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Prevalence and Factors Influencing Atopic Dermatitis in Korean Adults in Relation to Vitamin D Levels: Data from the Korea National Health and Nutrition Examination Survey 2008-2013

Sang Jin Ko and Hae Sook Hong*

College of Nursing·Research Institute of Nursing Science,
Kyungpook National University, Daegu, Korea
**Corresponding Author: hshong@knu.ac.kr*

Abstract

Purpose: The objective of this study was to identify the factors related to atopic dermatitis and its prevalence among Korean adults, and to examine the relationship of vitamin D levels to AD prevalence.

Methods: Combined data from the 2008-2013 Korea National Health and Nutrition Examination Survey were analyzed by using the chi-squared test and multivariable logistic regression.

Results: AD prevalence among 27,860 Korean adults was 2.7% and varied significantly with age, body mass index, and vitamin D levels, as well as presence of asthma, depression, and stress. Vitamin D deficiency and insufficiency were found in 66.8% and 27.5%, respectively. Only 5.7% had sufficient vitamin D levels. Age and asthma were factors associated with an increased prevalence of AD in those with vitamin D deficiency (7.57 times and 2.87 times, respectively), and insufficiency (4.42 times and 2.58 times). However, there were no such risk factors in patients with sufficient vitamin D levels.

Conclusion: This study showed that patients with higher vitamin D levels have decreased AD prevalence despite risk factors. Development of an intervention program including lifestyle improvement is suggested.

***Keywords**: Atopic dermatitis, Vitamin D, Korean, Adult*

1. Introduction

Atopic dermatitis (AD) is an allergic skin disease with onset at the age of 2-3 months and recurrences throughout life; it is also known as atopic eczema. This condition impairs the quality of life and is a major chronic disease incurring significant healthcare expenses [1,2]. The main symptoms of AD are pruritus, erythema, and scaling. In addition, the act of scratching due to pruritus damages normal skin and may cause a secondary bacterial infection by *Staphylococcus aureus* that forms a crust or pus [3]. Thus, AD needs to be managed by taking the exacerbating factors into account.[1]

Over the past 10 years, AD prevalence has increased by 2-3 times in industrialized countries and is continuously increasing. The worldwide prevalence of AD among adults has reached 1-3%, and the prevalence of AD among children has reached 20% [2]. Although 70% of AD cases that develop during childhood resolve before adulthood [2], recent AD prevalence among children and adults has increased. Prevalence among Korean adults has increased from 2.4% in 2007 to 3.4% in 2014; among adults in their 20s, AD has increased from 5.7% in 2007 to 8.7% in 2014 [4]. Although the cause of AD has not been clarified, complex factors

[1] Hae Sook Hong is the corresponding author.

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with genetic predisposition and various immunologic, physiologic, and biochemical factors are known to be involved. Environmental factors such as pollution and mental stress have been considered as other causes of the increased prevalence. Such factors are known to cause skin or immune dysfunction and AD [5,6].

Secretion of antimicrobial peptides (AMPs) plays an important role in the antimicrobial barrier of the stratum corneum by preventing infection. If levels of AMP decrease, AD develops. Vitamin D increases the synthesis of cathelicidin, a representative AMP [7]. Vitamin D contributes to formation and maintenance of the skin barrier including the cornified cell envelope and lipid permeation barriers [8], and plays an important role in the process of immune regulation [6,9]; thus, studies on the relationship of vitamin D and skin diseases, and AD in particular, are being performed [5-7,9,10]. A “vitamin D hypothesis” has emerged, claiming that vitamin D deficiency is the cause of the worldwide increase in the prevalence of AD and allergic diseases. In humans, over 80% of the required vitamin D is produced in the skin with exposure to ultraviolet radiation (UV). According to this hypothesis, changes in lifestyle caused by industrialization reduce sun exposure time, and vitamin D deficiency causes immunoregulatory disorders [6,11]. Moreover, the reason for a seasonal difference in severity or prevalence of AD is dependent on vitamin D. The results of the International Study of Asthma and Allergies in Children (ISAAC) on allergic disease reported that AD prevalence was high in areas in which sunlight-induced vitamin D synthesis is low because of high latitude and low temperature [12].

Although many studies on the relationship between AD and vitamin D are based on such a hypothesis, most have included children [6]. No studies have included adult AD patients. These studies only identified the relationship between AD prevalence and severity by examining vitamin D ingestion [5,6]. Large-scale data identifying a relationship between vitamin D and AD are lacking. Moreover, most previous domestic large-scale surveys targeted children and adolescents or adults who were limited by using 1-year data [13], and almost no studies explored the relationship with vitamin D. Because of the increasing AD prevalence among adults, contributory factors need to be identified. We aimed to determine how these factors can provide a basis for improving vitamin D intake and lifestyles.

The Korea National Health and Nutrition Survey (KNHANES) has been conducted since 1998, based on Article 16 of the National Health Promotion Act. It consists of 3 parts: health, nutrition, and examination surveys, and the statistical data are used to analyze health-related problems in all age groups.

Accordingly, this study aimed to provide basic information for effective AD management by examining prevalence among adults and the relationship to vitamin D levels and contributory factors by using 6 years of data (2008-2013).

2. Methods

2.1. Study Design

This was a descriptive research study that included a secondary analysis of 2008-2013 KNHANES data in order to understand the factors influencing AD in Korean adults.

2.2. Setting and Sample

This study used 2008-2013 statistical data from KNHANES, an annual survey of Koreans by the Korea Centers for Disease Control and Prevention. With approval from an institutional review board, the study was based on published raw data. In 2008-2009, 200 sampling plots and 4,600 households, respectively, were selected and surveyed. In 2010-2013, the survey was conducted among >1-year-old members of 3,840 households and residential facilities, including nursing homes, the army, and prisons, by annually extracting 192 sampling plots. Non-Koreans were excluded from the survey. The 2008-2011 KNHANES included 51,590 adults >19 years old. In all, data for 27,860 individuals with no missing values were used for the final analysis, and the estimated number of Korean adults was 31,518,219.

2.3. Ethical Considerations

The present study was conducted after approval for the use of raw data from the KNHANES homepage on July 20, 2015 and the Institutional Review Board at the K national university approved the study protocol (IRB No: 2015-0089).

2.4. Definition of AD

AD was defined by a "Yes" or "No" response to: "Have you ever been diagnosed with AD?"

2.5. Definition of Vitamin D Level

Vitamin D is synthesized in the skin, and can be ingested through food. In the liver, it is metabolized into 25-hydroxyvitamin D [25(OH)D], which is commonly used for vitamin D level measurement [14]. Serum 25(OH)D level was measured by using a ^{125}I radioimmunoassay (RIA) kit (DiaSorin, Co., Ltd., Stillwater, MN, USA. Vitamin D blood concentration of less than 20 ng/mL was classified as deficiency, 20-29 ng/mL as insufficiency, and more than 30 ng/mL as sufficiency [15].

2.6. Variables

Variables related to AD prevalence in the KNHANES data were used in the analysis, and were classified into sociodemographic characteristics (gender, age, residential area, income level), health state characteristics (smoking, physical activity, body mass index [BMI], asthma), and psychological characteristics (depression, stress).

In sociodemographic characteristics, the subjects were divided into 20-30, 40-50, and >60-year-old groups. Residential areas were classified as big city (metropolitan and urban), small and medium-sized city (cities excluding metropolitan areas), and rural, in accordance with the divisions used in the sample design of the Korea Youth Risk Behavior Web-based Survey by the Ministry of Education, Ministry of Health and Welfare, conducted annually with the Korea Centers for Disease Control and Prevention. The income level was classified as upper, upper middle, lower middle, and lower, in accordance with income quartile standard levels.

In health state characteristics, current smokers were classified as "Yes," while past smokers and non-smokers were classified as "No." Regarding physical activity, groups were divided according to frequency and time in accordance with the International Physical Activity Questionnaire (IPAQ) Short Form standard; this is based on responses in the KNHANES questionnaire for weekly walking, moderate activity, and strenuous activity, or by calculating the MET (Metabolic Equivalent Task)-minutes/week by using a score conversion formula. IPAQ was divided into low (not applicable to other groups; a group that performs the least amount of physical activity), moderate (either of the following 3 criteria; '3 or more days of vigorous activity of at least 20 minutes per days' or '5 or more days of moderate-intensity activity and/or walking of at least 30 minutes per days' or '5 or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of at least 600 MET-min/week), and high (vigorous-intensity activity on at least 3 days/week and accumulating at least 1,500 MET-min/week, or 7 or more days of any combination of walking, moderate- or vigorous-intensity activities accumulating at least 3,000 MET-min/week) [16]. BMI was determined using weight (kg) divided by the square of height (m^2), as a criterion that is highly correlated with body fat and obesity. The World Health Organization definition of obesity is based on Western countries; therefore, BMI was categorized as underweight (<18.5 kg/m^2), normal (18.5-22.9 kg/m^2), overweight (23-24.9 kg/m^2), and obese (≥25 kg/m^2) in this study, based on the WHO Asia-Pacific areas and diagnostic criteria for Asia-Pacific Obesity, reported by the Korean Society for the Study of Obesity [17].

As a psychological characteristic, depression was defined by a "Yes" or "No" response to the question: "Over the past 1 year, have you ever felt sadness or despair for over 2 consecutive weeks to the extent that it interferes with everyday living?" Stress was defined by the response: "I feel this very much," or "I feel this a lot," to the question: "During normal everyday life, to what extent do you feel stressed?"; classification was according to the responses: "A lot of stress," "A little stress," or "No stress."

2.7. Data Collection and Analysis

KNHANES raw data are not a census but data from a sampling survey; thus, an analysis was conducted by adjusting the complex sample design to estimate the results for the entire Korean population. The 2008-2013 KNHANES data were combined according to the Korea Centers for Disease Control and Prevention data analysis guidelines, and Strata, Cluster, Weight, and Finite Population Correction were applied as complex sample design elements for the analysis. The results were calculated using estimated frequency, generalized to all individuals, and were described with this focus in the present study. The results of the complex sample design analysis were displayed as percentages, and collected data were analyzed by using SPSS/WIN program version 20.0(SPSS Inc., Chicago, IL, USA).

3. Results

3.1. General Characteristics of Subjects

There were 27,860 research subjects and the estimated number of Korean adults was 31,518,219. There were 730 with AD, with an estimated total of 48,970 (Table 1).

A total of 50.7% subjects were male, while 49.3% were female. The largest group was in their 20-30s (42.4%), and the smallest was >60 years old (17.8%). The highest proportion of subjects were from big cities (48.3%), followed by small and medium-sized cities (40.4%), and rural areas (11.2%). The proportion of subjects from the upper income level (30.1%) was the greatest, followed by upper middle (29.7%), lower middle (25.9%), and lower (14.3%) income levels.

The number of non-smokers (74.1%) was 3 times greater than the number of smokers (25.9%). Low physical activity was reported by 35.8%, moderate by 34.3%, and high by 29.9%. The greatest proportion of subjects had normal BMI, at 40.2%, while only 4.5% were underweight. The number of subjects who were overweight and obese was significant at 23.6% and 31.7%, respectively.

Regarding depression, 89.6% responded "No." Most reported "A little stress" at 59.9%. In all, 27.1% of the subjects reported "A lot of stress" and 13.1% reported "No stress."

Most subjects had vitamin D deficiency (69.2%), 25.95% had insufficiency, and 5.0% had sufficient levels.

3.2. AD Prevalence by Subject Characteristics

The results of AD prevalence analysis and subject characteristics are shown in Table 1. AD prevalence among those in their 20-30s (5.5%) was 5 times greater than among those in their 40-50s (1.6%) and those >60 (1.1%) (p<.001).

AD prevalence was highest among underweight subjects (5.0%), followed by those who were normal (3.5%), obese (2.9%), and overweight (2.4%) (p=.001). AD prevalence among those who had asthma (7.1%) was 2 times greater than among those who did not (3.1%) (p<.001).

AD prevalence among subjects who felt depressed over the past 1 year (3.9%) was significantly higher than among those who had not felt depressed (3.0%) (p=.046); the AD prevalence (4.0%) among those who often felt stressed was higher than those who felt a little stress (2.9%) and those who had no stress(2.3%) (p<.001).

Adults with vitamin D deficiency had the highest AD prevalence at 3.5%, and adults with vitamin D insufficiency and sufficiency had AD prevalence of 2.3% and 1.8%, respectively.

Table 1. General Characteristics and AD Prevalence of Study Population

(n=27,860, *N*=31,518,219)

Characteristics	Total		Atopic Dermatitis Yes (n=730, *N*=48,970)		Atopic Dermatitis No (n=27,130, *N*=30,531,461)		X^2	*p*
	n	W%	n	W%	n	W%		
Gender								
Male	12,240	50.7	294	3.0	11,946	97.0	1.34	.415
Female	15,620	49.3	436	3.3	15,184	96.7		
Age (yr)								
≥60	7,860	17.8	98	1.1	7,762	98.9	373.63	<.001
40 ~ 59	10,565	39.8	178	1.6	10,387	98.4		
19 ~ 39	9,435	42.4	454	5.5	8,981	94.5		
Residential area								
Rural	4,226	11.2	82	2.2	4,144	97.8	9.22	.077
Small, Medium-sized city	10,873	40.4	295	3.3	10,578	96.7		
Big city	12,761	48.3	353	3.2	12,408	96.8		
Income level								
Lower	5,002	14.3	99	2.6	4,903	97.4	7.85	.279
Lower middle	7,018	25.9	184	3.1	6,834	96.9		
Upper middle	7,795	29.7	213	3.0	7,582	97.0		
Upper	8,045	30.1	234	3.5	7,811	96.5		
Smoking								
No	21,912	74.1	571	3.1	21,341	96.9	0.00	.979
Yes	5,948	25.9	159	3.1	5,789	96.9		
Physical activity								
Low	9,485	34.3	244	2.8	9,241	97.2	6.78	.186
Moderate	10,203	35.8	257	3.2	9,946	96.8		
High	8,172	29.9	229	3.4	7,943	96.6		
BMI								
Underweight	1,234	4.5	53	5.0	1,181	95.0	31.39	.001

Normal	11,194	40.2	309	3.5	10,885	96.5		
Overweight	6,615	23.6	145	2.4	6,470	97.6		
Obese	8,817	31.7	223	2.9	8,594	97.1		
Asthma								
No	27,007	97.2	687	3.1	26,320	96.9	43.11	<.001
Yes	853	2.8	43	7.1	810	92.9		
Depression								
No	24,027	87.6	612	3.0	23,415	97.0	8.27	.046
Yes	3,833	12.4	118	3.9	3,715	96.1		
Stress								
No Stress	4,220	13.1	78	2.3	4,142	97.7	30.19	<.001
A little stress	16,110	59.9	387	2.9	15,723	97.1		
A lot of stress	7,530	27.1	265	4.0	7,265	96.0		
Vitamin D levels								
Sufficiency	1,593	5.0	35	1.8	1,558	98.2	35.09	<.001
Insufficiency	7,667	25.9	148	2.3	7,519	97.7		
Deficiency	18,600	69.2	547	3.5	18,053	96.5		

BMI=Body Mass Index; n=Unweighted sample size; *N*=Weighted sample size; W%=Weighted percent.

3.3. Vitamin D Levels by General Characteristics of Subjects

In all, 18,600 research subjects had vitamin D deficiency, 7,667 had insufficiency, and 1,593 had sufficiency. These numbers extrapolated to 21,796,249, 8,150,922, and 1,571,048, respectively (Table 2).

More female subjects (53.6%) had vitamin D deficiency than male subjects (46.4%). However, there were more male subjects with insufficient or sufficient vitamin D levels (60.0%, 61.9%, respectively). The number of male subjects was greater than that of female subjects (40.0%, 38.1%), and therefore male subjects had higher vitamin D levels than female subjects (p<.001). Vitamin D deficiency in those in their 20-30s was most frequent (47.4%), and sufficiency was least frequent at 22.4%. Vitamin D sufficiency was the most common in those in their 40-50s (32.5%) and those >60 (45.1%). Younger age was associated with lower vitamin D levels (p<.001). The percentage of subjects with deficiency and insufficiency living in big cities was greatest at 50.7% and 44.4%, respectively, and that of subjects with vitamin D sufficiency living in small and medium-sized cities was 39.5% (p<.001). Only 7.0% of subjects whose income level was lower had sufficiency, which is significantly low compared to those with deficiency (13.3%) and insufficiency (15.8%) (p<.001).

In all, 29.5% of smokers had sufficiency, compared to those with insufficiency (26.8%) and deficiency (25.3%) (p=.012). Compared to subjects with moderate (36.7%) and low physical activity (35.9%) among those with deficiency, those with sufficient vitamin D had the greatest physical activity at 39.3%. Accordingly, less physical activity was associated with greater vitamin D deficiency (p<.001). The number of obese subjects was greater in those with vitamin D deficiency (31.1%) and insufficiency (33.9%), compared to those with sufficiency (28.7%). BMI showed a significant difference by vitamin D level (p<.001).

The number of those who reported “A lot of stress” was greatest among those with vitamin D deficiency (28.5%), followed by those with insufficiency (23.9%) and sufficiency (24.0%). The proportion of those who reported “A little stress” was greatest among those with vitamin D sufficiency (17.1%), followed by those with insufficiency (15.1%) and deficiency (12.0%). Accordingly, stress and vitamin D level showed a significant relationship (p<.001).

Table 2. Vitamin D Levels by General Characteristics of Subjects

(n=27,860, *N*=31,518,219)

Characteristics	Vitamin D Levels						χ^2	*p*
	Deficiency (n=18,600, *N*=21,796,249)		Insufficiency (n=7,667, *N*=8,150,922)		Sufficiency (n=1,593, *N*=1,571,048)			
	n	W%	n	W%	n	W%		
Gender								
Male	7,220	46.4	4,092	60.0	928	61.9	456.91	<.001
Female	11,380	53.6	3,575	40.0	665	38.1		
Age (yr)								
≥60	4,380	14.7	2,750	23.5	730	32.5	864.14	<.001
40-59	6,949	37.9	3,002	43.7	614	45.1		
19-39	7,271	47.4	1,915	32.8	249	22.4		
Residential area								
Rural	2,145	8.6	1,588	15.7	493	24.2	536.58	<.001
Small, medium-sized city	7,468	40.7	2,865	39.9	540	39.5		
Big city	8,987	50.7	3,214	44.4	560	36.4		
Income level								
Lower	2,958	13.3	1,616	15.8	428	7.0	78.06	<.001
Lower middle	4,679	26.0	1,919	25.3	420	27.7		
Upper middle	5,385	30.3	2,024	28.7	386	26.1		
Upper	5,578	30.4	2,108	30.2	359	26.1		
Smoking								
No	14,774	74.7	5,961	73.2	1,177	70.5	16.37	.012
Yes	3,826	25.3	1,706	26.8	416	29.5		
Physical activity								
Low	6,728	35.9	2,354	31.4	403	26.4	212.35	<.001
Moderate	6,934	36.7	2,705	33.5	564	35.3		
High	4,938	27.4	2,608	35.1	626	39.3		
BMI								
Underweight	899	5.0	261	3.4	74	3.8	92.89	<.001
Normal	7,698	41.3	2,857	37.1	639	41.5		
Overweight	4,247	22.6	1,936	25.5	432	26.0		
Obese	5,756	31.1	2,613	33.9	448	28.7		
Asthma								
No	18,043	97.1	7,423	97.3	1,541	97.4	1.33	.705
Yes	557	2.9	244	2.7	52	2.6		
Depression								
No	16,011	87.4	6,652	88.2	1,364	87.8	3.89	.303
Yes	2,589	12.6	1,015	11.8	229	12.2		
Stress								
No Stress	2,516	12.0	1,376	15.1	328	17.1	105.61	<.001
A little stress	10,812	59.5	4,411	61.1	887	58.8		
A lot of stress	5,272	28.5	1,880	23.9	378	24.0		

BMI=Body Mass Index; n=Unweighted sample size; *N*=Weighted sample size; W%=Weighted percent.

3.4. AD Prevalence by Vitamin D Level

The comparison of AD prevalence for each main characteristic according to the vitamin D level is as follows (Table 3).

Among cases with vitamin D deficiency, those >60 years had 0.9% prevalence, those in their 40-50s had 1.7%, and those in their 20-30s had 5.8% (*p*<.001). Vitamin D insufficiency in those in their 20-30s increased to 4.4%, to 1.1% in those >60, and to 1.3% in those in their 40-50s (*p*<.001). Accordingly, younger age was associated with a higher AD prevalence. However, in those with vitamin D sufficiency, age and AD prevalence did not show a significant relationship.

BMI significantly varied with AD prevalence only in cases with vitamin D deficiency (*p*=0.13). In underweight cases, AD prevalence was the greatest at 5.7%; in normal subjects, it was 3.8%. AD prevalence was 3.4% in obese cases and was lowest in overweight cases at 2.9%. In cases of vitamin D deficiency and insufficiency, AD prevalence among those with asthma was 8.3% and 5.1%, respectively. When subjects did not have asthma, AD prevalence was about 2 times higher at 3.4% and 2.2% (*p*<.001).

AD prevalence among those who were vitamin D-deficient who reported “A lot of stress” was 4.5%, which was 2 times greater than among those who reported “A little stress” (2.2%). This showed a significant difference (*p*<.001).

Table 3. AD Prevalence by Vitamin D Level

(n=27,860, *N*=31,518,219)

Characteristics	Vitamin D Levels											
	Deficiency (n=18,600, *N*=21,796,249)				Insufficiency (n=7,667, *N*=8,150,922)				Sufficiency (n=1,593, *N*=1,571,047)			
	n	W%	X^2	*p*	n	W%	X^2	*p*	n	W%	X^2	*p*
Gender												
Male	204	3.6	0.05	.870	75	2.1	1.63	.402	15	1.7	0.24	.662
Female	343	3.5			73	2.6			20	2.0		
Age (yr)												
≥60	54	0.9	264.31	<.001	29	1.1	75.24	<.001	15	1.9	2.70	.405
40 ~ 59	118	1.7			47	1.3			13	1.3		
19 ~ 39	375	5.8			72	4.4			7	2.7		
Residential area												
Rural	52	2.8	3.95	.307	19	1.6	4.79	.320	11	1.7	0.78	.739
Small, medium-sized city	226	3.8			55	2.2			14	2.2		
Big city	269	3.5			74	2.6			10	1.5		
Income level												
Lower	64	3.1	4.17	.542	23	1.4	11.92	.122	12	2.7	2.45	.656
Lower middle	133	3.3			42	2.8			9	1.9		
Upper middle	167	3.6			36	1.8			10	1.9		
Upper	183	3.9			47	2.8			4	1.1		
Smoking												
No	428	3.5	0.12	.807	115	2.4	0.63	.567	28	1.6	1.54	.354
Yes	119	3.6			33	2.1			7	2.5		
Physical activity												
Low	189	3.0	7.93	.141	47	2.2	7.25	.178	8	1.6	0.73	.767

Moderate	201	3.8			44	1.8			12	2.2		
High	157	3.9			57	2.9			15	1.6		
BMI												
Underweight	44	5.7	19.54	.013	5	3.0	8.41	.265	4	2.9	3.72	.260
Normal	233	3.8			61	2.8			15	2.5		
Overweight	105	2.9			34	1.7			6	0.9		
Obese	165	3.4			48	2.1			10	1.6		
Asthma												
No	515	3.4	36.31	<.001	138	2.2	7.28	.041	34	1.9	0.19	.507
Yes	32	8.3			10	5.1			1	0.9		
Depression												
No	461	3.4	5.76	.100	123	2.2	0.67	.531	28	1.6	3.50	.211
Yes	86	4.4			25	2.7			7	3.5		
Stress												
No Stress	47	2.2	27.79	<.001	25	2.9	7.59	.184	6	0.8	1.89	.307
A little stress	290	3.4			79	1.9			18	2.1		
A lot of stress	210	4.5			44	2.9			11	2.0		

BMI=Body Mass Index; n=Unweighted sample size; *N*=Weighted sample size; W%=Weighted percent.

3.5. Factors Affecting AD Prevalence by Vitamin D level

The results of multivariable logistic regression analysis to examine the factors affecting AD prevalence by vitamin D level are shown in Table 4.

Younger age was associated with higher AD prevalence. For vitamin D deficiency, AD prevalence among those in their 40-50s was 2.12 times higher than among those >60 (95% confidence interval [CI]: 1.33−3.38) (p<.001), and AD prevalence among those in their 20-30s was 7.57 times (95% CI: 5.05−11.34) higher (p=.002). For vitamin D insufficiency, AD prevalence among those in their 20-30s was 4.42 times higher than in those >60 (95% CI: 1.91−10.21) (p=.001), and for those with sufficiency, age had no effect on AD prevalence.

AD prevalence in those with asthma was 2.87 times (95% CI: 1.79−4.62) higher (p<.001) in subjects with vitamin D deficiency, and 2.58 times (95% CI: 1.15−5.81) higher (p=.022) in those with insufficiency. There was no effect when vitamin D level was sufficient.

Stress had an effect only in vitamin D insufficient cases (p<.031). AD prevalence among those who were slightly stressed was reduced by half compared to those with no stress (95% CI: 0.26−0.94).

AD prevalence among vitamin D-deficient subjects who reported “A lot of stress” was 4.5%, which was 2 times greater than those who reported “A little stress” (2.2%). This showed a significant difference (p<.001)

Table 4. Odds Ratios for Atopic Dermatitis Prevalence by Vitamin D Level

(n=27,860, *N*=31,518,219)

Characteristics	Vitamin D Levels					
	Deficiency (n=18,600, *N*=21,796,249)		Insufficiency (n=7,667, *N*=7,776,704)		Sufficiency (n=1,593, *N*=1,571,048)	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*

Gender						
Male	1.00		1.00		1.00	
Female	1.01 (0.77-1.33)	.931	0.87 (0.52-1.48)	.617	0.64 (0.30-1.36)	.243
Age (yr)						
≥60	1.00		1.00		1.00	
40 ~ 59	2.12 (1.33-3.38)	<.001	1.28 (0.57-2.90)	.547	0.81 (0.32-2.03)	.653
19 ~ 39	7.57 (5.05-11.34)	.002	4.42 (1.91-10.21)	.001	1.80 (0.67-4.86)	.243
Residential area						
Rural area	1.00		1.00		1.00	
Small, medium-sized city	1.05 (0.72-1.55)	.795	1.15 (0.56-2.39)	.698	1.26 (0.30-2.57)	.697
Big city	0.98 (0.67-1.43)	.914	1.32 (0.63-2.74)	.465	0.88 (0.39-4.05)	.812
Income level						
Lower	1.00		1.00		1.00	
Lower middle	0.78 (0.52-1.18)	.235	1.56 (0.70-3.57)	.266	0.67 (0.26-1.74)	.411
Upper middle	0.79 (0.54-1.16)	.227	0.93 (0.45-1.92)	.842	0.64 (0.21-1.93)	.427
Upper	0.87 (0.58-1.31)	.514	1.53 (0.74-3.15)	.253	0.41 (0.11-1.44)	.162
Smoking						
No	1.00		1.00		1.00	
Yes	0.85 (0.62-1.16)	.302	0.80 (0.46-1.38)	.411	1.90 (0.78-4.67)	.159
Physical activity						
Low	1.00		1.00		1.00	
Moderate	1.25 (0.95-1.67)	.111	0.77 (0.44-1.35)	.355	1.26 (0.46-3.42)	.651
High	1.26 (0.95-1.63)	.108	1.31 (0.77-2.21)	.318	0.87 (0.28-2.70)	.815
BMI						
Underweight	1.19 (0.80-1.79)	.392	0.92 (0.30-2.80)	.883	0.94 (0.23-3.75)	.927
Normal	1.00		1.00		1.00	.
Overweight	0.92 (0.69-1.24)	.596	0.68 (0.39-1.17)	.162	0.42 (0.14-1.29)	.130
Obese	1.06 (0.82-1.38)	.636	0.85 (0.47-1.53)	.586	0.79 (0.21-1.95)	.602
Asthma						
No	1.00		1.00		1.00	
Yes	2.87 (1.79-4.62)	<.001	2.58 (1.15-5.81)	.022	0.50 (0.06-4.53)	.539
Depression						
No	1.00		1.00		1.00	
Yes	1.28 (0.93-1.78)	.133	1.31 (0.71-2.44)	.386	2.22 (0.56-8.74)	.253
Stress						
No Stress	1.00		1.00		1.00	
A little stress	1.26 (0.85-1.88)	.257	0.50 (0.26-0.94)	.031	2.47 (0.84-7.23)	.099
A lot of stress	1.46 (0.94-2.27)	.090	0.65 (0.33-1.28)	.215	1.83 (0.56-5.94)	.316

BMI=Body Mass Index; n=Unweighted sample size; *N*=Weighted sample size; W%=Weighted percent.

4. Discussion

The present study determined AD prevalence in >19-year-old Korean adults and AD prevalence by vitamin D levels using KNHANES data. We aimed to establish an effective intervention strategy for adult AD management by examining factors affecting AD prevalence in accordance with vitamin D levels.

The results of the study showed that the average percentage of AD prevalence among adults was 2.7% from 2008 to 2013. This figure was similar to the prevalence (2.9%) reported in a study that used 2008 KNHANES data [13], and the

3.0% reported in the 2013 KNHANES [4]. The reason for the slight difference in these values is the difference in the yearly AD prevalence and the omission of data with missing values in the analysis.

AD prevalence among adults was related to age, BMI, asthma, depression, and stress, and significantly differed by vitamin D level.

AD prevalence among female subjects was generally higher than among male subjects [18]. However, this study did not show any gender-based differences in the prevalence of AD, which was consistent with the results of the study by Kim *et al*. [19]. AD prevalence among those in their 20-30s was 5 times higher than in subjects in their 40-50s and >60. This was consistent with the results of studies by Kim *et al*. [13] and Kim *et al*. [19], in which age and AD had a significant relationship. Younger age was associated with a higher prevalence of AD. Of all AD cases in childhood, 70% resolve in adolescence [2], and AD resolves naturally with age.

Residential area was not related to AD prevalence. This was in contrast to previous studies reporting that a rural environment exposed subjects to a variety of microorganisms and reduced AD prevalence, and that an urban environment and air pollution increased AD prevalence [2]. These studies targeted children and there are almost no reports on the relationship between adult AD and the community type [19]. As higher socioeconomic levels are associated with probability of residence in a big city or an apartment and different eating habits, the present study found no significant difference between AD prevalence among adults and the income level, unlike those in previous studies that claimed an increased AD prevalence [18].

BMI varied significantly in AD prevalence among adults. AD prevalence was greatest among underweight adults. In overweight or obese subjects, AD prevalence was lower than in normal subjects. BMI showed a significant correlation with AD prevalence only in those with vitamin D deficiency. In most previous studies, a relationship with overweight and obesity was observed. Previous studies have claimed that obesity is a risk factor for AD prevalence [2,20,21] but showed no correlation [22], and the relationship between obesity and AD remains controversial. Zhang and Silverberg [20] examined the relationship between overweight, obesity, and AD, and conducted a systematic review and meta-analysis; they found that adult AD prevalence increased by 1.15 times in those who were overweight and by 1.56 times in obese subjects. The analysis by region, including North America, Europe, and Asia, showed that adult AD prevalence in Asia increased by 1.28 times in underweight subjects and by 1.36 times in obese subjects. However, only 5 of 29 studies were conducted in Asia and were included in the meta-analysis, and only 1 was conducted in Korea. Furthermore, the subjects were over 18 years of age, which is the usual age of adulthood, in contrast to 19 years in this study. Unlike this study's overweight (23-24.9 kg/m^2) and obese (≥25 kg/m^2) standard, <25 BMI was set as normal, 25-30 as overweight, and over 30 as obese. The study by Yoo *et al*. [21] examined the correlation with overweight in Korean adolescents and reported that obese subjects had a 1.49 times higher AD prevalence. However, subjects with BMI 85% or greater for age and gender were set as the standard for overweight (overweight status was defined as a BMI greater than the local- and gender-specific 85th percentile). Zhang and Silverberg [20] used the WHO standard or the standard for diagnosis of AD in Asia, which is different from the standard in this study. The comparison with other studies is difficult, as this is the result of revisions related to factors including age, gender, smoking, physical activity, educational status of parents, asthma, family history, and parental smoking for determination of the relationship between obesity and AD. Sybilski *et al*. [22] used data of ISAAC and ECRHS (European Community Respiratory Health Survey), and found that obesity has no relationship with prevalence of AD in any age group (6-7 year olds, 13-14-year-old children, and 20-44-year-old adults). Thus, the reason for the correlation between BMI and AD prevalence could be the result of different definitions of overweight and obesity. A repeat study that combines the definition of obesity and overweight is needed.

In this study, the prevalence of AD doubled among those with asthma. Although this result differs from the study by Kim *et al*. [13], who reported that Korean adult AD and asthma have no relationship, it is consistent with studies by Ricci *et al*. [23] and Kim *et al*. [19] that found a relationship between asthma and AD, and ISAAC, which reported that asthma is observed in children with AD [24]. A strong correlation between AD and asthma has already been identified in many studies. A tendency toward development of asthma or allergic rhinitis in a child with AD is called "atopic march." In those with obesity and asthma, obesity has an indirect effect on AD prevalence, in accordance with previous research that reported obesity as a risk factor of asthma. However, further research is needed.

The presence of depression significantly varied with the prevalence of AD. Many studies have reported the relationship of depression with AD prevalence [25]. AD patients were reported to have depression and sleep disorders. A study by Cheng *et al*. [26] found that AD prevalence among adults and the diagnosis of depression have a significant relationship; the risk of development of major depressive disorder is 7 times higher, and the risk of any depressive disorder is 5.66 times higher, in adult AD patients. Redness or scaling in adult AD patients negatively affects social life, and may lead to depression.

Stress was related to AD. This is consistent with the results of previous research that reported a correlation with adult AD [13], and research by Utterströom and Lonne-Rahm [27] that found AD is caused by stress or worsens symptoms. This is because stress causes changes in the immune system. The development of appropriate intervention programs that can manage depression and stress is needed.

Regarding vitamin D level, 66.8% had deficiency, and 27.5% had insufficiency. Only 5.7% had sufficient vitamin D levels. In all, 77% had blood vitamin D levels of less than 30 ng/mL in the U.S. National Health and Nutrition Examination Survey data, whereas in this study, 94.3% had this level; thus Koreans have significantly lower vitamin D levels than subjects in the USA [28]. Humans produce over 80% of vitamin D in the skin through UV exposure [7]. As melanin absorbs 99% of the UV light and interferes with transmission, vitamin D deficiency is 10 times more likely in ethnic groups other than Caucasians [29]. Almost all subjects were Oriental because non-Koreans were excluded from the KNHANES survey. Although the U.S. is a multi-ethnic country, the percentage of Caucasians is high. That is why there was a difference in vitamin D concentration between two Countries. In addition, factors such as latitude or season are considered to have an effect.

Vitamin D showed a significant difference with respect to gender, age, residential area, income level, smoking, physical activity, BMI, and stress. As mentioned earlier, vitamin D is produced mostly by UV light. In relation to all the factors, urban life or differences in lifestyle, such as indoor activities, use of sunscreen, and intake of dairy foods, seem to have acted in combination.

When AD prevalence was analyzed based on vitamin D levels, BMI, asthma, and stress were considered to be risk factors in those with vitamin D deficiency; in those with vitamin D insufficiency, age and asthma showed a correlation; in those with vitamin D sufficiency, no associated factors were noted. The results of regression analysis showed that when vitamin D was deficient or insufficient, age and asthma were factors that increased prevalence of AD. This is because vitamin D acted as a protective factor to decrease AD prevalence [2], consistent with the results of previous studies stating that vitamin D supplementation can improve symptoms of AD in children [6,10].

Changes in lifestyle that can increase and maintain sufficient vitamin D levels will decrease the influence of risk factors in AD development. Thus, the present study indicates the need for an appropriate intervention program using factors known to be associated with vitamin D.

5. Conclusion

The present study examined factors related to adult AD by using 2008-2013 KNHANES statistical data, and risk factors for AD were analyzed by vitamin D level. We attempted to provide basic information to improve the health of adults with AD and to develop an intervention program.

The study results showed that factors related to adult AD were age, BMI, asthma, depression, stress, and vitamin D level. The results of the analysis of risk factors for AD in accordance with vitamin D levels showed that age and asthma were risk factors in cases of vitamin D deficiency and insufficiency, but that no variables acted as risk factors in cases of vitamin D sufficiency. Accordingly, increasing vitamin D levels in those with risk factors for AD will be helpful in reducing prevalence of AD. The development and application of an AD management program is required.

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Authors

Hae Sook Hong. (Ph. D), Professor, College of Nursing, Kyungpook National University, Daegu, Korea**.** Interest areas: Biological nursing, Genetics; DNA methylation, Biomaker analysis, Medical infomatics

Sang Jin Ko. Doctoral Student, College of Nursing, Kyungpook National University, Daegu, Korea**.** Interest areas: Biological nursing, Atopic Dermatitis, Microbiology.

