-24.1	557 (16.6)	19.6	18.5-20.6
70-	306 (12.3)	22.2	20.7-23.6	467 (13.9)	17.9	16.8-19.1
Season*						
Spring	689 (27.7)	17.0	16.2-17.8	868 (25.8)	14.6	13.8-15.3
Summer	734 (29.6)	23.7	22.5-24.9	1027 (30.5)	19.7	16.6-20.7
Fall	711 (28.7)	23.2	22.3-24.1	963 (28.6)	19.9	19.1-20.7
Winter	347 (14.0)	17.4	16.6-18.1	508 (15.1)	15.6	14.8-16.5
Residence*						
City	1845 (74.4)	20.1	19.3-20.8	2505 (74.3)	17.3	16.9-18.0
Province	636 (25.6)	23.9	22.3-25.5	864 (25.7)	20.0	18.7-21.2
Education*						
Middle school	803 (32.5)	23.2	22.2-24.2	1535 (45.7)	19.1	18.3-19.9
High school	884 (35.8)	20.2	19.3-21.0	1085 (32.3)	17.4	16.8-18.0
University	781 (31.7)	19.8	18.9-20.6	741 (22.0)	16.6	15.8-17.3
Marital status*						
Married	2065 (83.8)	21.7	21.0-22.4	2988 (89.1)	18.3	17.7-18.9
Unmarried	400 (16.2)	17.8	16.6-19.0	365 (10.9)	15.0	14.2-15.8
BMI, kg/m‡						
<23	974 (39.3)	20.8	19.9-21.6	1654 (49.2)	17.4	16.7-18.0
23-24.9	659 (26.6)	21.0	20.1-22.0	731 (21.7)	18.1	17.4-18.9
≥25	848 (34.1)	20.5	19.7-21.2	979 (29.1)	18.4	17.7-19.2
Physical activity*						
Sedentary	957 (38.9)	19.9	19.2-20.7	1474 (44.1)	17.1	16.5-17.7
Mild activity	778 (31.6)	20.4	19.5-21.3	996 (29.8)	17.7	17.0-18.5
Moderate activity	239 (9.7)	22.4	21.2-23.7	363 (10.9)	19.1	17.9-20.2
Vigorous activity	488 (19.8)	22.1	21.1-23.2	506 (15.2)	19.1	18.3-19.9
Multivitamin use‡						
No	1671 (84.1)	20.8	20.1-21.6	2360 (77.6)	17.7	17.0-18.3
Yes	316 (15.9)	21.2	20.1-22.2	682 (22.4)	18.8	18.0-19.5
Diabetes						
No	2110 (89.3)	20.8	20.1-21.5	2938 (90.5)	17.8	17.3-18.4
Yes	254 (10.7)	21.1	20.0-22.2	309 (9.5)	18.2	16.9-19.4
Hypertension*						
No	1777 (71.9)	20.4	19.6-21.1	2496 (74.4)	17.6	17.0-18.2
Yes	696 (28.1)	21.9	21.0-22.9	858 (25.6)	18.5	17.7-19.3
Alcohol drinking†						
No	649 (26.3)	19.9	19.0-20.8	2047 (61.0)	17.8	17.2-18.5
Yes	1821 (73.7)	21.0	20.2-21.7	1309 (39.0)	17.8	17.1-18.4
Smoking†						
No	1361 (55.1)	21.2	20.4-21.0	3149 (93.8)	17.9	17.3-18.4
Yes	1110 (44.9)	20.2	19.4-21.0	207 (6.2)	16.6	15.1-18.2
Calcium intake						
1st quartile	350 (17.5)	20.0	18.6-21.4	920 (29.7)	17.9	17.1-18.7
2nd quartile	455 (22.7)	21.3	20.3-22.4	814 (26.3)	17.8	17.1-18.5
3rd quartile	552 (27.6)	20.9	20.0-21.9	729 (23.6)	17.4	16.7-18.1
4th quartile	646 (32.2)	21.0	20.1-21.8	631 (20.4)	18.6	17.8-19.5

*$p<0.05$ for male and female
†$p<0.05$ for male
‡$p<0.05$ for female

activity (vs sedentary), alcohol consumption, and multivitamin supplementation were associated with higher 25(OH)D concentrations, whereas higher education (vs middle school) and unmarried status (vs married) were associated with a lower concentration, in both genders. For the males, diabetes was the predictor of a lower 25(OH)D concentration, and hypertension was the predictor of a higher concentration. For females, the 50s age group (vs the 20s age group), mild physical activity (vs sedentary), and the highest quartile of calcium intake (vs the lowest quartile) were the predictors of a higher 25(OH)D concentration, whereas the 40s age group (vs



a) Male



b) Female

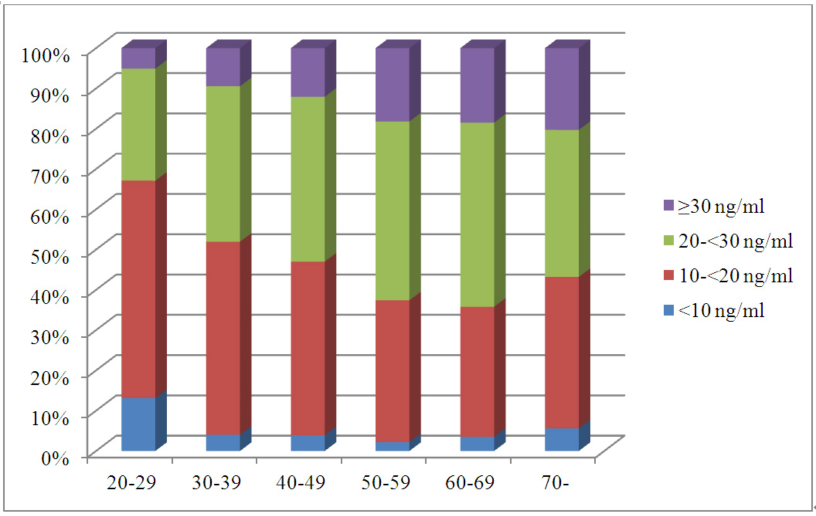
Figure 1. Percentage of participants according to the status of the 25(OH)D concentration by gender and season.

the 20s age group) was the predictor of a lower 25(OH)D concentration. All of these variables accounted for 25% and 19% of the variance in the 25(OH)D concentrations for the males and females, respectively (Table 2). Season and the residence area explained 14.0% and 5.0% of the variance for the males, and 12.2% and 2.8% for the females, respectively.

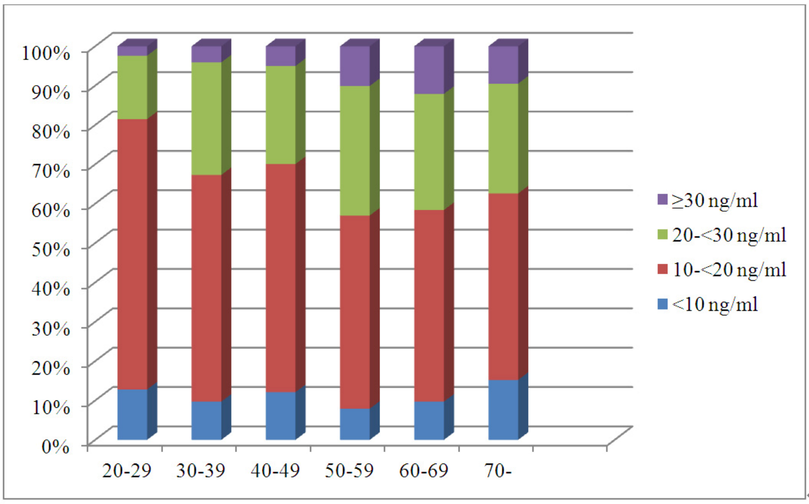
DISCUSSION

Vitamin D deficiency is a common condition among Korean adults. Fully 49.9% of Korean males and 67.4% of Korean females show this deficiency. As many as 5.7% of Korean males and 11.1% of females have severe 25(OH)D deficiency. Only 12.2% of Korean males and 6.4% of females show 25(OH)D sufficiency. There are only a limited number of previous studies on 25(OH)D status among Korean adults.[3,5] One of these, focusing on one small Korean city, showed that the mean concentrations of 25(OH)D in middle-aged Koreans (mean age: 65.7 years) were 49.2±18.2 nmol/L for males and 42.5 ±15 nmol/L for females, respectively.[5] These figures are similar to those found in the present study. However, no direct prevalence comparison was possible, as the previous study did not specifically treat the deficiency prevalence. In a past NHANES study (2000-2004), the prevalence of 25(OH)D deficiency was reported as 29% and 27% for males in the age categories of 20-49 and 70 years old, respectively, and 35% and 34% for females in the age categories of 20-49 and 70 years old, respectively.[6] In the present study, the prevalence of 25(OH)D deficiency was 55.5% and 43.2% for males, and 72.5% and 62.6% for females for the same age categories. These figures are significantly higher than those of the NHANES study. Although little is known about the exact genetic and environmental contributors to 25(OH)D deficiency, plausible explanations for the high prevalence of 25(OH)D deficiency among Korean adults are as follows: 1) higher skin pigmentation than that of Caucasians reduces the UVR–mediated synthesis of vitamin D per the same dose of sun exposure; 2) vitamin-D-fortified foods are less readily available in Korea than in Western countries; 3) cultural habits, such as avoiding direct sun exposure and wearing more clothing and a hat, lead to absorption of lesser amounts of ultraviolet radiation; 4) vitamin D supplementation might be less prevalent in Koreans than in Westerners.

Season was the strongest correlate of 25(OH)D concentration in the present study, explaining 14.0% and 12.2% of the concentration variation for males and females, respectively. The prevalence of 25(OH)D deficiency was 2



a) Male



b) Female

Figure 2. Percentage of participants according to the status of the 25(OH)D concentration by gender and age.

and 1.5 times higher during winter and spring than during summer and fall for males and females, respectively. The prevalence of severe 25(OH)D deficiency was more than 4 and 5 times higher during winter and spring than during summer and fall for males and females, respectively. During winter and spring, the 25(OH)D concentration fell to three quarters of that during summer and fall; and indeed, only approximately 3% of both males and females had sufficient 25(OH) D concentrations during winter and spring. These findings are in agreement with the seasonal variability shown in other studies.[7-11] Wearing long-sleeved clothing in sunshine, which could prevent the synthesis of vitamin D in the skin, along with a tendency to stay indoors, could contribute to the poor 25(OH)D status of many Koreans during spring and winter.

The mean 25(OH)D concentration was significantly higher among the males than among the females (20.7, 95% CI: 20.0-21.4 vs 17.8, 95% CI: 17.2-18.4 ng/mL, respectively). The prevalence of severe 25(OH)D deficiency was nearly two times higher in the females than in the males (5.7% vs 11.1%). Most of the previous studies have shown higher 25(OH)D levels among males than females,[6-7,9,12-16] but some studies have not.[11,17-20] This gender difference, in the present study, might be due to gender differences in the amount of time spent outdoors or in sun-protective behaviors such as use of sunscreen. Excess adiposity of females compared with males has been suggested as a factor contributing to lower 25(OH)D concentrations in females.[12] However, it is difficult to concur, because the BMI, a body-fat measure, was not a correlate of 25(OH)D concentration in the present study. Further research exploring the relationship of body fat to 25(OH)D concentration using methods of direct body-fat measurement such as DEXA (Dual Energy X-ray absorptiometry) are required.

In the present study, the subjects in their 20s showed the lowest 25(OH)D concentration and the highest prevalence of 25(OH)D deficiency in both genders, which conflicts with the current belief that the 25(OH)D concentration declines with age.[7,21-23] The reduced cutaneous production of vitamin D-3 in the elderly is thought to contribute to this inverse relationship of age to 25(OH)D concentration.[23] However, several studies have reported a lack of any linkage between age and 25(OH)D concentration.[11,15,18,24,25] A US study posited that persons aged 60 or more years can synthesize enough vitamin D from daily outdoor activities to maintain levels similar to those of young adults.[26] In the present study, the 60s age group for males and the 50s and 60s age groups for females also showed a significantly positive relationship to the

Table 2. Variables associated with 25(OD) D Concentrations (ng/mL) among Korean adults in stepwise regression models† by gender

	Male		Female	
	β	*p*-value	β	*p*-value
Number of participants	2481		3366	
R^2	0.25		0.19	
Age group				
20-29 (referent)				
30-39	0.01	0.675	0.00	0.886
40-49	0.00	0.937	-0.67	0.047
50-59	0.02	0.448	1.06	0.004
60-69	1.15	0.007	1.10	0.004
70-	0.00	0.963	-0.03	0.088
Season				
Spring (referent)				
Summer	5.45	<0.001	5.48	<0.001
Fall	5.83	<0.001	5.18	<0.001
Winter	0.03	0.149	1.56	<0.001
Province (vs city)	2.67	<0.001	2.13	<0.001
Education				
Middle school (referent)				
High school	-1.22	0.002	-0.71	0.026
University	-1.22	<0.001	-1.30	<0.001
Unmarried (vs married)	-2.92	<0.001	-2.14	<0.001
Physical activity				
sedentary (referent)				
mild activity	0.03	0.140	0.80	0.005
moderate activity	1.65	0.001	1.58	<0.001
vigorous activity	1.61	<0.001	1.53	<0.001
Multivitamin use	0.85	0.041	0.85	0.003
Diabetes (yes vs no)	-1.93	<0.001		
Hypertension (yes vs no)	0.74	0.032		
Alcohol drinking (vs no current use)	1.42	<0.001	0.78	0.002
Calcium intake				
1st quartile (referent)				
2nd quartile			0.02	0.312
3rd quartile			0.00	0.913
4th quartile			0.85	0.005

†The results were mutually adjusted for all the variables shown.
β indicates the linear regression coefficient.

25(OH)D concentration. This finding reflects physically active lifestyles of Koreans aged 50-60 years, most of whom have retired from their jobs and spend more time outdoors than younger Koreans. Correspondingly, fewer opportunities for outdoors physical activity during the day contributes to the lower 25(OH)D concentrations in younger subjects, most of whom are working. Decline of the 25(OH)D concentration with age is more due to illness than to aging *per se*,[18] though this distinction needs to be clarified.

Residential area also was an important correlate of 25(OH)D concentration in the present study. It explained 5% and 2.8% of the male and female variances in the 25(OH)D concentration, respectively. The male and female 25(OH)D concentrations for urban residents were 16% and 13% lower than those for rural residents, respectively. This difference could be due to both the active lifestyle of rural residents and the lower levels of air pollution in rural areas. Previous studies have reported that residents living in areas with high levels of air pollution were at an increased risk of developing vitamin D deficiency.[27-29] Certainly, the level of air pollution is inversely related to the extent of solar UVB that reaches the Earth's surface.[29] As a result, residence in a city, which typically is a highly polluted area, could result in lower cutaneous synthesis of vitamin D, and this might have an important role in the development of vitamin D deficiency. As few foods in Korea naturally contain vitamin D or are fortified with it, exposure of the skin to sunlight might be the major source of vitamin D for most Koreans. Although neither the number of hours spent outside nor the amount of solar UVB photons reaching the ground were measured in the present study, correlation between 25(OH)D and residential area in the present study could be the indirect evidence that air pollution is related with 25(OH)D deficiency.

Physical activity, multivitamin supplementation, and alcohol consumption were positive correlates of 25(OH)D concentration for both genders in the present study. Previous work has shown a positive association between greater amounts of physical activity and 25(OH)D concentration,[9,12,26,30-37] as is consistent with the current findings. Although the present study did not distinguish outdoor physical activity from indoor, a positive association with physical activity might be the result of higher sun exposure during the course of outdoor physical activity. Multivitamin supplementation was a positive correlate of 25(OH)D concentration for both genders. Vitamin D-fortified foods are rarely available in Korea, and so the role of multivitamin (or vitamin D) supplementation could be important in preventing and treating vitamin D deficiency. The positive correlation between 25(OH)D concentration with alcohol consumption in the present study is in agreement with the results of previous studies.[16,38-40] Although the reason for this is uncertain, alcohol consumption could reflect some other lifestyle factors.[38] Further research is needed to determine the mechanism by which alcohol influences 25(OH)D concentration.

Unmarried status and higher education were inversely correlated with the 25(OH)D concentration for both genders. The beneficial impact of marriage on the 25(OH)D concentration may be due to better nutritional status and a healthier lifestyle.[41] Higher education was negatively associated with the 25(OH)D concentration for both genders, which somewhat conflicted with a US study showing that vitamin D deficiency was more common among those who had no college education.[42] In Korea, highly educated personnel are more likely to have a white collar job and, accordingly, a sedentary lifestyle,[4] which contribute to a higher prevalence of 25(OH)D deficiency among highly educated people.

The present study also showed that diabetes was inversely correlated with the 25(OH)D concentration for males, as is consistent with a previous systematic review and a meta-analysis.[43,44] In prospective studies,[45-48] 25(OH)D was revealed to be associated with an decreased risk of type 2 diabetes. Vitamin D is thought to influence the development of type 2 diabetes through defects in the pancreatic-cell function, insulin sensitivity, and systemic inflammation.[43] There have been no randomized clinical trials supporting the hypothesis that an increased 25(OH)D concentration prevents new-onset type 2 diabetes. In the present study, there was no apparent inverse relationship between 25(OH)D concentration and diabetes for females, the reason for which is not clear. Further investigation is required to identify the role of vitamin D in type 2 diabetes prevention and its gender differences. Current smoking was not a significant correlate of 25(OH)D concentration for either gender in the present study. Some previous studies[38,49,50] have shown a significant inverse relationship between smoking and 25(OH)D concentration, but others have not.[40,51] Further investigation should be conducted to validate the relationship between smoking and 25(OH)D concentration.

The present study has some limitations. Firstly, detailed information on outdoor activity, sunscreen use, the degree of skin pigmentation and the dietary intake and supplementation of vitamin D were not collected, and could contribute substantially to variances in 25(OH)D concentration. Secondly, single measurements of 25(OH)D concentration can include measurement errors, and single measurements cannot provide insight into seasonal variations within individuals. Third, the cross-sectional design precludes cause-and-effect assessment. Repeated and prospective measurement of 25(OH)D concentrations could yield better information about the relationship between lifestyle factors and 25(OH)D concentration. Fourth, the 25(OH)D data for January, which might be expected to be one of the lowest among the 12 months, was not included, due to the difference of the measurement method for 25(OH)D; therefore, the prevalence of 25(OH)D deficiency might have been slightly underestimated. These drawbacks notwithstanding, the present study demonstrated the association of 25(OH)D concentration with demographic and lifestyle variables in a nationally representative Korean population.

In conclusion, vitamin D deficiency was found to be a prevalent condition among Korean adults. Season was the most important determinant of 25(OH)D concentration. Unmarried persons, urban residents, nondrinkers, physically inactive persons, persons who do not take multivitamins, and highly educated persons were determined to be more likely to have lower 25(OH)D concentrations in both genders. As vitamin D deficiency is related to an increased risk of many chronic diseases, it is important for health care professionals to know the determinants of the vitamin D level and to implement corrective intervention strategies. These research findings could help to identify and treat persons who are at risk of 25(OH)D deficiency.

AUTHOR DISCLOSURES

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Original Article

25(OH)D status and demographic and lifestyle determinants of 25(OH)D among Korean adults

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韓國成人 25-羥基維生素 D 狀態與其人口學及生活型態決定因子

目的：維生素 D 缺乏是一個全面性健康問題，它與主要疾病危險性的增加有關。這個研究探討韓國成年人 25-羥基維生素 D[25(OHD]狀況，和它的人口學及生活型態決定因子。方法：總共 5847 名成人參與 2008 年韓國國民健康營養評估調查被納入這個研究。以逐步直線迴歸分析評估 25(OH)D 濃度的人口學及生活型態的決定因子。結果：25(OH)D 缺乏(<20 ng/mL)的加權盛行率(標準誤)男性為 49.9(2.1)%、女性為 67.4(1.7)%。嚴重缺乏 25(OH)D(<10 ng/mL)的男性有 5.7(0.8)%、女性有 11.1(1.0)%。這個比率在春天及冬天達到巔峰。只有 12.1(1.1)%的男性及 6.4(0.6)%女性顯示 25(OH)D 足夠(≥30 ng/mL)。男女性都顯示，較高的 25(OH)D 與夏天及秋天(對比春天)、60 歲年齡層(與 20 歲相比)、鄉下居民(比上都市)、中度或強度體能活動(相較久坐者)、酒精攝取和綜合維他命的補充有關。較高的教育程度和未婚者，在男女性都與 25(OH)D 濃度有負相關。25(OH)D 濃度的最強預測因子為季節及居住區域。結論：25(OH)D 缺乏在韓國是普遍的情形。了解 25(OH)D 的預測因子，有助於確認處於 25(OH)D 缺乏危險性的人群。

關鍵字：25(OH)D、盛行率、決定因子、生活型態、韓國人