Original Article

Kimchi intake and atopic dermatitis in Korean aged 19-49 years: The Korea National Health and Nutrition Examination Survey 2010-2012

Hye Jung Kim MS[1], Se-young Ju PhD[2], Yoo Kyoung Park PhD[1,3]

[1]*Department of Medical Nutrition, Graduate School of East-West Medical Science, Kyung Hee University, Yongin, Republic of Korea*
[2]*Department Food Bioscience, Konkuk University, Chungju, Republic of Korea*
[3]*Institute of Medical Nutrition, Kyung Hee University, Seoul, Republic of Korea*

Background and Objectives: Many studies have reported that fermented foods have favorable effects in preventing and managing atopic dermatitis (AD). Although kimchi, a major fermented food, is an important part of the traditional diet in Korea, only a few studies have investigated the relationship between AD and kimchi. This study aimed to examine the association between the risk of AD and kimchi intake among Korean adults aged 19 to 49 years. **Methods and Study Design:** We conducted a population-based, cross-sectional study among a total of 7,222 adults who participated in the 2010-2012 Korea National Health and Nutrition Examination Surveys. We defined AD based on responses to a health interview and assessed kimchi intake using a 24-hour recall method administered by well-trained interviewers. **Results:** In the multivariable logistic regression analysis, we observed a significantly decreased odds ratio (OR) of having AD according to kimchi consumption after adjustment for confounding factors. In particular, subjects in the third quartile of kimchi consumption (85.0-158 g) had a 32% lower presence of AD than those in the first quartile of kimchi consumption (0-36.0 g) (Odds ratio: 0.68, 95% confidence interval: 0.50-0.92). **Conclusions:** We found that consuming 85.0-158 g/day of kimchi was significantly associated with a lower presence of AD. Considering that one serving size of kimchi is 40g, this corresponds to about 2-4 servings per day. This finding suggests that adequate amount of kimchi intake might have a protective effect against AD.

Key Words: kimchi, atopic dermatitis, fermented food, adult, KNHANES

INTRODUCTION

Atopic dermatitis (AD) is one of the most common skin diseases not only in children, but also in adults.[1] AD is a chronic, relapsing disease accompanied by rashes, skin lesions, and pruritus.[2] Over time, many patients develop physical problems such as severe itching, discharge, and skin discoloration, as well as psychological problems such as depression and anxiety.[3-5]

According to the results of the Korea National Health and Nutrition Examination Survey (KNHANES), the prevalence of AD among individuals aged 19 years and older was 2.4% in 2007 and increased consistently to 3.5% in 2014.[6] Especially the number of middle-aged AD patients, particularly those in their 40s, increased by 8.3%, from 2008 to 2012, and the number of AD patients even in their 50s increased by 28% over the same period.[7] This has led to further recognition of the need for research on AD in adults.

The increased prevalence of AD is thought to be associated with the numerous environmental factors including westernization of dietary patterns, and numerous studies have investigated the relationship between AD and various foods.[8,9] Among them, many researches have recently been conducted on the relationship between fermented foods and AD, in particular.[10,11] However, while kimchi is one of the staple side dish in Korean, only a few studies have been conducted on the relationship between AD and kimchi.[12,13]

Kimchi is an ideal health food made by mixing vegetables, fish, and shellfish in the form of fermented seafood. As a lactic acid-fermented food, kimchi has numerous benefits.[14] Since kimchi was first registered in the Codex Alimentarius in 2001, it has been recognized as a global food. Global interest was further boosted by reports of the efficacy of kimchi consumption in treating severe acute respiratory syndrome (SARS) in 2003 and avian influenza (AI) in 2005.[15] Moreover, Health Magazine selected kimchi as one of the top five health foods in 2006.[16] Kimchi is reported to be highly beneficial for maintaining health.

Corresponding Author: Prof Yoo Kyoung Park, Department of Medical Nutrition, Graduate School of East-West Medical Science, Kyung Hee University, 1732, Deogyeong-daero, Giheung-gu, Yongin 17104, Republic of Korea.
Tel: 82-31-201-3816; 82-10-6231-1931; Fax: 82-31-203-3816
Email: ypark@khu.ac.kr
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It contains low-calorie ingredients (18 kcal/100 g) and is high in vitamins and minerals, making it an excellent food for supplying micronutrients.[17,18] In addition, both the dietary fiber in kimchi and the organic acids produced during fermentation by lactic acid bacteria (LAB) have regulatory actions on the intestine and strong, preventive effects against constipation and colon cancer.[18,19] When kimchi is made with Napa cabbage, it contains approximately 160 different strains of LAB in ample concentrations of 107-9 CFU/g, making it a major source of probiotic bacteria.[20,21] A recent report shows that probiotics effectively alleviate inflammation and food allergy responses, and that a lack of probiotics can lead to the development of atopic skin disease.[22] Consumption of LAB improves intestinal immune response, thereby preventing AD and improving symptoms. Notably, in a previous study, oral administration of a *Bifidobacterium* culture for 1 month resulted in significant improvement in the allergic symptoms of children with AD who had *Bifidobacterium*-deficient microflora.[23]

In particular, plant-derived LAB, which is found in plant-based fermented foods such as kimchi, grow in a harsher environment with fewer nutrients, making them superior to animal-derived LAB in their ability to break down and digest nutrients.[24]

Despite the excellent nutritional characteristics of kimchi and its status as a traditional fermented food in South Korea, research on its relationship with AD is lacking, even domestically. Meanwhile, the relationship between AD and other cultured foods such as yogurt and cheese continues to be actively studied.[11,25,26]

Therefore, this study aimed to identify the relationship between kimchi intake and AD. We used data collected through the KNHANES V (2010-2012) among adults aged 19-49 years, separating respondents into groups with and without AD. Then we analyzed the presence of AD by comparing general characteristics, health and dietary habits, and kimchi intake.

METHODS

Survey design and participants

The KNHANES is a national, cross-sectional survey performed by the Korea Centers for Disease Control and Prevention (CDC) using a multistage, clustered, stratified, and rolling sampling method. The survey consists of a health examination, health interview, and nutrition survey. The health examination consists of physical measurements and blood pressure, as well as a blood profile. The health interview investigated injuries (accidents or poisoning), diseases, physical activity, use of healthcare services, smoking, and alcohol consumption, etc. The nutrition survey uses 24-hour recall and food frequency questionnaires to examine dietary lifestyles and current intake of food and nutrients.

The initial subjects of this study were 9,447 adults aged 19-49 years selected from among the 25,534 individuals who participated in the KNHANES V study between 2010 and 2012. We excluded subjects who did not answer the health interview relating to AD, those who reported implausible energy intakes (<500 or 5,000 kcal/day) in the 24-hour recall survey, and those who were pregnant. After those exclusions, we included 7,222 subjects in our final analysis.

This study was approved by the Korea CDC Institutional Review Board (IRB: 2010-02CON-21-C, 2011-02CON-06-C, and 2012-01EXP-01-2C).

General characteristics

The general characteristics considered in this study were sex, age (19-29 or 30-49 years), marital status (married or unmarried), educational level (less than high-school graduate, high-school graduate, college or higher), residence (large city, medium or small city, rural area), occupation (worker or non-worker), household income (high, middle-high, middle-low, and low), and family size.

Health-related characteristics

The health-related and physical characteristics considered in this study were smoking status (non-smoking, past smoking, smoking), alcohol consumption (≥1 time/month, <1 time/month), exercise (<1 time/week, 1-2 times/week, 3-4 times/week, or ≥5 times/week), body mass index (BMI), height, and weight. We applied the Asia-Pacific BMI cutoffs in evaluation of obesity. BMI status was categorized as underweight (BMI <18.5 kg/m^2), normal (18.5 kg/m^2≤BMI<23.0 kg/m^2), overweight (23.0 kg/m^2≤BMI<25.0 kg/m^2), and obese (BMI ≥25.0 kg/m^2).

Dietary lifestyle

We considered the following dietary lifestyle information in this study: the consumption of meals (breakfast, lunch, and dinner) and snacks, the number of meals per day, and the frequency of eating out. We classified the respondents as "eaters" or "non-eaters" based on their consumption of meals and snacks. We grouped the frequency of eating out into ≥2 times/day, 1 time/day, 5-6 times/week, 3-4 times/week, 1-2 times/week, 1-3 times/month, and <1 time/month (seldom).

Classification of AD

We used the following four questions included in the health interview to determine the presence or absence of AD. (1) Have you ever suffered from AD? (2) Have you ever been diagnosed with AD by a doctor? (3) Are you suffering from AD now? (4) Are you receiving treatment for AD? We considered all subjects with a positive response to at least one of the above four questions to be "with AD" and the remaining subjects to be "without AD." In addition, the subjects in the "with AD" group were further subdivided into a "doctor-diagnosed AD" group if they responded "yes" to question (2) above or to a "self-reported AD" group if they responded "no".

Kimchi intake

Total daily kimchi intake was assessed using food name, food code, dish name, dish code, and the amount of food intake from the KNHANES nutrition survey (24-hour recall). Kimchi was classified as "fermented" or "non-fermented" based on the methods of preparing kimchi. We defined kimchi as fermented if it was aged for at least 2 days in an anaerobic environment, and we defined non-fermented kimchi which had undergone less than 2 days of anaerobic aging. The main vegetables used for fermented kimchi are napa cabbage, mustard leaf, diced rad-

ish, water radish, young summer radish, young radish, stuffed cucumber, green onion, rapeseed leaf. The varieties of non-fermented kimchi included fresh, water cucumber, cucumber, and perilla leaf kimchi.

Food and nutrients intake

For the analysis of vegetables, we excluded starchy vegetables (potato, sweet potato, corn, etc.) and dried vegetables. Other foods were classified as either animal or vegetable foods according to the corresponding variables and were further classified into one of 24 types of food using the food codes. For nutrient intake, we used the values recorded by the subjects in the nutrition survey (24-hour recall). We used all of the intake data in the analysis after combining the daily food and nutrient intake variables for each individual.

Statistical analyses

Statistical analyses were performed with stratified sampling weights using SAS version 9.4 (Statistical Analysis System, SAS Institute, Cary, NC, USA), as the KNHANES data consisted of a multistage stratified cluster sampling design. General characteristics, meal consumption, and eating-out frequency according to AD status were presented in terms of frequency and weighted percentage. Statistical significance was tested using the Chi-square test with the SURVEYFREQ procedure. Food and nutrient intakes according to AD status were expressed in terms of mean and standard error, and the statistical significance was tested using the t-test with the SURVEYREG procedure.

Finally, logistic regression analysis was conducted to determine the odds ratio (OR) and 95% confidence interval (CI) for risk of AD across the quartiles of kimchi intake (Q1, Q2, Q3, and Q4) using the SURVEYLOGISTIC procedure.

Multivariable logistic regression analysis was performed, after adjusting for the effects of sex, energy intake, age, residence, exercise, smoking status, alcohol consumption, stress, income level, snack intake, frequency of eating-out, breakfast intake, sodium intake, fruit intake, vegetable intake, yogurt intake, cheese intake, and fish/shellfish intake.

RESULTS

AD presence rates of participants

Table 1 shows atopic dermatitis presence rates among participants. The number of participants who had atopic dermatitis was 437 (6.7%), which included participants with doctor-diagnosed (n=234, 3.8%) and self-reported AD (n=203, 2.9%). The other 6,785 participants among the total of 7,222 participants were determined to not have atopic dermatitis.

Table 1. Presence of atopic dermatitis among participants

Variables	n	%†
With AD group‡	437	6.7
Doctor-diagnosed AD group	234	3.8
Self-reported AD group	203	2.9
Without AD group	6785	93.3
Total	7222	100

†Weighted %.
‡Both doctor-diagnosed and self-reported AD groups.

General characteristics

Table 2 shows the general characteristics of the participants. Of the 7,222 subjects, 50.9% were male and 49.1% were female. The average age of the subjects was 39.4 years. Compared with the group without AD, the group with AD was significantly younger, included a lower proportion of workers, had a significantly higher educational level, and included a higher proportion of unmarried subjects ($p<0.05$).

Health-related characteristics

Table 3 shows the health-related characteristics of the participants. We analyzed smoking status, alcohol consumption, exercise, and BMI status, but we found no significant differences in these variables between subjects with and without AD.

Dietary lifestyle

Table 4 shows the dietary lifestyle-related characteristics of the participants. The average frequency of eating out was significantly higher among subjects with AD than among those without AD ($p<0.05$). We did not observe any significant differences between the two groups in terms of breakfast, lunch, and dinner consumption; daily meal frequency; or snack intake.

Food intake

Table 5 shows the results from analyzing the vegetable and animal food intakes of the participants. In the unadjusted results, subjects with AD showed a significantly lower intake of vegetables, fruits, fish, and shellfish ($p<0.05$), although such associations did not remain statistically significant after further adjustment for sex, age, and energy intake. In contrast, subjects with AD showed a significantly higher intake of cheese than those without AD ($p<0.05$).

Kimchi intake

Table 6 shows the results of analyzing participant kimchi intake according to the method of preparation. The average kimchi intake of the subjects with AD (101±5.7 g) was lower than the average kimchi intake among the subjects without AD (113±1.7 g). In terms of preparation methods, the subjects with AD showed a particularly lower intake of fermented kimchi and uncooked kimchi ($p<0.05$).

Nutrient intake

Table 7 shows the results from analyzing participant nutrient intake. In the unadjusted results, subjects with AD showed significantly lower intake of potassium and phosphorus than subjects without AD ($p<0.05$), although such associations did not remain statistically significant after further adjusting for sex, age, and energy intake.

Relationship between kimchi consumption and AD

Table 8 shows the OR for the risk of AD across the quartiles of kimchi intake calculated using a multivariable

Table 2. General characteristics of study subjects

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value§
	n	%‡	n	%	n	%	
Sex							0.383
Men	2737	50.9	2582	51.1	155	48.4	
Women	4485	49.1	4203	48.9	282	51.6	
Age (y)							<0.001
19-29	1682	31.0	1492	29.3	190	54.8	
30-49	5540	69.0	5293	70.7	247	45.2	
Average age	34.9±0.2††		35.2±0.2		30.6±0.5		<0.001¶
Marital status							<0.001
Married	5311	65.0	5071	66.4	240	44.7	
Unmarried	1899	35.0	1702	33.6	197	55.3	
Education level							0.005
Less than high school graduate	317	4.9	304	5.0	13	2.8	
High school graduate	2344	33.4	2229	33.8	115	27.2	
College or higher	4378	61.7	4069	61.1	309	69.9	
Residence							0.784
Large city	3513	51.3	3294	51.2	219	51.8	
Medium or small city	2807	35.0	2640	35.0	167	35.8	
Rural area	902	13.7	851	13.8	51	12.4	
Occupation							0.006
Worker	4598	68.9	4334	69.4	264	62.0	
Non-worker	2441	31.1	2268	30.6	173	38.0	
Household income							0.953
Low	482	8.4	454	8.5	28	7.6	
Low-middle	1830	27.9	1716	27.9	114	27.5	
Middle-high	2460	33.3	2315	33.3	145	33.7	
High	2374	30.3	2225	30.3	149	31.2	
Family size (n)							0.782
1	216	4.6	202	4.6	14	4.7	
2	640	10.5	597	10.3	43	12.8	
3	1890	27.1	1780	27.2	110	26.3	
4	3151	40.0	2952	40.0	199	40.2	
5	984	13.1	928	13.2	56	11.6	
≥6	330	4.8	315	4.8	15	4.3	
Average family size	7211	3.6±0.03††	6774	3.6±0.03	437	3.6±0.1	0.285¶

†Both doctor-diagnosed and self-reported AD groups.
‡Weighted %.
§*p*-value by Chi-square.
¶*p*-value by t-test.
††Mean±standard error.

logistic regression analysis. When analyzing the association between AD group (doctor-diagnosed or self-reported AD groups) and quartile of kimchi intake, unadjusted model 1 and model 2 adjusted for sex and energy intake tended to show a decreased risk of AD with increasing quartile of kimchi intake (p for trend <0.05). However, this trend did not remain statistically significant after further adjustment for confounders such as age, residence, exercise, smoking status, and alcohol consumption. Nevertheless, compared with the Q1 group that reported the lowest quantity of kimchi intake (0-36.0 g), the Q3 group for kimchi consumption (85.0-158 g) was found to have a significantly decreased OR of having AD in all adjusted models (OR: 0.68, 95% Cl: 0.50-0.92). In addition, when analyzing the association between the doctor-diagnosed AD group and the quartile of kimchi intake, the Q3 group was associated with a significantly lower prevalence of AD (OR: 0.65, 95% Cl: 0.43-0.99). However, the self-reported AD group was not significantly associated with the presence of AD according to the quartile of kimchi intake.

DISCUSSION

In this study, we examined the association between AD and the intake of kimchi, a traditional Korean fermented food, among Korean adults between the ages of 19 and 49 years. The results showed that an appreciable kimchi intake of 85.0-158 g/day was significantly associated with a lower presence of AD.

Recent human clinical trial demonstrated that when Lactobacillus plantarum was isolated from kimchi and was orally administered to children, the subjects showed reduced SCORAD index, which is used to evaluate the severity of AD.[12] However, this study examined only one or two extracts of the 160 LAB strains found in kimchi, which is not how kimchi is typically consumed by Koreans. Hence, research is needed to examine the association between AD and kimchi, the food itself, rather than just probiotic extracts.

When we analyzed food intake, we found that subjects with AD consumed fewer vegetables, kimchi, fruit, fish, and shellfish than subjects without AD. Recently, multiple studies have reported that a lack of antioxidant vitamin intake due to a reduced intake of fruit and vegetables

Table 3. Health-related characteristics according to the presence of atopic dermatitis

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value§
	n	%‡	n	%	n	%	
Smoking status							0.306
Non-smoking	4429	54.0	4157	53.7	272	58.0	
Past smoking	1077	17.1	1020	17.3	57	14.4	
Smoking	1588	28.9	1480	29.0	108	27.6	
Alcohol consumption							0.239
≥1 time/month	1303	16.3	1226	16.5	77	14.1	
<1 time/month	5919	83.7	5559	83.5	360	85.9	
Exercise							0.384
<1 time /week	3050	43.8	2849	43.5	201	47.6	
1-2 times /week	1819	24.7	1709	24.8	110	24.2	
3-4 times /week	1283	17.2	1203	17.3	80	16.6	
≥5 times /week	899	14.3	853	14.5	46	11.5	
BMI status (kg/m^2)							0.211
<18.5	513	6.7	488	6.9	25	4.5	
18.5-23	3337	43.9	3118	43.6	219	48.2	
23-25	1394	19.8	1313	19.8	81	19.7	
≥25	1978	29.6	1866	29.7	112	27.6	
BMI (kg/m^2)	7189	23.4±0.1¶	6752	23.4±0.1	437	23.4±0.2	0.995††
Height (cm)	7198	166±0.1¶	6761	167±0.1	437	166 ±0.5	0.495††
Weight (kg)	7193	65.2±0.2¶	6756	65.2±0.2	437	64.9±0.8	0.770††

†Both doctor-diagnosed and self-reported AD groups.
‡Weighted %.
§*p*-value by Chi-square.
¶Mean±standard error.
††*p*-value by t-test.

Table 4. Dietary lifestyle factors according to the presence of atopic dermatitis

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value§
	n	%‡	n	%	n	%	
Breakfast							0.876
Skipped	1877	29.5	1759	29.6	118	29.1	
Eaten	5340	70.5	5022	70.4	318	70.9	
Lunch							0.640
Skipped	529	8.3	497	8.3	32	7.6	
Eaten	6688	91.7	6284	91.7	404	92.4	
Dinner							0.057
Skipped	375	5.2	345	5.0	30	7.5	
Eaten	6842	94.8	6436	95.0	406	92.5	
Meal consumption (/day)							0.413
1	234	3.8	216	3.7	18	5.1	
2	2303	35.3	2158	35.4	145	34.0	
3	4681	61.0	4407	61.0	274	60.8	
Average meal consumption (/day)	2.6±0.01¶		2.6±0.01		2.6±0.04		0.655††
Snack							0.963
No	404	6.5	382	6.5	22	6.4	
Yes	6813	93.5	6399	93.5	414	93.6	
Frequency of eating out							<0.001
≥2 times/day	713	11.5	651	11.1	62	16.9	
1 time/day	1388	22.2	1294	22.1	94	23.3	
5-6 times/week	1334	18.9	1245	18.7	89	21.7	
3-4 times/week	771	10.7	730	10.9	41	8.5	
1-2 times/week	1721	20.6	1625	20.7	96	18.9	
1-3 times/month	1099	13.5	1054	13.9	45	8.2	
Seldom	193	2.6	183	2.6	10	2.5	
Average frequency of eating out (/week)	6.8±0.1¶		6.8±0.1		7.6±0.3		0.006††

†Both doctor-diagnosed and self-reported AD groups.
‡Weighted %.
§*p*-value by Chi-square.
¶Mean±standard error.
††*p*-value by t-test.

Table 5. Food intake according to the presence of atopic dermatitis

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value1‡	*p*-value2§
	Mean	SE	Mean	SE	Mean	SE		
Total food intake (g)	1597	13.9	1598	14.1	1587	47.0	0.818	0.177
Total plant food intake (g)	1285	12.2	1285	12.3	1278	43.6	0.875	0.121
Total vegetables (g)	318	3.6	320	3.7	294	10.7	0.016	0.937
Cereals and grain products (g)	307	2.6	306	2.3	324	15.5	0.240	0.054
Potatoes and starches (g)	34.1	1.2	34.5	1.3	28.9	3.0	0.085	0.175
Seeds and nuts (g)	3.3	0.2	3.4	0.2	3.0	0.5	0.529	0.653
Sugars and sweets (g)	10.6	0.3	10.6	0.3	10.8	1.2	0.862	0.671
Legumes and their products (g)	39.8	1.3	40.0	1.3	36.0	4.6	0.394	0.569
Mushrooms (g)	6.3	0.4	6.2	0.4	7.7	1.1	0.175	0.157
Fruits (g)	154	4.2	156	4.5	124	12.2	0.017	0.174
Seaweeds (g)	3.8	0.3	3.9	0.3	3.0	0.5	0.141	0.609
Beverages (g)	328	8.3	327	8.3	339	30.8	0.710	0.581
Seasonings (g)	40.1	0.6	40.1	0.6	39.5	2.5	0.816	0.544
Plant oils and fats (g)	9.9	0.2	9.9	0.2	9.8	0.6	0.832	0.837
Other plant food (g)	4.6	0.4	4.4	0.5	6.8	2.0	0.247	0.255
Total animal food intake (g)	314	4.1	314	4.3	308	14.4	0.687	0.423
Meat, poultry & products (g)	120	2.7	120	2.8	120	7.8	0.969	0.729
Eggs (g)	30.0	0.7	30.0	0.7	29.5	2.3	0.845	0.978
Fish and shellfish (g)	62.5	1.5	63.4	1.6	50.6	4.2	0.004	0.134
Milks and dairy products (g)	100	2.8	99.8	2.9	106	12.1	0.598	0.865
Yogurt (g)	15.5	0.8	15.3	0.9	17.3	3.4	0.581	0.780
Cheese (g)	1.1	0.1	1.0	0.1	2.8	0.7	0.008	0.011
Milk and other dairy products (g)	83.6	2.6	83.4	2.7	86.2	2.6	0.817	0.673
Animal oils and fats (g)	0.2	0.01	0.2	0.01	0.4	0.1	0.145	0.246
Other animal food (g)	0.9	0.1	0.8	0.1	1.1	0.4	0.461	0.644

†Both doctor-diagnosed and self-reported AD groups.
‡Crude.
§Adjusted for sex, age, and energy intake.

Table 6. Kimchi intake according to the presence of atopic dermatitis

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value1‡	*p*-value2§
	Mean	SE	Mean	SE	Mean	SE		
Total kimchi intake (g)	113	1.6	113	1.7	101	5.7	0.031	0.046
Cooked kimchi (g)	19.6	0.7	19.6	0.7	18.7	2.7	0.734	0.913
Uncooked kimchi (g)	92.9	1.5	93.7	1.5	81.9	5.3	0.030	0.045
Fermented kimchi (g)	110	1.6	111	1.7	98.3	5.7	0.037	0.049
Unfermented kimchi (g)	2.8	0.5	2.8	0.5	2.3	2.2	0.528	0.639

†Both doctor-diagnosed and self-reported AD groups.
‡Crude.
§Adjusted for sex, age, energy intake, and frequency of eating out.

is associated with an increase in atopic disease.[27-29] AD is significantly affected not only by genetic factors, but also by the environment. Reactive oxygen species produced by environmental pollution and solar radiation cause protein damage in the stratum corneum, degrading the skin-barrier function and aggravating AD symptoms.[30]

Like vegetables and fruits, kimchi is rich in antioxidant nutrients. A study that analyzed the nutritional characteristics of kimchi has reported that green, yellow, and purple cabbages; green onions; and carrots contain a large concentration of carotene, and that the red pepper powder used for seasoning contains abundant amount of vitamin C.[19] Antioxidant nutrients have been reported to decrease the risk of asthma and atopic disease by reducing inflammatory and allergic responses.[31,32] The subjects with AD also showed a lower intake of fish and shellfish than the subjects without AD, probably because those foods are known to induce allergic reactions.[33]

When we analyzed the daily kimchi intakes of participants, we found that subjects with AD showed a total kimchi intake of 101±5.7 g, which was lower than the 113±1.7 g consumed daily by subjects without AD. Concerning the preparation methods, subjects with AD showed a particularly low intake of fermented and uncooked kimchi.

An imbalance between two types of cell responses that are mutually antagonistic has been reported to be a cause of AD.[34] CD4+ T lymphocytes, also called helper T (Th) cells, play an important role in immunity and are classified into Th1 and Th2 cells according to the type of cytokines they secrete.[35] AD patients are characterized by dominance of the Th2 cell response at early stage of AD.[36,37] Repeated study results show that probiotics have a positive effect in the treatment of atopic patients by restoring balance between the Th1/Th2 cell responses.[38,39] Unlike unfermented kimchi, fermented kimchi contains

Table 7. Nutrient intake according to the presence of atopic dermatitis

	Total (n=7,222)		Without AD (n=6,785)		With AD† (n=437)		*p*-value1‡	*p*-value2§
	Mean	SE	Mean	SE	Mean	SE		
Energy (kcal)	2134	13.8	2138	14.1	2081	49.9	0.266	0.440
Carbohydrate (g)	323	2.0	324	2.0	312	7.4	0.124	0.287
Protein (g)	79.6	0.7	79.8	0.7	76.6	2.1	0.128	0.310
Fat (g)	50.4	0.5	50.4	0.5	50.3	1.8	0.937	0.409
Sodium (mg)	5234	51.9	5245	52.2	5080	180	0.357	0.391
Potassium (mg)	3155	25.3	3170	26.0	2945	79.8	0.006	0.398
Calcium (mg)	533	5.3	534	5.5	520	19.0	0.485	0.600
Phosphorus (mg)	1248	8.4	1252	8.7	1193	29.0	0.049	0.596
Iron (g)	15.3	0.2	15.4	0.2	14.5	0.5	0.146	0.883
Vit A (μgRE)	901	20.3	905	20.8	845	61.3	0.333	0.979
Carotene (μg)	4547	117	4571	121	4210	358	0.326	0.994
Retinol (μg)	142	5.9	142	6.3	135	9.9	0.569	0.749
Vit B1 (mg)	1.5	0.0	1.5	0.0	1.4	0.0	0.277	0.519
Vit B2 (mg)	1.4	0.0	1.4	0.0	1.3	0.0	0.117	0.342
Niacin (mg)	18.7	0.2	18.7	0.2	17.7	0.5	0.075	0.336
Vit C (mg)	112	1.7	112	1.7	111	6.2	0.895	0.360
Energy Contribution								
Carbohydrate (%)	64.3	0.2	64.4	0.2	63.3	0.6	0.074	0.861
Protein (%)	14.9	0.1	14.9	0.1	15.0	0.3	0.587	0.679
Fat (%)	20.8	0.1	20.7	0.1	21.7	0.5	0.063	0.991

†Both doctor-diagnosed and self-reported AD groups.
‡Crude.
§Energy intake was adjusted for sex and age. The other nutrients were adjusted for sex, age, and energy intake.

Table 8. Odds ratios and 95% confidence intervals for atopic dermatitis according to kimchi intake

	Q1 (0-36.0 g/d)	Q2 (36.1-84.9 g/d)	Q3 (85.0-158 g/d)	Q4 (158-601 g/d)	*p* for trend§
Two AD groups†					
Model 1	1	0.80 (0.58-1.09)‡	0.61 (0.45-0.82)	0.69 (0.51-0.93)	0.016
Model 2	1	0.81 (0.59-1.10)	0.62 (0.46-0.83)	0.71 (0.51-0.98)	0.036
Model 3	1	0.92 (0.67-1.26)	0.73 (0.54-0.99)	0.93 (0.66-1.31)	0.584
Model 4	1	0.92 (0.67-1.26)	0.73 (0.54-0.99)	0.95 (0.67-1.33)	0.645
Model 5	1	0.81 (0.59-1.12)	0.68 (0.50-0.92)	0.84 (0.59-1.20)	0.327
Doctor-diagnosed AD group					
Model 1	1	0.70 (0.45-1.09)	0.57 (0.39-0.85)	0.62 (0.41-0.94)	0.031
Model 2	1	0.71 (0.46-1.10)	0.58 (0.39-0.85)	0.63 (0.41-0.99)	0.049
Model 3	1	0.84 (0.54-1.32)	0.74 (0.49-1.10)	0.95 (0.59-1.53)	0.790
Model 4	1	0.83 (0.53-1.30)	0.74 (0.50-1.11)	0.99 (0.61-1.58)	0.905
Model 5	1	0.73 (0.46-1.14)	0.65 (0.43-0.99)	0.77 (0.47-1.25)	0.304
Self-reported AD group					
Model 1	1	0.87 (0.57-1.33)	0.67 (0.42-1.06)	0.81 (0.51-1.29)	0.364
Model 2	1	0.88 (0.58-1.34)	0.68 (0.43-1.07)	0.84 (0.54-1.33)	0.446
Model 3	1	0.90 (0.59-1.38)	0.70 (0.44-1.11)	0.89 (0.56-1.41)	0.575
Model 4	1	0.91 (0.59-1.38)	0.70 (0.45-1.11)	0.89 (0.56-1.42)	0.595
Model 5	1	0.93 (0.61-1.43)	0.73 (0.45-1.18)	0.94 (0.56-1.59)	0.762

Model 1: Crude.
Model 2: Adjusted for sex and energy intake.
Model 3: Adjusted for sex, energy intake, and age.
Model 4: Adjusted for sex, energy intake, age, residence, exercise, smoking status, alcohol consumption, stress, and snack intake.
Model 5: Adjusted for sex, energy intake, age, residence, exercise, smoking status, alcohol consumption, stress, snack intake, income level, frequency of eating-out, breakfast intake, sodium intake, fruit intake, vegetable intake, yogurt intake, cheese intake, and fish/shellfish intake.
†Both doctor-diagnosed and self-reported AD groups.
‡Odds ratio (95% CI: confidence interval).
§Obtained by Survey logistic procedure from SAS.

various LAB, including *Lactobacillus* spp., *Lactococcus* spp., *Pediococcus* spp., and *Weissella* spp.[14] Moreover, the microbes originating from fermented foods synthesize vitamins K and B-12, which are reported to be effective in the prevention and treatment of AD by suppressing the inflammatory response.[13,40]

We conducted a multivariable logistic regression analysis to determine the OR for the risk of AD across the quartiles of kimchi intake. When we analyzed the two AD groups together (doctor-diagnosed and self-reported AD groups) and the doctor-diagnosed AD group only, model 1 (unadjusted) and model 2 (adjusted for sex and energy

intake) showed a decreasing risk for AD with increasing kimchi intake (p for trend <0.05). However, this trend was no longer noted when we considered additional adjustments for variables such as age, residence and exercise. Nevertheless, relative to Q1 group, which had the lowest kimchi intake, the Q3 group was associated with a significantly lower presence of AD. The daily kimchi intake of the Q3 group was 85.0-158 g, which we thus recommend as inclined to have a protective effect against AD.

Studies have reported that plant-derived LAB found in fermented kimchi has superior survivability and is more beneficial to health than the animal-derived LAB from milk-based fermentations.[24,41] Recent studies that examined the association between AD in Korean adults with the intake of fermented food found that the group who consumed higher levels (>92 times/month) of fermented foods (such as kimchi, doenjang, chungkookjang, fermented seafood, and makgeolli) had a lower prevalence of AD than the group with lower levels of consumption (<54 times/month; OR: 0.56, 95% CI: 0.37-0.84).[13] Therefore, consuming kimchi, which contains many leafy vegetables, could be effective at alleviating AD.

Our study has several limitations. First, the results do not show a causal relationship between kimchi intake and AD because the study used a cross-sectional design. Second, using 24-hour recall for the intake estimates might have resulted in difficulties in evaluating the usual dietary intake of the subjects because of individual variations in food consumption. Third, because consumption of nutritional supplements such as probiotics, antioxidant vitamins, and ɣ-linolenic acid was not surveyed, we could not consider their effects.

Despite its limitations, this was a study of AD in adults, which has been lacking both in Korea and elsewhere. It is the first large-scale investigation of the relationship between kimchi and AD. This study is significant because it investigated the relationship of fermented food kimchi as a whole rather than using only one or two probiotic properties extracted from kimchi.

In conclusion, consuming 85.0-158 g/day of kimchi was significantly associated with a lower presence of AD (OR: 0.68, 95% CI: 0.50-0.92). Given that a typical serving size of kimchi is 40 g, this corresponds to about two to four servings per day. Since this study also showed that subjects without AD consumed significantly more fermented and uncooked kimchi than subjects with AD, these forms of kimchi are thought to be more effective against AD. This may be due to the beneficial actions of the probiotics and fermentation-related microbes. However, as this study was cross-sectional, understanding of the accurate effects of kimchi requires further controlled, intervention studies to compare kimchi consumption with placebo effect or fermented kimchi with non-fermented kimchi. We expect that the results of this study will provide insights when preparing guidelines for future studies and for the prevention and alleviation of AD.

AUTHOR DISCLOSURES

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