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 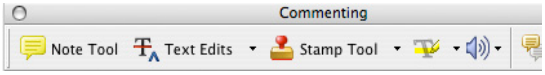

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 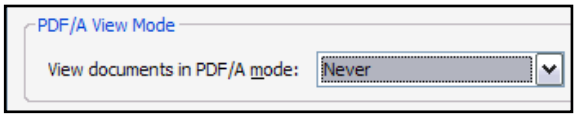

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 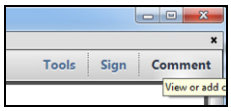

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 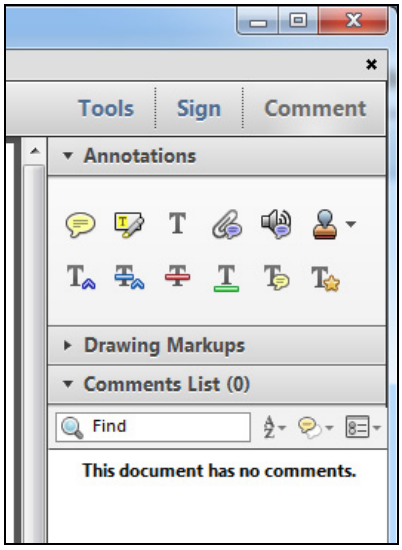
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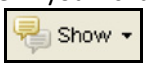
Review	To review your changes, click on the 'Show' button  on the Commenting tool bar. Choose 'Show Comments List'. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.	Your changes will appear automatically in a list below the Comment tool bar. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.
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Allergic rhinitis and serum 25-hydroxyvitamin D level in Korean adults

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ABSTRACT

Background: Recently, it has been suggested that airway hyper-responsiveness, asthma, and atopic dermatitis are associated with a low vitamin D level.
Objective: To evaluate whether the occurrence of allergic rhinitis (AR) is related to serum vitamin D levels in the general Korean adult population.
Methods: Data obtained as part of the fourth annual Korean National Health and Nutrition Examination Survey (2009) of 8,012 adults older than 18 years were analyzed. The correlation between serum 25-hydroxyvitamin D (25[OH]D) level and presence of AR using questionnaires on symptoms, history of diagnosis of AR, and rhinoscopic findings were analyzed. All estimates were calculated based on sampling weight.
Results: Mean age was 44.41 years and men constituted 49.8% of the sample. Participants with diagnosed AR constituted 11.1%. The mean 25(OH)D level of the AR group was lower than that of the non-AR group (16.71 ± 0.30 vs 17.75 ± 0.25 ng/mL, $P < .001$). A comparison of the prevalence of AR in the 3 groups showed that AR steadily decreased in the higher 25(OH)D groups (13.0% in group I [<15 ng/mL], 11.5% in group II [≥15–<25 ng/mL], and 7.2% in group III [≥25 ng/mL], $P < .001$). After adjusting for body mass index, smoking status, age, sex, sun exposure, income quartile, exercise, and body fat percentage, lower serum 25(OH)D levels remained significantly associated with the presence of AR compared with group III (hazard ratio 1.559 in group I and 1.430 in group II).
Conclusion: This study suggested a potential association between low vitamin D levels and AR prevalence in Korean adults.

Introduction

Vitamin D has an essential role in bone mineralization and its deficiency has been associated with rickets, osteomalacia, osteoporosis, and increased fracture risk.[1] Research in the past 20 years has associated even mild insufficiency of vitamin D with the development of cardiovascular disease, diabetes, cancer, and immune disease, thus spurring active research into the effects of vitamin D on the immune system.[1–3]

The prevalence of allergic diseases has been increasing since 1960 and currently affects more than 300 million people worldwide.[4] Many recent reports have linked the increase of allergic diseases to vitamin D deficiency. According to studies from the National Health and Nutrition Examination Survey (NHANES) in the United States, mean 25-hydroxyvitamin D (25[OH]D) levels in adults were 30 ng/mL in the 1988 to 1994 survey[5] and 24.2 ng/mL in the 2001 to 2006 survey.[6] It has been hypothesized that as countries become more industrialized, more time is spent indoors, leading to less sunlight exposure and decreased skin vitamin D production. Insufficient vitamin D intake from foods and supplements also is believed to be a factor of vitamin D deficiency.[7]

Some reports have suggested an important role for vitamin D in immune regulation.[8,9] Receptors of 1α,25-dihydroxyvitamin D_3 ($1,25[OH]_2D_3$), the active form of vitamin D3, have been found on human lymphocytes, and the expression of key enzymes required for vitamin D production has been found on dendritic cells. In addition, vitamin D has been shown to inhibit differentiation, maturation, activation, and survival of dendritic cells, leading to impaired T-cell activation.[10] Specifically, it modulates the immune processes of lymphocytes.[11] Vitamin D also promotes $FoxP3^+$ regulatory T-cell profiles from CD4 T lymphocytes and decreases T-helper cell type 17 differentiation, and this is believed to be an important mechanism for its immunomodulatory effects.[12]

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Through these effects on the immune system, it is likely that vitamin D has an important role in asthma and allergic diseases. Recent studies have reported that patients with asthma have lower serum vitamin D levels than normal individuals, and extremely low levels have been related to severe asthma and more frequent exacerbations.[13,14] An association between vitamin D deficiency and atopic dermatitis also has been reported.[15] Exposure to an allergen can induce immune-mediated inflammatory reactions in the human body.

Allergic rhinitis (AR) is a representative disease that is caused by this mechanism. Although not life threatening, AR lowers quality of life and, because of its high prevalence compared with other diseases, can considerably increase health care costs. There are several studies of the relation between AR and low vitamin D levels but relatively fewer studies compared with the number of studies on asthma.[16–19] Therefore, this study investigated the relation between AR and serum vitamin D levels in Korean adults.

Methods

Study Population

Data from the Korean NHANES IV conducted in 2009 were analyzed. The survey was approved by the institutional review board of the Korea Centers for Disease Control and Prevention (approval number 2009-01CON-03-2C) and all study participants provided informed consent. From a total of 10,533 subjects, 8,012 adults who were at least 18 years of age were included in the study population.

Participants' age, sex, body mass index (BMI), smoking status, and income quartile were surveyed. Survey data on average daily sun exposure time, which is related to vitamin D levels, amount of exercise, and data on body fat percentage as measured by a body fat analyzer were used for analysis. Participants were determined as having AR when they answered "yes" to the survey item "AR diagnosed by a doctor." Diagnosis of other comorbidities, such as hypertension, diabetes, hyperlipidemia, asthma, and atopic dermatitis, were determined in a similar manner.

Survey items related to persistent rhinosinusitis and AR included a history of rhinitis symptoms, such as runny nose, sneezing, and nasal blockage, within the previous 1 year; sustained symptoms for at least 4 days per week; sustained symptoms for at least 1 month; specific symptoms of postnasal drip, nasal obstruction, facial tenderness, and smell disturbance persisting for at least 3 months; disturbances in study and sleep; and voice change.

Rhinoscopic data were available for 7,167 participants. Findings of pale mucosa, watery rhinorrhea, inferior turbinate hypertrophy, and mucopurulent secretion were observed before topical vasoconstrictor use and findings of pus drainage in the middle meatus, nasal polyps, and other masses were observed after vasoconstrictor use.

Serum 25(OH)D Level

Serum 25(OH)D levels were measured by radioimmunoassay method using a 25(OH)D iodine-125 radioimmunoassay kit (DiaSorin, Stillwater, Minnesota) and a 1470 WIZARD gamma-counter (PerkinElmer, Turku, Finland). Participants were divided into 3 groups according to serum 25(OH)D levels: group I, lower than 15 ng/mL; group II, at least 15 to lower than 25 ng/mL; and group III, at least 25 ng/mL.[20]

Statistical Analysis

Statistical analyses were performed using SPSS 17.0 (SPSS, Inc, Chicago, Illinois). As required by the survey rules of the Korean NHANES IV survey, the recommended subsample weights were applied for the survey data plus examination data to account for unequal probabilities of selection and to accurately represent estimates for the Korean population. All results are presented as weighted values. Categorical variables are presented as proportion (percentage) and standard error, and continuous variables are presented as mean ± standard deviation. Differences between groups were assessed by χ^2 tests for categorical variables and by unpaired *t* tests or analysis of variance for continuous variables. Unadjusted binary logistic regression was used to determine the hazard ratios (HRs) of vitamin D level subgroups and other variables associated with AR prevalence. To evaluate the independent association between serum vitamin D levels and AR prevalence, the authors adjusted for the factors BMI, smoking status, age, sex, average daily sun exposure of at least 5 hours, income quartile, days of moderate exercise per week, and body fat percentage. The risk of AR according to vitamin D level subgroup was reported in HRs with 95% confidence intervals (CIs). All tests were 2-sided and *P* values lower than .05 were considered significant.

Table 1
Demographic data of study population (N = 8,012)[a]

Women, %	50.3 (0.5)
Age (y)	44.41 ± 0.37
Income quartile, %	24.9/24.9/24.5/25.7
Body mass index (kg/m^2)	23.60 ± 0.05
Smoking status, %	
Current/former/nonsmoker	26.6/18.9/54.8
Body fat percentage	27.06 ± 0.16
Sun exposure ≥5 h/d	21.2 (0.8)
Days of moderate exercise/wk	2.65 ± 0.05
Serum 25-hydroxyvitamin D (ng/mL)	17.55 ± 0.24
Allergic rhinitis, %	11.4 (0.5)
Other comorbid diseases, %	
Hypertension	16.0 (0.6)
Diabetes	6.0 (0.4)
Hyperlipidemia	6.7 (0.3)
Asthma	2.8 (0.2)
Atopic dermatitis	5.0 (0.2)

[a]Data are presented as proportion (standard error) or mean ± standard deviation.

Results

Demographic Data of Study Population

In total, 8,012 participants were available for analysis. Average age (mean ± standard deviation) was 44.41 ± 0.37 years and 50.3% of participants were women (Table 1). For smoking status, 26.6% were current smokers, 18.9% were former smokers, and 54.8% were nonsmokers. Mean 25(OH)D level was 17.55 ± 0.24 ng/mL. The proportion of participants diagnosed with AR was 11.4%, and 16.0% had hypertension, 6% had diabetes, and 2.8% had asthma.

Participants were divided into 3 groups according to serum 25(OH)D levels and the demographics and comorbidities were compared among groups (Table 2). The proportions of women were 58.5% in group I, 46.5% in group II, and 33.8% in group III, showing significant differences ($P < .001$). Age also showed a significant intergroup difference: group I was the youngest at 40.88 ± 0.46 years, with groups II and III being 44.84 ± 0.45 and 50.84 ± 0.74 years old, respectively ($P < .001$). BMI showed a similar pattern to age, with the lowest BMI in group I at 23.25 ± 0.08 kg/m^2 and increasing in succession in groups II and III ($P < .001$). Group I had the largest body fat percentage (28.1%) and proportion of nonsmokers (59.4%; $P < .001$). Group III had the largest proportion of participants with at least 5 hours of daily sun exposure ($P < .001$).

Frequency of AR and Rhinoscopic Findings According to Serum 25(OH)D Level

Prevalences of AR were 13.0% in group I, 11.5% in group II, and 7.2% in group III, showing a significant difference ($P < .001$). The rhinoscopic findings of 7,167 participants according to serum

Table 2
Demographics and allergic rhinitis according to serum 25-hydroxyvitamin D level[a]

	I (<15 ng/mL) (n = 2,644)	II (≥15 ng/mL) (n = 3,543)	III (≥25 ng/mL) (n = 1,099)	*P* value
Women, %	58.5 (1.1)	46.5 (1.1)	33.8 (1.6)	<.001
Age (y)	40.88 ± 0.46	44.84 ± 0.45	50.84 ± 0.74	<.001
Income quartile, %	25.4/24.0/25.5/25.1	23.7/24.7/25.0/26.6	25.3/27.6/22.5/24.7	.420
Body mass index (kg/m^2)	23.25 ± 0.08	23.89 ± 0.07	23.77 ± 0.10	<.001
Smoking status, %				<.001
Current	25.7 (1.0)	27.5 (0.9)	29.0 (1.6)	
Former	14.9 (0.8)	19.4 (0.7)	29.6 (1.9)	
Nonsmoker	59.4 (1.1)	53.1 (1.0)	41.4 (1.9)	
Body fat percentage	28.05 ± 0.27	26.68 ± 0.21	24.89 ± 0.27	<.001
Average daily sun exposure ≥5 h, %	18.6 (1.0)	26.7 (1.3)	43.8 (2.5)	<.001
Days of moderate exercise/wk	2.50 ± 0.06	2.74 ± 0.06	2.3 ± 0.10	<.001
25-hydroxyvitamin D (ng/mL)	11.80 ± 0.08	19.14 ± 0.08	29.78 ± 0.16	<.001
Allergic rhinitis, %	13.0 (0.8)	11.5 (0.7)	7.2 (0.9)	<.001
Other comorbid disease, %				
Hypertension	13.1 (0.8)	15.3 (0.8)	24.6 (1.6)	<.001
Diabetes	4.9 (0.5)	6.2 (0.5)	7.4 (0.9)	.017
Hyperlipidemia	6.0 (0.5)	7.2 (0.5)	7.6 (0.9)	.129
Asthma	2.7 (0.4)	2.7 (0.3)	2.5 (0.6)	.926
Atopic dermatitis	3.1 (0.4)	2.7 (0.4)	2.1 (0.6)	.350

[a]Data are presented as proportion (standard error) or mean ± standard deviation.

25(OH)D level are presented in Table 3. Watery rhinorrhea was found in 14.1% of group I, 11.0% of group II, and 9.4% of group III ($P = .002$). Inferior turbinate hypertrophy was discovered in 36.9% of group I, 31.4% of group II, and 23.5% of group III ($P = .012$), also showing the highest prevalence in the group with the lowest 25(OH)D levels.

Vitamin D Level in Relation to AR and Persistent Nasal Symptoms

The mean 25(OH)D level of the AR group was lower than that of the non-AR group (16.71 ± 0.30 vs 17.75 ± 0.25 ng/mL, $P < .001$; Figure 1). Serum 25(OH)D levels also were compared in relation to the presence and absence of certain nasal symptoms (Fig 1). Serum 25(OH)D levels were slightly lower in participants who had a history of rhinitis symptoms (runny nose, sneezing, and nasal blockage) within the previous 1 year than in those who never had these symptoms (17.19 ± 0.28 vs 17.81 ± 0.25 ng/mL, $P = .005$). Participants with rhinitis symptoms lasting longer than 4 days per week or at least 1 month also had lower 25(OH)D levels compared with those without (17.07 ± 0.33 vs 17.7 ± 0.24 ng/mL, $P = .017$, and 16.89 ± 0.39 vs 17.69 ± 0.24 ng/mL, $P = .008$, respectively). In regard to chronicity, participants with postnasal drip for at least 3 months had lower 25(OH)D levels than those with postnasal drip for shorter than 3 months (16.66 ± 0.43 vs 17.70 ± 0.24 ng/mL, $P = .004$) and this tendency was found for prolonged nasal obstruction of 3 months (16.71 ± 0.45 vs 17.71 ± 0.24 ng/mL, $P = .010$). However, there was no difference of 25(OH)D levels in according to the presence and absence of smell disturbance, facial tenderness, and voice change.

Table 3
Rhinoscopic findings and serum 25-hydroxyvitamin D levels[a]

	I (<15 ng/mL)	II (≥15 ng/mL)	III (≥25 ng/mL)	*P* value
Pale mucosal color, %	11.7 (1.4)	12.4 (1.3)	10.3 (1.8)	.535
Watery rhinorrhea, %	14.1 (1.3)	11.0 (0.9)	9.4 (1.4)	.002
Hypertrophy of inferior turbinate, %	36.9 (3.1)	31.4 (2.5)	23.5 (5.1)	.012
Mucopurulent secretion, %	6.0 (0.8)	5.2 (0.6)	3.9 (0.7)	.100
Pus drainage in middle meatus, %	1.9 (0.3)	1.7 (0.3)	3.1 (0.8)	.098
Nasal polyp, %	2.7 (0.4)	2.4 (0.4)	2.6 (0.5)	.843
Mass other than nasal polyp, %	0.3 (0.1)	0.7 (0.2)	0.2 (0.1)	.066

[a]Data are presented as proportion (standard error).

Risk of AR and Related Parameters According to Serum 25(OH)D Level

Binary logistic regression analysis was performed to determine the risk of AR prevalence (Table 4). In women, an increased AR prevalence risk (HR 1.199, 95% CI 1.028–1.398) was found. Participants 41 to 60 years old had a higher risk of AR compared with those older than 60 years (HR 2.547, 95% CI 1.907–3.401) and 18 to 40 years old (HR 4.159, 95% CI 3.230–5.355). Daily sunlight exposure shorter than 5 hours increased the risk of AR (HR 1.408, 95% CI 1.121–1.769). Income quartile, BMI, and smoking status showed no significant effect on AR risk. Subanalysis of 25(OH)D subgroups showed that group I (HR 1.932, 95% CI 1.442–2.587) and group II (HR 1.692, 95% CI 1.247–2.296) had a higher risk of AR prevalence compared with group III.

The association among subgroups was investigated according to 25(OH)D levels and risk of AR prevalence after adjusting for potential confounders (Table 5). When adjusted by BMI, smoking status, age, sex, average daily sun exposure of at least 5 hours, income quartile, days of moderate exercise per week, and body fat percentage, group I (HR 1.559, 95% CI 1.099–2.210) and group II (HR 1.430, 95% CI 1.020–2.006) still had a significantly higher risk of AR prevalence compared with group III. Even after adjustment for all these compounding factors, the mean 25(OH)D level still showed a significant difference according to the presence and absence of AR ($P = .024$). Q3

AR and Serum 25(OH)D Level According to Sex

To determine whether there was a sex difference for the prevalence of AR and vitamin D level, subgroup analysis was performed separately for male and female participants. In men, the mean 25(OH)D level of the AR group was lower than that of the non-AR group (17.51 ± 0.41 vs 18.90 ± 0.30 ng/mL, $P < .001$). After adjustment for all compounding factors, the mean 25(OH)D level remained significantly different according to the presence and absence of AR ($P = .017$) in men. Analysis of 25(OH)D subgroups in men showed that group I (HR 1.861, 95% CI 1.164–2.973) and group II (HR 1.624, 95% CI 1.017–2.593) had a higher risk of AR prevalence compared with group III after adjustment for all compounding

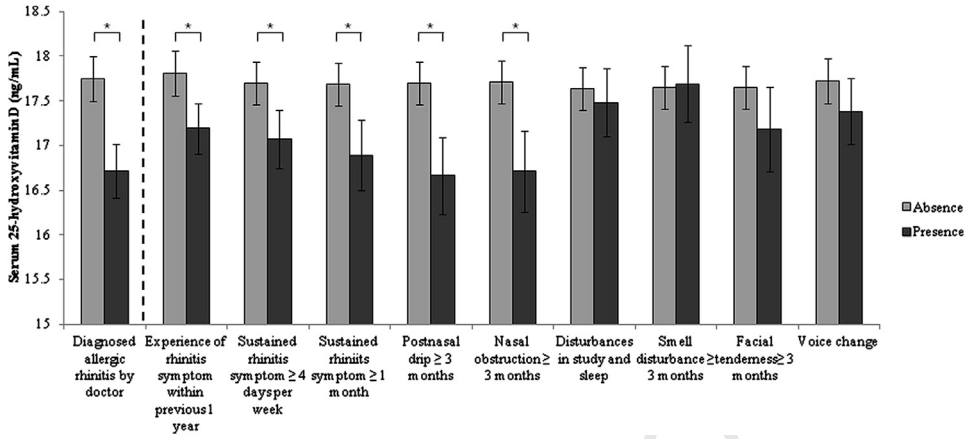

Figure 1. Results of the presence of diagnosed allergic rhinitis and questionnaires related to persistent rhinosinusitis and serum 25-hydroxyvitamin D levels. The mean 25-hydroxyvitamin D level of the allergic rhinitis group was lower than that of the nonallergic rhinitis group. The 25-hydroxyvitamin D levels were slightly lower in participants who had rhinitis symptoms than in those who never had rhinitis symptoms. Participants with rhinitis symptoms lasting longer than at least 4 days per week or at least 1 month had lower 25-hydroxyvitamin D levels. Participants with postnasal drip for at least 3 months or prolonged nasal obstruction for 3 months had lower 25-hydroxyvitamin D levels. $^{*}P < .05$.

factors (Table 5). However, there was no statistical difference in mean 25(OH)D levels according to the presence and absence of AR (16.01 ± 0.33 vs 16.55 ± 0.22, $P = .088$) and AR prevalence according to 25(OH)D subgroups in women.

Discussion

The present study used data from a large-scale national survey and therefore can be regarded as representative of the Korean population. An association was found between vitamin D levels and AR prevalence, with lower vitamin D levels showing a higher AR prevalence. The results remained significant even after adjusting for confounding variables related to 25(OH)D.

The relation between serum vitamin D level and AR prevalence has been reported in other studies. A cohort study in 2009 reported that maternal intake of vitamin D from food during pregnancy was inversely related to the risk of asthma (HR 0.80, 95% CI 0.64–0.99) and AR (HR 0.85, 95% CI 0.75–0.97) in their 5-year-old children.[16] Another study of vitamin D levels in patients with AR vs the general population showed an increased prevalence of severe vitamin D deficiency in the AR patient group.[17]

However, conflicting data also have been reported from the NHANES III in the United States, namely that the high vitamin D level group in white non-Hispanic participants had more AR diagnoses and symptomatic episodes.[18]

The difficulty of studying vitamin D is that many factors influencing vitamin D levels, such as physical activity, outdoor sunlight exposure, and calcium and vitamin supplement intake, can confound the results. Another important point is that disease status can limit physical activities (indoor and outdoor), possibly decreasing exposure to sunlight and thus lowering serum vitamin D levels. Therefore, it can be difficult to differentiate the cause-and-effect relation between vitamin D level and disease development. Body fat percentage can be another relevant factor in different serum 25(OH)D levels because 25(OH)D is stored in adipose tissues. The lack of information in previous studies on these factors can considerably limit the interpretation of the results. The present study adjusted for factors that can effect vitamin D levels (eg, BMI, smoking status, age, sex, sunlight exposure, amount of exercise, and body fat percentage) and found that the low vitamin D level group still had a higher AR prevalence even after adjustment.

Table 4
Unadjusted risk of allergic rhinitis

	HR	95% CI
Female sex	1.199	1.028–1.398
Age (y)		
18–40	4.159	3.230–5.355
41–60	2.547	1.907–3.401
>60	1.00[a]	
Income quartile	1.055	0.979–1.138
Body mass index (kg/m^2)	NS	
<18.5	1.490	0.837–2.650
18.5–22.9	1.401	0.893–2.198
23–24.9	1.393	0.835–2.325
25–29.9	1.251	0.763–2.049
≥30	1.00[a]	
Smoking status		
Current	0.760	0.605–0.956
Former	1.005	0.812–1.246
Nonsmoker	1.00[a]	
Body fat percentage	0.991	0.983–0.999
Average daily sun exposure ≥5 h	1.408	1.121–1.769
Days of moderate exercise per week (1 d)	0.994	0.957–1.033
Serum 25-hydroxyvitamin D		
Group I (<15 ng/mL)	1.932	1.442–2.587
Group II (≥15–<25 ng/mL)	1.692	1.247–2.296
Group III (≥25 ng/mL)	1.00[a]	

Abbreviations: CI, confidence interval; HR, hazard ratio; NS, not significant.
[a]Chosen as the reference group.

Table 5
Risk of allergic rhinitis according to serum 25-hydroxyvitamin D level adjusted by body mass index, smoking status, age, sex, average daily sun exposure of at least 5 hours, income quartile, days of moderate exercise per week, and body fat percentage

	HR	95% CI
Allergic rhinitis		
Group I (<15 ng/mL)	1.559	1.099–2.210
Group II (≥15–<25 ng/mL)	1.430	1.020–2.006
Group III (≥25 ng/mL)	1.00[a]	
Allergic rhinitis in men		
Group I (<15 ng/mL)	1.861	1.164–2.973
Group II (≥15–<25 ng/mL)	1.624	1.017–2.593
Group III (≥25 ng/mL)	1.00[a]	
Allergic rhinitis in women		
Group I (<15 ng/mL)	1.221	0.757–1.968
Group II (≥15–<25 ng/mL)	1.164	0.734–1.846
Group III (≥25 ng/mL)	1.00[a]	

Abbreviations: CI, confidence interval; HR, hazard ratio.
[a]Chosen as the reference group.

A previous study reported that participants with nasal polyps alone showed no difference in IgE, interleukin-4, interleukin-10, interferon-γ, and vitamin D levels compared with normal controls, but those levels significantly differed from the normal controls when participants with nasal polyposis had combined AR.[19] In the present study, the presence of nasal polyps at rhinoscopy had no association with 25(OH)D. Rather, rhinoscopic findings of watery rhinorrhea, a classic symptom of AR, was more prevalent in the low 25(OH)D group and this result supports the association of AR with vitamin D level.

Many studies are being performed on the relation between vitamin D and allergen sensitization or allergic diseases. The US NHANES 2005 to 2006 cohort of 3,136 children and adolescents showed allergic sensitization was more common in those with 25(OH)D deficiency.[21] Another report showed that the number of positive aeroallergen skin prick test responses and total IgE levels had significant inverse correlations with vitamin D levels.[22] The relation between allergen sensitization and vitamin D levels may be an important key for linking AR prevalence with vitamin D. Because allergen sensitization data were not available in the present study, further analyses on this matter were not possible. In a study of food allergy, cord blood vitamin D deficiency was associated with food sensitization in individuals with single-nucleotide polymorphisms in genes regulating IgE and 25(OH)D concentrations.[23] For asthma, the Western Australian Pregnancy (Raine) cohort study reported that children with inadequate vitamin D were at increased risk of developing atopy, asthma, and bronchial hyper-responsiveness.[24] Regarding asthma exacerbations, it was reported that vitamin D insufficiency increased the odds of any hospitalization or emergency department visit,[25,26] and that participants with uncontrolled asthma had lower 25(OH)D levels than those with well-controlled asthma.[13] Lower 25(OH)D levels have been shown to correlate with increased inhaled or oral steroid use and with decreased percentage of predicted forced expiratory volume in 1 second and the ratio of forced expiratory volume in 1 second to forced vital capacity.[22] Another study reported vitamin D administration enhanced glucocorticoid responsiveness in patients with steroid-resistant asthma.[27] Cord blood 25(OH)D levels can represent maternal intake of vitamin D during pregnancy and its low levels have been associated with respiratory infection risk and childhood wheezing.[28] Studies on genes have shown asthma and atopy are significantly associated with polymorphisms of vitamin D receptor genes[29] and other genes involved in the vitamin D metabolism pathway.[30]

A study from the US NHANES 1988 to 1994 survey reported that the mean 25(OH)D level in adults was 30 ng/mL.[5] According to a study using the US NHANES 2001 to 2006 survey, the mean 25(OH)D level in adults was 24.2 ng/mL and non-Hispanic black participants had a significantly lower mean level (14.6 ng/mL) compared with white participants (25.6 ng/mL).[6] A high prevalence of vitamin deficiency in Korean adults was found in the present study, showing a mean 25(OH)D level of 17.55 ng/mL. This finding may be due to racial disparities in vitamin D metabolism. In the present study, the group with lowest vitamin D level (group I, <15 ng/mL) included more women, younger participants, and participants with less sunlight exposure compared with the other groups. The association with AR prevalence was found in these participants with low vitamin D levels.

Conversely, some studies have suggested that vitamin D may be a risk factor for asthma and other allergic diseases. One cohort study reported that higher vitamin D intake during infancy was related to more prevalent atopic manifestations, such as atopic dermatitis, AR, or asthma, up to 6 years of age.[31] Hypponen et al[32] reported similar findings of vitamin D supplementation in infancy and an increased risk of atopy and AR later in life. Another study associated low (<50 nmol/L) and high (≥100 nmol/L) levels of cord blood 25(OH)D with increased total IgE and inhalant allergen-specific IgE through 5 years of age, indicating a U-shaped relation.[33] Several studies on other diseases have reported that overdose and deficiency of vitamin D level are related to morbidity and mortality of disease.[34–36] A possible U-shaped relation with immune function might exist but more research is needed.

Vitamin D insufficiency is generally defined as a serum 25(OH)D level lower than 30 ng/mL and deficiency is defined as a serum 25(OH)D level lower than 20 ng/mL.[1] However, this definition is for bone health and the exact level for appropriate function of the immune system has not been established. In allergic diseases, differences in baseline vitamin D levels, supplementation periods, and a certain threshold level of vitamin D insufficiency for the development of diseases are the probable reasons for the different results in various studies and further research in this area is needed.

In women, vitamin D level is variable and vitamin D insufficiency is more prevalent.[37–39] This might be caused by factors affecting the cutaneous synthesis of vitamin D, such as a more frequent use of sunscreen and a relatively lower level of outdoor activity in women.[37] In addition, estrogen can affect vitamin D level; the estrogen component of oral contraceptives may alter the relative proportion of free and protein-bound 25(OH)D[38] and postmenopausal women have relatively low vitamin D levels.[39] In the present study, there was no statistical difference in AR prevalence among 25(OH)D subgroups and mean 25(OH)D levels according to the presence and absence of AR in women. The authors speculate that the factors mentioned earlier might affect these results.

The present study showed statistically significant findings after adjustment for various factors affecting vitamin D levels. However, clear clinical significance cannot be established owing to limitations of the study. First, the diagnosis of AR was not based on interviews by physicians but on the result of a self-reported questionnaire. Also, an individual allergen sensitization status for each participant was not available. Second, as a cross-sectional study, it could not address the causal relation of AR and 25(OH)D. Third, the seasonal variance of vitamin D levels might have affected the results because vitamin D levels can vary by season and time of measurement. However, because the participants were tested as part of a national survey during a limited period, the seasonal effects are believed to be minimal. Fourth, the present study used 25(OH)D levels, which can be easily measured in the blood, as performed in many other previous studies on vitamin D. However, the optimal circulating level of 25(OH)D has not been defined and whether 25(OH)D levels actually represent the amount of activated vitamin D in the body requires further study.

To date, the effect of vitamin D on allergic diseases remains inconclusive despite many studies. The present study suggested a potential association between low vitamin D levels and AR prevalence in Korean adults.

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