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Association Between Kimchi Intake and Asthma in Korean Adults: The Fourth and Fifth Korea National Health and Nutrition Examination Survey (2007–2011)

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ABSTRACT This study was performed to investigate the relationship between dietary factors and asthma in a representative population-based sample of 19,659 men and women, aged 19–64 years, using data from the fourth and fifth Korean National Health and Nutrition Examination Survey (KNHANES), 2007–2011. The presence of asthma was based on self-reported physician diagnosis of asthma in the Health Interview Surveys. Food intake was estimated by trained interviewers using a 24-h recall method. The prevalence of asthma in Korean adults was 2.4%. Adults with asthma consumed fewer amounts of kimchi ($P = .0444$) and fish ($P = .0175$) but had a higher cereal intake than those without asthma ($P = .0056$). Multiple logistic regression analysis after controlling for confounding factors showed a significant inverse relationship between kimchi consumption and the prevalence of asthma [odds ratio (95% confidence interval) for subjects consuming 1 to <2 servings (40–79.9 g), 2 to <3 servings (80–119.9 g), and ≥3 servings (≥120 g), relative to those consuming <1 serving (<40 g): 0.726 (0.534–0.987), 0.506 (0.348–0.736), and 0.678 (0.502–0.916), respectively; *P* for trend = 0.0131]. These results warrant future studies to explore the mechanisms responsible for the association between kimchi consumption and asthma.

KEY WORDS: • *adults* • *asthma* • *kimchi* • *KNHANES*

INTRODUCTION

ASTHMA IS ONE OF THE most common chronic respiratory diseases, and the prevalence of asthma in adults ranges from 1.8% in Vietnam to 32.8% in Australia.[1] In most countries, the prevalence of asthma has been increasing in the past few decades.[2,3] In Korea, the prevalence of physician-diagnosed asthma increased from 1998 to 2008 (1998: 0.7%, 2008: 2.0%),[4] although the reason for increasing prevalence of asthma diagnosis is unclear. Because of its increasing prevalence among adults and children, the burden of this disease is internationally recognized as a serious public health problem.

It is widely believed that a modern lifestyle through industrialization, such as increasing air pollution, changed indoor environments, enhanced hygiene, and reduced burden of infections during early life, and increasing obesity have contributed to the risk of developing asthma. A number of lifestyle aspects have changed over the past decades, and their relationship to asthma has been investigated.[5] Diet is another aspect that has changed, and a number of studies have suggested that increased risk of asthma is associated with dietary factors, such as low consumption of fermented food, fruits and vegetables, fish, butter and dairy fat, *n*-3 fatty acids, vitamins C and E, β-carotene, selenium, and magnesium, and a high consumption of margarine, *n*-6 fatty acids, and sodium.[6–13] However, evidence for the role of diet in the prevalence of asthma among adults remains scarce and conflicting.[14,15]

Kimchi, a Korean fermented vegetable side dish that most Koreans consume every day, is rich in various biological compounds, such as dietary fiber, vitamin C, β-carotene, minerals, and other health promoting phytochemicals as well as lactic acid bacteria.[16] It has been documented in *in vitro* and *in vivo* studies using animal models that various strains of lactic acid bacteria, which are derived from kimchi ingredients and/or the fermentation process, have a function as an immune modulator for diverse allergic diseases,[17–19] including asthma.[20–22] In humans, lactic acid bacteria is beneficial in the treatment of pediatric atopic dermatitis[23] as well as prevents the occurrence of atopic disease.[24,25]

Although diet is important and kimchi with probiotics may play a role in asthma, the relationship between kimchi consumption and asthma has never been studied in a Korean population other than one study in elementary schoolchildren reporting that intake of fresh seafood, fresh fruits and vegetables including kimchi may help protect against

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the development of asthma symptoms.[26] No adult population study has investigated the association between kimchi or other fermented food consumption and asthma in Korea.

Therefore, the purpose of this study was to identify the association between dietary factors and asthma in Korean adults, using the Korean National Health and Nutrition Examination Survey (KNHANES) data.

SUBJECTS AND METHODS

Study population

This study was based on cross-sectional data obtained from the first to third years (2007–2009) of the KNHANES IV (2007–2009) and the first to second years (2010–2011) of KNHANES V (2010–2012). These surveys have been conducted periodically since 1998 by the Korean Ministry of Health and Welfare to assess the health and nutritional status of the Korean population using a rolling sampling design involving a complex, stratified, multistage, probability-cluster survey of a representative sample of the noninstitutionalized civilian population. The survey consists of a health interview survey, a health examination survey, and a nutrition survey. These surveys were completed by 4594 participants (71.2% of the total target population of 6455), 9744 participants (77.8% of the total target population of 12,528), 10,533 participants (82.8% of the total target population of 12,722), 8958 participants (81.9% of the total target population of 10,938), and 8518 participants (80.4% of the total target population of 10,589) in 2007–2011, respectively. Among 42,347 eligible subjects who participated in the survey, those who were aged 19–64 years were included in data analyses. We excluded subjects ($n = 81$) with chronic obstructive pulmonary disease (COPD), which can affect the prevalence of asthma. The remaining 19,659 subjects (7787 men and 11,872 women) were included in the final analyses. This study was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (2007-02-CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C), and written consent was obtained from all participants.

General characteristics and anthropometrics

The health interview and health behavior surveys included well-established questions to determine the demographic and socioeconomic characteristics of the subjects. These surveys included questions on age, residence, family income, education level, occupation, marital status, smoking habit, alcohol consumption, exercise, previous and current diseases, and family disease history. Height was measured within 0.1 cm, and weight was measured with a metric weight scale to the nearest 0.01 kg in light clothing without shoes. Body mass index (BMI) was calculated as weight (kg)/height (m^2). Education level was categorized as less than high school, high school, or college and more. Residential area was categorized as urban (administrative division of a city) or rural (not classified as an administrative division of a city). Smoking status was divided into three categories: current smoker, ex-smoker, or nonsmoker. Subjects were questioned about the frequency at which they exercised per week when they exercised with an intensity that left them with slight difficulty breathing and sweating. Exercise status was divided into three categories: < 1 day/week, 1–3 days/week, and 4–7 days/week.

Definition of asthma

Asthma was defined as self-reported physician diagnosis of asthma in the health interview surveys. The following survey question was used in this study: ''Have you ever been diagnosed with asthma by a doctor?'' Information about the forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) ratio in the health examination surveys was used to represent pulmonary function, and subjects were classified on the basis of 70% of FEV1/FVC ratio.[27]

Dietary assessment

Trained dietitians interviewed each subject to collect dietary data through a 24-h dietary recall. Kimchi in the vegetable group, which is one of the common food groups based on Korean nutrient database, was separated into a single food group, as it is traditionally served as a single side dish in the Korean diet.[28]

Kimchi consumption was categorized as follows: < 1 serving (< 40 g), 1 to < 2 servings (40–79.9 g), 2 to < 3 servings (80–119.9 g), and ≥ 3 servings (≥ 120 g). Consumption of cereal was classified into four categories of < 1 serving (< 90 g), 1 to < 2 servings (90–179.9 g), 2 to < 3 servings (180–269.9 g), and ≥ 3 servings (≥ 270 g), while fish/shellfish consumption was categorized as < 1 serving (< 50 g), 1 to < 2 servings (50–99.9 g), and ≥ 2 servings (≥ 100 g). Serving sizes of representative food items in each food group were defined according to the Dietary Reference Intakes for Koreans.[29]

Statistical analysis

All statistical analyses were performed using SAS software version 9.3 (SAS Institute, Cary, NC, USA). Due to the complex sampling design of the KNHANES study, the relevant primary sampling units, stratification, and sample weights were considered in our analysis. The prevalence of self-reported asthma was calculated using the SURVEYFREQ procedure, and differences in means and the distribution of general characteristics and anthropometrics between the group without asthma and the group with asthma were performed using Student's *t*-test and chi-square test. The difference in food and nutrient intake according to the presence of asthma was tested by the generalized linear model procedure. Multivariate logistic regression was performed to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for asthma or FEV1/FVC ratio of < 0.7 across kimchi, cereal, and fish/shellfish intake levels, considering the subjects' consumption < 1 serving (< 40 g), < 1 serving (< 90 g), and < 1 serving (< 50 g) as the reference group, respectively. Model 1 was adjusted for age

(continuous), BMI (continuous), education level (less than high school, high school, college and more), and log-transformed energy intake (continuous). Model 2 was adjusted for sex (male, female), residential area (urban, rural), smoking status (current smoker, ex-smoker, nonsmoker), and exercise (1 day/week, 1–3 days/week, 4–7 days/week) in addition to the adjustments made in Model 1. All reported probability tests were two-sided, and differences were considered significant at the 5% level.

RESULTS

General characteristics according to the presence of asthma

The prevalence of asthma in Korean adults, aged 19–64 years, was 2.4% (data not shown). Among the 19,659 subjects, 484 (2.5%) had asthma; no sex difference was observed between subjects with and without asthma (men, 48.8%; women, 51.2%). Subjects with asthma had a higher BMI than subjects without asthma, and the proportion of subjects with asthma was lower in those with a higher education level. Except for BMI and education level, general information on demographic and socioeconomic factors as well as health-related behavior did not differ significantly between subjects with and without asthma (Table 1).

Table 1. Demographic Features According to the Presence of Asthma in Korean Adults Aged 19–64 Years

	Asthma		
	Without (n = *19,175*)	*With* (n = *484*)	P *value*
Age (years)	40.4 ± 0.1	39.9 ± 0.8	.4770
BMI[a] (kg/m^2)	23.6 ± 0.1	24.2 ± 0.2	.0031
Sex			
Male	7615 (50.8)	172 (48.8)	.4984
Female	11,560 (49.2)	312 (51.2)	
Education[a]			.0017
Less than high school	5033 (21.2)	180 (27.8)	
High school	7714 (43.8)	179 (45.2)	
College and more	6376 (35.1)	123 (27.0)	
Residential area			.0515
Urban	15,276 (82.6)	386 (86.2)	
Rural	3899 (17.4)	98 (13.8)	
Smoking status[a]			.2494
Current smoker	4185 (28.2)	90 (23.8)	
Ex-smoker	3281 (19.1)	88 (19.5)	
Nonsmoker	11,710 (52.7)	305 (56.8)	
Exercise[a]			.5366
< 1 day/week	12,430 (61.9)	304 (59.6)	
1–3 days/week	4737 (27.3)	120 (27.5)	
4–7 days/week	1964 (10.8)	58 (12.8)	

Values are weighted mean ± standard error or *n* (%); *N* = 19,659.

[a]Data availability was limited in the following categories: BMI [without asthma (*n* = 19,088); with asthma (*n* = 483)], education [without asthma (*n* = 19,123); with asthma (*n* = 482)], smoking status [without asthma (*n* = 19,149); with asthma (*n* = 483)], and exercise [without asthma (*n* = 19,131); with asthma (*n* = 482)].

BMI, body mass index.

Dietary food and nutrient consumption according to the presence of asthma

Adults with asthma consumed less kimchi ($P = .0273$) and fish/shellfish ($P = .0164$) than those without asthma after adjusting for age, BMI, education level, and energy intake (Model 1). In contrast, we found that subjects with asthma consumed larger amounts of cereal than those without asthma ($P = .0052$). These results coincided with Model 2 (adjustment for sex, residential area, smoking status, and exercise in addition to the adjustments made in Model 1; Table 2).

No significant difference was observed in nutrient intake between subjects with and without asthma (data not shown). However, subjects with asthma tended to consume fewer nutrients contained in kimchi, such as fiber, sodium, potassium, β-carotene, vitamin B_1, vitamin B_2, and vitamin C in Model 1. Furthermore, when we determined the association between intake of nutrients contained in kimchi and asthma, nutrient intake was inversely associated with the risk of asthma after adjusting for potential confounders (data not shown).

Relationship between kimchi consumption and asthma

The multiple logistic regression analysis after controlling for confounding factors showed a significant inverse relationship between kimchi consumption and the prevalence of asthma [OR (95% CI) for subjects consuming 1 to < 2 servings (40–79.9 g), 2 to < 3 servings (80–119.9 g), and ≥ 3 servings (≥ 120 g), relative to those consuming < 1 serving (< 40 g): 0.726 (0.534–0.987), 0.506 (0.348–0.736), and 0.678 (0.502–0.916), respectively; *P* for trend = 0.0131; Table 3]. However, when we estimated the ORs and 95% CIs for asthma across cereal and fish/shellfish intake levels using the subjects consuming < 1 serving (< 90 g) and < 1 serving (< 50 g) as reference groups, cereal and fish/shellfish intake was not significantly related with the risk of asthma. Furthermore, these results coincided with those for Model 2 (data not shown).

DISCUSSION

We found a significant inverse association between kimchi consumption and the asthma. We believe that this is the first study showing an inverse relationship between kimchi consumption and asthma in adults.

Kimchi has been spotlighted for its health-promoting functions, including antioxidative activity,[30] anti-aging effects,[31] antimutagenic and anticancer activities,[32] antimicrobial activity,[33] immune stimulatory activity,[34] weight reduction and lipid lowering effects,[35] and anti-atherogenic activity.[36,37] The health-promoting properties of kimchi may be derived from nutrients and functional components present in kimchi, such as vitamins, minerals, fibers, and phytochemicals from the biological compounds present either in kimchi ingredients, such as garlic, ginger, red pepper powder, the fermentation products, and the lactic acid bacteria involved, or a combination of these.[38] It is now understood

Table 2. Daily Food Intake According to the Presence of Asthma in Korean Adults Aged 19–64 Years

	Asthma			
	Without (n = *19,175*)	*With* (n = *484*)	P *value*[a]	
			Model 1	*Model 2*
Cereals (g)	308.47 ± 1.58	330.63 ± 9.71	.0052	.0056
Potatoes (g)	39.31 ± 1.08	42.41 ± 5.73	.3087	.3823
Kimchi (g)	128.82 ± 1.34	111.18 ± 6.44	.0273	.0444
Vegetables (g)	337.39 ± 2.51	324.83 ± 12.59	.7657	.7819
Vegetables/fruits (g)	523.68 ± 4.67	530.81 ± 23.93	.1761	.2897
Vegetables without kimchi (g)	208.57 ± 2.10	213.65 ± 10.59	.6367	.7468
Vegetables/fruits without kimchi (g)	394.86 ± 4.45	419.63 ± 21.82	.0393	.1166
Jang (g)	25.04 ± 0.27	23.76 ± 1.65	.7268	.8144
Beans (g)	40.51 ± 0.72	40.76 ± 5.09	.2863	.2509
Nuts (g)	3.27 ± 0.11	3.19 ± 0.58	.3017	.3814
Beans/nuts (g)	43.78 ± 0.74	44.00 ± 5.11	.9780	.8913
Total plant food (g)	1218.71 ± 8.28	1212.95 ± 37.98	.7669	.7922
Milk and milk products (g)	82.18 ± 1.72	88.45 ± 9.45	.9060	.7751
Milk without yogurt and cheese (g)	69.34 ± 1.56	71.56 ± 8.50	.2057	.3074
Yogurt and cheese (g)	12.84 ± 0.47	16.88 ± 3.47	.6179	.5550
Meat (g)	100.73 ± 1.62	103.55 ± 9.24	.5510	.5782
Fish and shellfish (g)	63.44 ± 1.00	52.70 ± 5.62	.0164	.0175
Eggs (g)	25.86 ± 0.44	26.71 ± 2.49	.3341	.3028
Total animal food (g)	272.47 ± 2.74	272.14 ± 14.07	.7083	.5069

Values are weighted mean ± standard error; $N = 19,659$.

[a]Model 1: adjusted for age, BMI, education level, and energy intake (ln). Model 2: adjusted for Model 1 plus sex, residential area, smoking status, and exercise.

Log-transformed data are available for cereal ($n = 19,577$), potatoes ($n = 8665$), kimchi ($n = 18,178$), vegetables ($n = 19,524$), vegetables/fruits ($n = 19,556$), vegetables without kimchi ($n = 19,256$), vegetables/fruits without kimchi ($n = 19,400$), *jang* ($n = 18,197$), beans ($n = 12,898$), nuts ($n = 14,198$), beans/nuts ($n = 17,276$), total plant food ($n = 19,605$), milk ($n = 6757$), milk without yogurt and cheese ($n = 5264$), yogurt and cheese ($n = 2477$), meat ($n = 13,960$), fish and shellfish ($n = 16,801$), eggs ($n = 10,191$) and total animal food ($n = 19,116$).

that various strains of lactic acid bacteria, which are derived from kimchi ingredients and/or the fermentation process, are primarily responsible for imparting the health benefits, and a variety of lactic acid bacteria strains benefit a number of host physiological responses, including immune function.[39] Of these lactic acid bacteria, particularly *Lactobacillus plantarum* isolated from kimchi may have beneficial effects in asthma[17] and pruritus[19] by enhancing the expression of regulatory factors, such as Foxp3 and interleukin (IL)-10, in intestinal laminar propria cells,[17] and by inhibiting IL-4 expression in the colon of mice,[19] respectively. In a randomized, double-blind placebo-controlled study, oral administration of *L. plantarum* CJLP133 isolated from kimchi showed reduction of Scoring of Atopic Dermatitis (SCORAD) scores, total eosinophil count, IFN-γ, and IL-4 in children with atopic dermatitis.[23] Several *Lactobacillus* strains isolated from kimchi may reduce allergic reactions through macrophage-mediated induction of the Th1 response.[18]

Table 3. Odds Ratios and 95% Confidence Intervals for Asthma and FEV1/FVC (< 0.7) According to Kimchi Intake by Korean Adults Aged 19–64 Years

	n *(weighted percentile)*	*Asthma*[a]		*FEV1/FVC (< 0.7)*[a]	
		Model 1	*Model 2*	*Model 1*	*Model 2*
Kimchi					
< 1 serving (< 40 g)	4994 (25.3)	1.000	1.000	1.000	1.000
1 to < 2 serving (40–79.9 g)	3694 (18.4)	0.708 (0.521–0.962)	0.726 (0.534–0.987)	0.909 (0.811–1.020)	0.905 (0.807–1.015)
2 to < 3 serving (80–119.9 g)	3155 (15.3)	0.494 (0.340–0.718)	0.506 (0.348–0.736)	0.909 (0.809–1.021)	0.904 (0.804–1.016)
≥ 3 serving (≥ 120 g)	7816 (41.0)	0.654 (0.487–0.879)	0.678 (0.502–0.916)	0.860 (0.779–0.949)	0.851 (0.770–0.941)
P for trend		0.0063	0.0131	0.0044	0.0025
Kimchi					
< 1 serving (< 40 g)	4994 (25.3)	1.000	1.000	1.000	1.000
≥ 1 serving (≥ 40 g)	14,665 (74.7)	0.634 (0.494–0.815)	0.654 (0.507–0.844)	0.883 (0.810–0.964)	0.877 (0.803–0.957)

Values are odds ratio (95% confidence interval); $N = 19,659$.

[a]Model 1: adjusted for age, BMI, education level, and energy intake (ln). Model 2: adjusted for Model 1 plus sex, residential area, smoking status, and exercise.

In this study, unlike the relationship between kimchi consumption and the prevalence of asthma, we did not find a significant relationship between vegetable consumption and the prevalence of asthma. The overall results of several studies on the association between vegetable consumption and adult asthma are inconclusive. A population-based case–control study on adult asthma conducted in the United Kingdom showed a nonsignificant relationship between a ''vegetarian'' dietary pattern and asthma,[15] and a recent large prospective E3N (Etude Epidémiologique auprès des femmes de la MGEN) study (of French females, mostly teachers) also found no clear relationship between ''prudent'' dietary patterns (fruits and vegetables) and asthma.[40] Interestingly, results from another E3N cohort study suggested that leafy vegetables, carrots, and tomatoes may decrease the prevalence of adult asthma.[12] Diets rich in starch, cereals, and vegetables show a protective association with asthma[13] and allergic rhino conjunctivitis.[41] Therefore, the relationship between kimchi consumption and asthma in our study may not have been due to the consumption of vegetables containing components, such as vitamins, minerals, fibers, and phytochemicals, but was due to another kimchi component, such as lactic acid bacteria.

Lactic acid bacteria are produced by the fermentation of milk (such as yogurt and cheese) or multifarious vegetables. Several animal and human studies have suggested that yogurt and cheese containing lactic acid bacteria, unlike milk, lead to improved immune and clinical responses.[42–44] However, considerable evidence has been gathered to support the idea that fiber-fermenting lactobacilli from fermented fruits and vegetables possess much stronger health promoting potential than bacteria found in milk-based products.[18] Therefore, kimchi, the most popular leafy vegetable Korean food fermented by *Lactobacillus*, is considered to be a better source of lactic acid bacteria compared to other fermented foods, such as yogurt and cheese. We did not show an association between yogurt and cheese consumption and asthma. This may have been due to a quantitatively insignificant amount (12–16 g in our study) of fermented milk products, which is contrary to the higher amounts consumed by the Western people. This may also have been due to the differences in status (form) of the lactic acid bacteria derived from fermented milk products and kimchi ingredients and/or the fermentation process.

In the present study, the prevalence of physician-diagnosed asthma (2007–2011) in Korean adults aged 19–64 years was 2.4%, and that was relatively low compared to other countries (3.9% in 2006 in Japan[45]; ranged from 6.05% (Italy) to 20.09% (Sweden) in Western Europe in 2002–2003[46]). However, Korea's increasing prevalence rate is also evident (1998: 0.7%, 2008: 2.0%).[4] Although the causes for increasing prevalence of asthma diagnosis are unclear, a rising trend in adult obesity along with other changes in lifestyle may play a role. In our study, however, an inverse association between kimchi consumption and adult asthma was still significant even after adjustment for BMI. Interestingly, in pediatric atopic dermatitis, a recent randomized clinical trial[23] revealed that the supplementation of *Lactobacillus* isolated from kimchi improved clinical and immunological parameters. To investigate whether kimchi consumption can prevent asthma or reduce the clinical severity in asthma, more studies including randomized clinical trials are needed in adult as well as children.

The limitations of our study include the following. First, we could not confirm the temporal causal relationship between kimchi intake and asthma due to the cross-sectional design. Second, information on several confounders was unavailable and thus could not be factored into the analysis. The KNHANES does not have information on breast feeding and parent's allergic diseases, and only in 2010 survey, information on allergens, such as mites and dogs, which would directly affect asthma, and IgE is available. Third, we depended on the collection of dietary data only from the 24-h recall, which may be less dependable than a 3-day dietary recall. However, trained dietary nutritionists conducted direct face-to-face interviews and made desperate efforts to minimize potential errors when assessing dietary consumption. Nevertheless, our study had certain strengths. We believe that this is the first report to identify the association between dietary factors and asthma in Korean adults. These findings can be generalized to the Korean general population, as the study participants were a representative population-based sample of Koreans.

In conclusion, we found a significant inverse association between kimchi consumption and adult asthma. Adult asthma may be connected to concomitant diseases, such as COPD and rhinitis, and more attention should be given to the relevance of diet and asthma prevalence; thus, our results are very significant. Future studies are warranted to explore any mechanisms responsible for the association between kimchi consumption and asthma. Our results suggest that health and nutrition promotion or nutrition education programs are needed to maintain a proper amount of kimchi consumption.

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AUTHOR DISCLOSURE STATEMENT

The authors declare that they have no conflicts of interest.

REFERENCES

1. Sembajwe G, Cifuentes M, Tak SW, Kriebel D, Gore R, Punnett L: National income, self-reported wheezing and asthma diagnosis from the World Health Survey. *Eur Respir J* 2010;35:279–286.
2. Global Initiative for Asthma (GINA): Global Burden of Asthma. www.ginasthma.com/ReportItem.asp?l1=2&l2=2&intId=94 (accessed September 30, 2010).
3. Eder W, Ege MJ, von Mutius E: The asthma epidemic. *N Engl J Med* 2006;355:2226–2235.
4. Kim SY, Jung JY, Park MS, Kang YA, Kim EY, Kim SK, Chang J, Kim YS: Increased prevalence of self-reported asthma among

Korean adults: an analysis of KNHANES I and IV data. *Lung* 2013;191:281–288.
5. Devereux G, Seaton A: Diet as a risk factor for atopy and asthma. *J Allergy Clin Immun* 2005;115:1109–1117.
6. Tricon S, Willers S, Smit HA, Burney PG, Devereux G, Frew AJ, Halken S, Host A, Nelson M, Shaheen S, Warner JO, Calder PC: Nutrition and allergic disease. *Clin Exp Allergy Rev* 2006;6:117–188.
7. Troisi RJ, Willett WC, Weiss ST, Trichopoulos D, Rosner B, Speizer FE: A prospective study of diet and adult onset asthma. *Am J Respir Crit Care Med* 1995;151:1401–1408.
8. Monteleone CA, Sherman AR: Nutrition and asthma. *Arch Intern Med* 1997;157:23–34.
9. Nagel G, Linseisen J: Dietary intake of fatty acids, antioxidants and selected food groups and asthma in adults. *Eur J Clin Nutr* 2005;59:8–15.
10. Molinas LJ, Torrent CM, Zapata EM: Frequency of sea fish consumption and symptoms of allergic diseases in adults from Rosario. *Rev Esp Nutr Comunitaria* 2010;16:120–127.
11. Uddenfeldt M, Janson C, Lampa E, Leander M, Norback D, Larsson L, Rask-Andersen A: High BMI is related to higher incidence of asthma, while a fish and fruit diet is related to a lower: results from a long-term follow-up study of three age groups in Sweden. *Respir Med* 2010;104:972–980.
12. Romieu I, Varraso R, Avenel V, Leynaert B, Kauffmann F, Clavel-Chapelon F: Fruit and vegetable intakes and asthma in the E3N study. *Thorax* 2006;61:209–215.
13. Woods RK, Walters EH, Raven JM, Wolfe R, Ireland PD, Thien FC, Abramson MJ: Food and nutrient intakes and asthma risk in young adults. *Am J Clin Nutr* 2003;78:414–421.
14. Hooper R, Heinrich J, Omenaas E, Sausenthaler S, Garcia-Larsen V, Bakolis I, Burney P: Dietary patterns and risk of asthma: results from three countries in European community respiratory health survey. *Brit J Nutr* 2010;103:1354–1365.
15. Bakolis I, Hooper R, Thompson RL, Shaheen SO: Dietary patterns and adult asthma: population-based case–control study. *Allergy* 2010;65:606–615.
16. Cheigh HS, Park KY: Biochemical, microbiological and nutritional aspects of kimchi (Korean fermented vegetable products). *Crit Rev Food Sci Nutr* 1995;34:175–203.
17. Hong HJ, Kim E, Cho D, Kim TS: Differential suppression of heat-killed lactobacilli isolated from kimchi, a Korean traditional food, on airway hyper-responsiveness in mice. *J Clin Immunol* 2010;30:449–458.
18. Won TJ, Kim B, Song DS, Lim YT, Oh ES, Lee do I, Park ES, Min H, Park SY, Hwang KW: Modulation of Th1/Th2 balance by *Lactobacillus* strains isolated from kimchi via stimulation of macrophage cell line J774A.1 *in vitro. J Food Sci* 2011;76:H55–H61.
19. Jang SE, Hyun YJ, Trinh HT, Han MJ, Kim DH: Anti-scratching behavioral effect of *Lactobacillus plantarum* PM008 isolated from kimchi in mice. *Immunopharmacol Immunotoxicol* 2011; 33:539–544.
20. Feleszko W, Jaworska J, Rha RD, Steinhausen S, Avagyan A, Jaudszus A, Ahrens B, Groneberg DA, Wahn U, Hamelmann E: Probiotic-induced suppression of allergic sensitization and airway inflammation is associated with an increase of T regulatory-dependent mechanisms in a murine model of asthma. *Clin Exp Allergy* 2007;37:498–505.
21. Yu J, Jang SO, Kim BJ, Song YH, Kwon JW, Kang MJ, Choi WA, Jung HD, Hong SJ: The effects of *Lactobacillus rhamnosus* on the prevention of asthma in a murine model. *Allergy Asthma Immunol Res* 2010;2:199–205.
22. Jang SO, Kim HJ, Kim YJ, Kang MJ, Kwon JW, Seo JH, Kim HY, Kim BJ, Yu J, Hong SJ: Asthma prevention by *Lactobacillus rhamnosus* in a mouse model is associated with CD4(+) CD25(+)Foxp3(+) T cells. *Allergy Asthma Immunol Res* 2012;4: 150–156.
23. Han Y, Kim B, Ban J, Lee J, Kim BJ, Choi BS, Hwang S, Ahn K, Kim J: A randomized trial of *Lactobacillus plantarum* CJLP133 for the treatment of atopic dermatitis. *Pediatr Allergy Immunol* 2012;23:667–673.
24. Kalliomäki M, Salminen S, Arvilommi H, Kero P, Koskinen P, Isolauri E: Probiotics in primary prevention of atopic disease: a randomised placebo-controlled trial. *Lancet* 2001;357:1076–1079.
25. Kukkonen K, Savilahti E, Haahtela T, Juntunen-Backman K, Korpela R, Poussa T, Tuure T, Kuitunen M: Probiotics and prebiotic galacto-oligosaccharides in the prevention of allergic diseases: a randomized, double-blind, placebo-controlled trial. *J Allergy Clin Immunol* 2007;119:192–198.
26. Hong SJ, Lee MS, Lee SY, Ahn KM, Oh JW, Kim KE, Lee JS, Lee HB; Korean ISAAC Study Group, Korean Academy of Pediatric Allergy and Respiratory Disease: High body mass index and dietary pattern are associated with childhood asthma. *Pediatr Pulmonol* 2006;41:1118–1124.
27. Pauwels RA, Buist AS, Calverley PM, Jenkins CR, Hurd SS: Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. *Am J Respir Crit Care Med* 2001;163:1256–1276.
28. Song Y, Joung H, Engelhardt K, Yoo SY, Paik HY: Traditional v. modified dietary patterns and their influence on adolescents' nutritional profile. *Br J Nutr* 2005;93:943–949.
29. The Korean Nutrition Society: *Dietary Reference Intakes of Koreans*. The Korean Nutrition Society, Seoul, Korea, 2005, pp. 119–126.
30. Lee YM, Kwon MJ, Kim JK, Suh HS, Choi JS, Song YO: Isolation and identification of active principle in Chinese cabbage kimchi responsible for antioxidant effect. *Korean J Food Sci Technol* 2004;36:129–133.
31. Kim JH, Ryu JD, Lee HG, Park JH: The effect of kimchi on production of free radicals and anti-oxidative enzyme activities in the brain of SAM. *J Korean Soc Food Sci Nutr* 2002;31:117–123.
32. Park KY: The nutritional evaluation and anti-mutagenic and anticancer effects of kimchi. *J Korean Soc Food Sci Nutr* 1995; 24:169–182.
33. Sheo HJ, Seo YS: The antibacterial action of Chinese cabbage kimchi juice on *Staphylococcus aureus*, *Salmonella enteritidis*, *Vibrio parahaemolyticus* and *Enterobacter cloacae. J Korean Soc Food Sci Nutr* 2003;32:1351–1356.
34. Kim MJ, Kwon MJ, Song YO, Lee EK, Youn HJ, Song YS: The effects of kimchi on hematological and immunological parameters *in vivo* and *in vitro. J Korean Soc Food Sci Nutr* 1997;26:1–7.
35. Kwon JY, Cheigh HS, Song YO: Weight reduction and lipid lowering effects of kimchi lactic acid powder in rats fed high fat diets. *Korean J Food Sci Technol* 2004;36:1014–1019.
36. Kim HJ, Lee JS, Chung HY, Song SH, Suh H, Noh JS, Song YO: 3-(40-hydroxyl-3050-dimethoxyphenyl) propionic acid, an active principle of kimchi, inhibits development of atherosclerosis in rabbits. *J Agric Food Chem* 2007;55:10486–10492.

37. Noh JS, Kim HJ, Kwon MJ, Song YO: Active principle of kimchi, 3-(40-hydroxyl-3050-dimethoxyphenyl)propionic acid, retards fatty streak formation at aortic sinus of apolipoprotein E knockout mice. *J Med Food* 2009;12:1206–1212.
38. Lee H, Yoon H, Ji Y, Kim H, Park H, Lee J, Shin H, Holzapfel W: Functional properties of *Lactobacillus* strains isolated from kimchi. *Int J Food Microbiol* 2011;145:155–161.
39. Macfarlane GT, Cummings JH: Probiotics and prebiotics: can regulating the activities of intestinal bacteria benefit health? *Br Med J* 1999;318:999–1003.
40. Varraso R, Kauffmann F, Leynaert B, Le Moual N, Boutron-Ruault MC, Clavel-Chapelon F, Romieu I: Dietary patterns and asthma in the E3N study. *Eur Respir J* 2009;33:33–41.
41. Woods RK, Weiner J, Thien F, Abramson M, Walters EH: Do dairy products induce bronchoconstriction in adults with asthma? *J Allergy Clin Immunol* 1998;101:45–50.
42. de Moreno de LeBlanc A, Chaves S, Carmuega E, Weill R, Antoine J, Perdigon G: Effect of long-term continuous consumption of fermented milk containing probiotic bacteria on mucosal immunity and the activity of peritoneal macrophages. *Immunobiology* 2008;213:97–108.
43. Yang YJ, Sheu BS: Probiotics-containing yogurts suppress Helicobacter pylori load and modify immune response and intestinal microbiota in the *Helicobacter pylori*-infected children. *Helicobacter* 2012;17:297–304.
44. Guillemard E, Tondu F, Lacoin F, Schrezenmeir J: Consumption of a fermented dairy product containing the probiotic *Lactobacillus* casei DN-114001 reduces the duration of respiratory infections in the elderly in a randomised controlled trial. *Br J Nutr* 2010;103:58–68.
45. Fukutomi Y, Taniguchi M, Watanabe J, Nakamura H, Komase Y, Ohta K, Akasawa A, Nakagawa T, Miyamoto T, Akiyama K: Time trend in the prevalence of adult asthma in Japan: findings from population-based surveys in Fujieda City in 1985, 1999, and 2006. *Allergol Int* 2011;60:443–448.
46. To T, Stanojevic S, Moores G, Gershon AS, Bateman ED, Cruz AA, Boulet LP: Global asthma prevalence in adults: findings from the cross-sectional world health survey. *BMC Public Health* 2012;12:204.