ORIGINAL ARTICLE

Asian Pacific Journal of
Allergy and Immunology

APJAI

# Association between sleep duration and the prevalence of atopic dermatitis and asthma in young adults

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## Abstract

**Background:** Sleep duration affects allergic diseases; however, this association requires further investigation.

**Objective:** To evaluate the association between sleep duration and the prevalence of atopic dermatitis and asthma in young Korean adults.

**Method:** We analyzed data of 10,148 subjects (4,239 men; 5,909 women) aged 19-39 years from the Korean National Health and Nutrition Examination Survey 2008-2010. Self-reported sleep duration was categorized into five groups: ≤5h, 6h, 7h, 8h, and ≥9h. The prevalence of atopic dermatitis and asthma was examined based on a questionnaire and compared between participants from five sleep duration groups after adjusting for potential confounding factors, including model 1 [age], model 2 [model 1 + BMI, current smoking, current alcohol use, regular physical activity, household income, and serum 25(OH)D level], and model 3 [model 2 + stress levels].

**Results:** In female participants, a higher risk of atopic dermatitis was associated with sleep duration ≤5 hours [odds ratio (OR): 1.665, 95% confidence interval (CI): 1.004–2.762; model 1], and ≥9 hours (OR, 1.746, 95% CI, 1.145–2.661; model 3), compared to a 7-hour sleep duration. Similarly, a higher risk of asthma was associated with sleep duration ≤5 hours and ≥9 hours (OR, 1.553, 95% CI, 1.023–2.359 and OR, 1.569, 95% CI, 1.048–2.349, respectively; model 3). In male participants, there was no significant association between sleep duration and the prevalence of atopic dermatitis or asthma.

**Conclusions:** Sleep duration ≤5 and ≥9 hours may be a risk factor for atopic dermatitis and asthma in young female adults.

**Keywords:** sleep duration; allergy; atopic dermatitis; asthma; young adults

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## Introduction

The importance of sleep duration is a controversial issue. Sleep duration varies according to individuals and the clinical repercussions on health are interesting. According to the ICSD-3 (International Classification of Sleep Disorders, 3rd edition), sleep duration is associated with numerous sleep disorders, such as chronic and short-term insomnia, insufficient sleep syndrome, and short and long sleepers.[1] It is known that adequate sleep plays a critical role in maintaining alertness and health. Excessive or insufficient sleep are associated with a greater risk of health conditions, including hypertension, coronary heart disease, stroke, type 2 diabetes mellitus, obesity, metabolic syndrome, and increased all-cause mortality.[2-8]

An allergy is defined as a hypersensitivity reaction of the immune system caused by a specific allergen. Atopic dermatitis and asthma are typical allergic diseases. Atopic dermatitis is a common chronic skin disorder characterized by cutaneous inflammation, which results in severe itching.[9] Similarly, asthma is a common chronic inflammatory disorder of the

airways, characterized by wheezing and difficulty in breathing.[10] A recent paper reported that the prevalence of atopic dermatitis and asthma among Korean adults was approximately 3%.[11] These allergic diseases are more prevalent in young persons than in the elderly.[9,10] Many studies exploring the connection between poor quality of sleep and allergic diseases have been undertaken.[12,13] However, to the best of our knowledge, there are no studies exploring the relationship between sleep duration and the prevalence of allergic diseases, including atopic dermatitis or asthma, in a large adult population. We postulated that too much or too little sleep can disrupt the immune function and cause allergic diseases. Therefore, we hypothesized that short (≤5 hours) or long (≥9 hours) sleep duration were associated with an increased prevalence of atopic dermatitis or asthma, compared to adequate sleep duration (7 hours). The aim of this study was to evaluate the association between self-reported sleep duration and the prevalence of atopic dermatitis and asthma, in a nationally representative population-based sample of young Korean adults.

## Methods

### *Survey and study participants*

The Korean National Health and Nutrition Examination Survey (KNHANES) is a nationwide survey of non-institutionalized civilians, conducted by the Division of Chronic Disease Surveillance, under the Korean Center for Disease Control and Prevention (KCDC) and the Korean Ministry of Health and Welfare. Data have been collected since 1998. The survey was designed to assess the health and nutritional status of Korean nationals and consists of a health interview, nutritional assessment, and health examination. Participants were selected by sampling household units, based on household registries, using a stratified, multi-stage, and probability-based sampling design with proportional allocation. In this study, data only covers between 2008 and 2010 was utilized for analysis because specific measurements including 25-hydroxyvitamin D [25(OH)D] level were done during only this period.

Of the 45,811 survey participants, those with missing data or those <19 years old or >39 years old, were excluded. Finally, data from 10,148 young adults aged 19-39 years (4,239 men and 5,909 women) were used for the analyses. All participants gave their informed consent, and the institutional review board of the KCDC approved the study protocol.

### *Variable definitions*

The prevalence of asthma and atopic dermatitis were based on the participants' responses to the following question: "Have you been diagnosed with asthma/atopic dermatitis by a physician?" All subjects were asked about the following factors: sleep duration, smoking status, alcohol intake, physical activity, recognition of psychological stress, and household income level. Sleep duration was self-reported by study subjects and categorized into five groups: ≤5h, 6h, 7h, 8h, and ≥9h per night. Subjects were classified as non-smokers or ever-smokers, based on their answers in the self-reported questionnaire. Ever-smokers were defined as subjects who had smoked at least 100 cigarettes in their lifetime. Subjects were categorized as non-drinkers, light to moderate drinkers (1–30 g of alcohol per day), or heavy drinkers (>30 g/day), based on their average alcohol intake per day during the month prior to the interview.[14] The International Physical Activity Questionnaire short form, modified for the Korean population, was used to assess physical activity.[15] Subjects were considered regular exercisers if they performed moderate exercise more than 5 times per week for over 30 minutes per session or if they performed vigorous exercise more than 3 times per week for over 20 minutes per session. Psychological stress was evaluated from the subjects' responses to the following question: "How much stress do you feel in your everyday life?" Subjects answering "feel very strongly," "feel strongly," or "feel somewhat" were categorized as having psychological stress. Subjects answering, "feel a little" were categorized as having no stress. To assess monthly household income, subjects were divided into two groups. A lower income level was defined as the 25$^{th}$ percentile of the income level of all subjects.

### *Measurements*

Trained staff measured the height (cm) and weight (kg) of each subject to the nearest 0.1 cm and 0.1 kg, with subjects wearing light clothing and no shoes. Body mass index (BMI) was calculated by dividing the weight (kg) by the square of the height ($m^2$). Waist circumference (WC) was measured at the midpoint between the lower border of the rib cage and the iliac crest with subjects in the standing position.

Blood sampling was performed after a minimum fast of 8 hours. The samples were processed, immediately refrigerated, and then transported in cold storage to the Central Testing Institute in Seoul Korea. The 25-hydroxyvitamin D [25(OH)D] level was measured by radioimmunoassay (RIA) with an RIA kit (DiaSorin Inc., Stillwater, MN, USA) using a 1470 Wizard gamma counter (PerkinElmer, Turku, Finland).

### *Statistical analyses*

All variables are presented as the mean±standard error (SE) or as percentages (SE). To assess differences according to sex, chi-square tests for categorical variables or independent t-tests for continuous variables were performed. The chi-square test was used to assess the prevalence of atopic dermatitis and asthma according to sleep duration. Multivariable logistic regression analysis was used to evaluate the risk of atopic dermatitis or asthma, according to sleep duration, and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated after adjusting for potential confounders. In model 1, adjustments for age were made. In model 2, adjustments for age, BMI, smoking status, alcohol consumption, regular physical activity, monthly household income, and serum 25(OH)D level were made. Model 3 consisted of the adjusted variables in model 2 in addition to the adjusted psychological stress variable. The survey procedure in SAS Version 9.2 (SAS Institute, Cary, NC, USA) was used for statistical analyses, to account for the complex sampling design, and to provide nationally representative estimates. *P*-values <0.05 were considered statistically significant.

## Results

Baseline data of the young adult population in the KNHANES survey are described in **Table 1**. Of the 10,148 subjects (mean age: 26.7 years) included in this study, there were 4,239 men and 5,909 women. The mean sleep duration of all subjects was 7.1 hours. Of the 4,239 male subjects, 368 (8.7%), 1,317 (31.1%), 1,316 (31.0%), 972 (22.9%), and 266 (6.3%) slept for ≤5h, 6h, 7h, 8h, and ≥9h, respectively. Of the 5,909 female subjects, 430 (7.3%), 1,230 (20.8%), 1,840 (31.1%), 1,723 (29.2%), and 686 (11.6%) slept for ≤5, 6, 7, 8, and ≥9 hours, respectively. The prevalence of atopic dermatitis was 4.6% (469/10,148) and of asthma was 9.0% (911/10,148). In the male group, the prevalence of atopic dermatitis was 4.3% (182/4,239) and the prevalence of asthma was 10.7% (454/4,239). In the female group, the prevalence of atopic dermatitis was 4.9% (287/5,909) and the prevalence of asthma was 7.7% (457/5,909). There were significant differences in age, current smoking status, current alcohol use, regular physical activity, and stress level between the male and female groups.

The prevalence of atopic dermatitis and asthma, according to sleep duration, in this young adult population, is presented in **Table 2**. In the male group, there were no significant differences in the prevalence of atopic dermatitis and asthma, according to sleep duration. However, in the female group, significant differences were found in the prevalence of atopic dermatitis and asthma, according to sleep duration.

The prevalence and adjusted OR for atopic dermatitis and asthma according to sleep duration in the young adult population are presented in **Table 3**. In the male cohort, no significant associations between sleep duration and the prevalence of atopic dermatitis and asthma were observed. However, in the female cohort, there were significant associations between sleep duration and the prevalence of atopic dermatitis and asthma. After adjusting for age (model 1), the ORs of atopic dermatitis prevalence in female adults with short (≤5 hours) and long (≥9 hours) sleep duration were, respectively, 1.665 (95% CI: 1.004–2.762) and 1.571 (95% CI: 1.054–2.341) times higher than those with a sleep duration of 7 hours. After adjusting for age, BMI, current smoking status, current alcohol use, regular physical activity, household income, serum 25(OH)D level (model 2), and stress level (model 3), sleep duration ≥9 hours was significantly associated with an increased risk of atopic dermatitis (OR: 1.732, 95% CI: 1.138–2.635 in model 2 and OR: 1.746, 95% CI: 1.145–2.661 in model 3) compared to a sleep duration of 7 hours. Female subjects with a sleep duration ≤5 hours were 55.3–71.1% more likely to have asthma (OR, 1.711; 95% CI, 1.159–2.525 in model 1, OR, 1.648; 95% CI, 1.084 – 2.504 in model 2, and OR, 1.553; 95% CI, 1.023 – 2.359 in Model 3) compared to subjects with a 7-hour sleep duration. In addition, female subjects with a sleep duration ≥9 hours were 51.4–56.9% more likely to have asthma (OR, 1.514; 95% CI, 1.053–2.176 in model 1, OR, 1.551; 95% CI, 1.039–2.314 in model 2, and OR, 1.569; 95% CI, 1.048–2.349 in model 3) than those with a sleep duration of 7 hours.

**Figure 1** shows the prevalence of atopic dermatitis and asthma in a young adult population, according to sleep duration. In the male cohort, the prevalence of allergic diseases, including atopic dermatitis and asthma, in subjects with short (≤5 hours) and long (≥9 hours) sleep duration was higher than in those with a sleep duration of 7 hours [17.5% (≤5 hours) and 13.4% (≥9 hours) vs. 12.9% (7 hours)]. In addition, in the female cohort, the prevalence of allergic diseases in adults who slept ≤5 hours or ≥9 hours was higher than those who slept 7 hours [19.6% (≤5 hours) and 18.1% (≥9 hours) vs. 11.3% (7 hours)].

**Table 1. Baseline data of the young adult population studied in the KNHANES**

| | Total (N=10,148) | Male (n=4,239) | Female (n=5,909) | *P*-value |
|---|---|---|---|---|
| Age (years) | 29.7±0.1 | 27.3±0.4 | 26.3±0.4 | <0.001 |
| BMI (kg/m$^2$) | 23.1±0.1 | 24.1±0.3 | 22.1±0.3 | 0.841 |
| WC (cm) | 78.4±0.1 | 82.2±0.8 | 72.9±0.6 | 0.533 |
| Sleep duration (hours) | 7.1±0.0 | 6.9±0.1 | 7.3±0.1 | 0.814 |
| Smoking status (ever, %) | 40.9 (0.6) | 67.2 (0.9) | 14 (0.6) | <0.001 |
| Alcohol use (heavy, %) | 11.2 (0.4) | 17.7 (0.7) | 4.2 (0.4) | <0.001 |
| Exercise (yes, %) | 22.3 (0.5) | 26.2 (0.8) | 18.1 (0.7) | <0.001 |
| Income (low Q1, %) | 8.5 (0.5) | 9.2 (0.7) | 7.9 (0.5) | 0.084 |
| Stress (%) | 33.5 (0.6) | 30.4 (0.8) | 36.6 (0.8) | <0.001 |
| Atopic dermatitis (%) | 5.2 (0.3) | 4.7 (0.4) | 5.7 (0.4) | 0.082 |
| Asthma (%) | 9.8 (0.4) | 11.2 (0.6) | 8.3 (0.4) | <0.001 |

Data are presented as the mean±SEM or percentage (SE)
Independent t-tests for continuous variables or chi-square tests for categorical variables were performed
KNHANES: Korean National Health and Nutrition Examination Survey, SEM: standard error of the mean, SE: standard error, BMI: body mass index, WC: waist circumference

**Table 2. Prevalence of atopic dermatitis and asthma according to sleep duration in a young adult population**

| | | ≤5 hours | 6 hours | 7 hours | 8 hours | ≥9 hours | *P*-value |
|---|---|---|---|---|---|---|---|
| Prevalence of atopic dermatitis | Male | 5.7 (1.5) | 4.8 (0.7) | 4.1 (0.6) | 4.6 (0.8) | 5.7 (1.8) | 0.777 |
| | Female | 8.3 (1.6) | 6.2 (1.0) | 4.4 (0.6) | 4.5 (0.7) | 8.7 (1.3) | 0.002 |
| Prevalence of asthma | Male | 13.3 (2.2) | 12.5 (1.0) | 9.6 (1.0) | 11.5 (1.3) | 8.9 (2.1) | 0.200 |
| | Female | 12.6 (1.9) | 7.7 (0.9) | 7.6 (0.7) | 7.1 (0.7) | 11.6 (1.5) | 0.001 |

Data are presented as percentages (SE)
Chi-square tests were performed
SE: standard error

**Table 3. Prevalence and adjusted odds ratio for atopic dermatitis and asthma according to sleep duration in a young adult population**

| | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
| Sleep duration | Atopic dermatitis | | | | | |
| ≤5 hours | 1.404 (0.754, 2.612) | 1.468 (0.764, 2.823) | 1.465 (0.755, 2.841) | 1.665 (1.004,2.762) | 1.598 (0.921, 2.771) | 1.548 (0.887, 2.701) |
| 6 hours | 1.171 (0.776, 1.766) | 1.105 (0.714, 1.71) | 1.104 (0.713, 1.71) | 1.31 (0.844, 2.033) | 1.402 (0.892, 2.204) | 1.38 (0.877, 2.17) |
| 7 hours | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 hours | 1.01 (0.62, 1.643) | 0.957 (0.575, 1.592) | 0.958 (0.576, 1.591) | 0.952 (0.64, 1.417) | 0.975 (0.652, 1.458) | 0.985 (0.658, 1.476) |
| ≥9 hours | 1.091 (0.534, 2.227) | 1.061 (0.49, 2.295) | 1.061 (0.49, 2.297) | 1.571 (1.054, 2.341) | 1.732 (1.138, 2.635) | 1.746 (1.145, 2.661) |
| *P*-value | 0.806 | 0.786 | 0.800 | 0.066 | 0.047 | 0.054 |
| Sleep duration | Asthma | | | | | |
| ≤5 hours | 1.447 (0.948, 2.21) | 1.376 (0.87, 2.175) | 1.265 (0.79, 2.026) | 1.711 (1.159, 2.525) | 1.648 (1.084, 2.504) | 1.553 (1.023, 2.359) |
| 6 hours | 1.343 (1.011, 1.783) | 1.345 (0.995, 1.819) | 1.299 (0.959, 1.759) | 1.005 (0.731, 1.382) | 1.096 (0.783, 1.533) | 1.06 (0.757, 1.484) |
| 7 hours | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 hours | 1.184 (0.844, 1.661) | 1.149 (0.809, 1.633) | 1.178 (0.827, 1.676) | 0.92 (0.691, 1.224) | 0.95 (0.693, 1.301) | 0.963 (0.701, 1.322) |
| ≥9 hours | 0.85 (0.482, 1.5) | 0.872 (0.489, 1.553) | 0.87 (0.492, 1.538) | 1.514 (1.053, 2.176) | 1.551 (1.039, 2.314) | 1.569 (1.048, 2.349) |
| *P*-value | 0.111 | 0.200 | 0.330 | 0.003 | 0.022 | 0.038 |

Data are presented as odds ratios (OR) and 95% confidence intervals (CI)
Model 1: adjusted for age. Model 2: adjusted for age, BMI, current smoking status, current alcohol use, regular physical activity, household income, and serum 25(OH)D level. Model 3: adjusted for age, BMI, current smoking, current alcohol use, regular physical activity, household income, serum 25(OH)D level, and stress level.

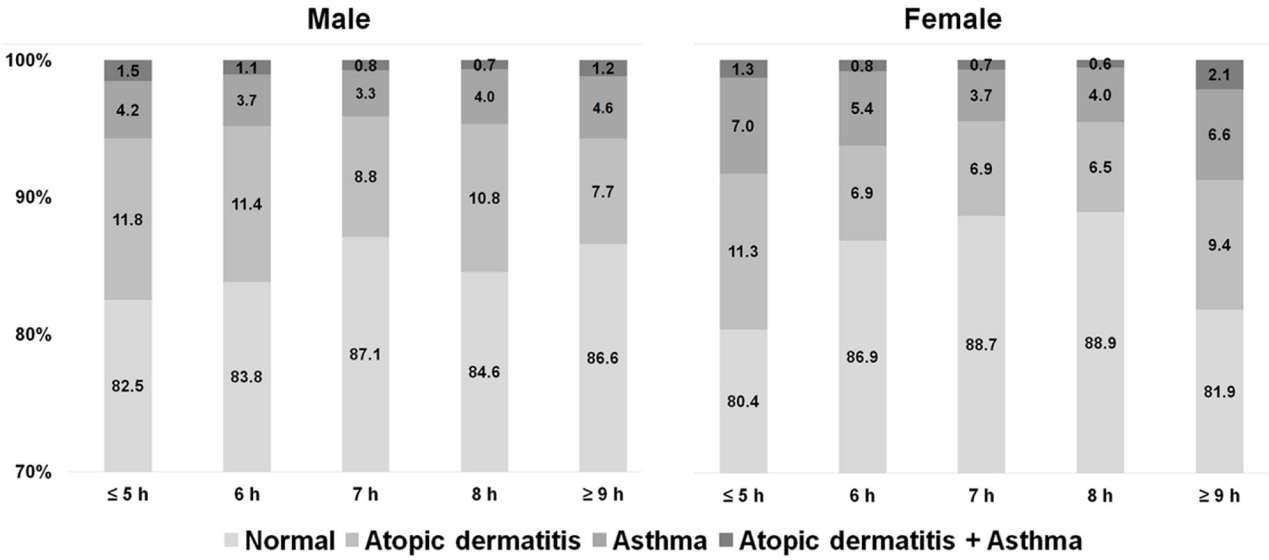


**Figure 1. Association between sleep duration and prevalence of atopic dermatitis and asthma in a young adult population.** In the male group, the prevalence of allergic diseases such as atopic dermatitis and asthma in adults who slept ≤5 hours and ≥9 hours was higher than those who slept 7 hours [17.5% (≤5 hours) and 13.4% (≥9 hours) vs. 12.9% (7 hours)]. Additionally, in the female group, the prevalence of allergic diseases in subjects with short (≤5 hours) and long (≥9 hours) sleep durations was higher than those with 7-hour sleep durations [19.6% (≤5 hours) and 18.1% (≥9 hours) vs. 11.3% (7 hours)].

## Discussion

To test the hypothesis that short or long sleep duration may be associated with allergic diseases in a large adult population, we examined the prevalence of atopic dermatitis and asthma, according to sleep duration, in a nationally representative sample of young adults identified through the KNHANES survey. To our knowledge, this is the first study evaluating the association between sleep duration and the prevalence of atopic dermatitis and asthma based in a young adult population. The results suggest that sleep duration may affect the prevalence of allergic diseases, such as atopic dermatitis or asthma, in young adult women. In this cohort, long (≥9 hours) and short (≤5 hours) may cause atopic dermatitis or asthma.

In adults, it is widely recognized that short sleep duration is associated with an increased risk of disease, low health-related quality of life scores, and high levels of suicidal ideation.[16,17] In this study, short sleep duration was significantly associated with an increased prevalence of atopic dermatitis, after adjusting for age, and with an increased prevalence of asthma, after adjusting for confounding factors, compared to a 7-hour sleep duration. Although the mechanisms underlying the association between short sleep duration and prevalence of atopic dermatitis and asthma are not clearly established, several explanations have been proposed. First, sleep loss or sleep deprivation is associated with a weakened immune response by means of detrimental immunologic, endocrine, and metabolic processes.[18-21] Second, sleep loss or poor sleep are also associated with low-grade systemic inflammation.[22-24] In particular, sleep loss leads to a functional change in monocyte proinflammatory cytokine responses and may result in severe inflammatory concequences.[23,24] It is widely accepted that allergic diseases, such as atopic dermatitis and asthma, can develop diverse responses via IgE-mediated allergic reactions or inflammation. Third, sleep deprivation is associated with an increased risk of overweight and obesity.[25,26] Reduced sleep duration may trigger weight gain by complex pathways, including dysregulation of appetite-regulating hormones (e.g., reduced leptin levels and elevated ghrelin levels) and obesogenic behaviors (e.g., decreased physical activity and increased food intake).[25-29] Research indicates that obesity may be associated with allergic diseases, such as atopic dermatitis and asthma.[30,31]

Conversely, allergic symptoms may reduce participants' sleep duration.[12,13] There is increasing evidence suggesting that allergic diseases may cause poor sleep quality or sleep disturbances.[12,13] Furthermore, immune modulators during allergic reactions may be linked with shorter duration of sleep.[32,33] For example, interleukin 4 and 13 may reduce non-rapid eye movement sleep.[32,33] In our study, longer sleep duration was significantly associated with atopic dermatitis and asthma, after adjusting for potential confounding factors. However, the precise mechanisms underlying the association between the longer sleep duration and the increased prevalence of atopic dermatitis and asthma are not fully understood. Furthermore, there is limited literature on comparisons between the effects of long sleep duration and short sleep duration. However, there are several potential explanations for this association. First, long sleep duration may be associated with a decreased immune function and an elevated inflammatory response.[34-36] Second, long sleep duration may simply reflect an extended time in bed due to compensation for poor sleep quality or sleep disturbance.[34,37] Third, immune modulators, such as interleukin 6 and tumor necrosis factor α, may enhance non-rapid eye movement sleep.[33] Thus, habitual short and long sleep duration can increase the risk of atopic dermatitis and asthma.

In the current study, we observed a U-shaped pattern in the prevalence of atopic dermatitis and asthma according to sleep duration in young female adults. Although there was a trend for increased allergic diseases with short sleep duration in male subjects, this effect was not statistically significant. One explanation for these findings is that there may be some sex-based differences in the prevalence of allergic diseases, allergic sensitization, and environmental and hormonal conditions related to allergies.[38] Clinical studies with large population sizes are needed to confirm the association between sex and the prevalence of allergic diseases, according to sleep duration.

One of the strengths of the current study is that subjects represent a national population-based sample of young Korean adults. However, this study also has several limitations. First, this is a cross-sectional study. The cause and effect relationship between sleep duration and the prevalence of allergic diseases cannot be elucidated. Second, sleep duration was not objectively measured, but examined on the basis of a single questionnaire, due to limited resources. Nevertheless, questionnaires are widely accepted for epidemiologic studies assessing sleep duration. Third, the prevalence of atopic dermatitis and asthma was also estimated based on a questionnaire and there is a possibility of bias associated with self-reported diagnosis of allergic diseases. However, questions also included the diagnosis of atopic dermatitis or asthma by physicians. To address these weaknesses, further longitudinal studies, based on objective sleep measures and diagnoses of atopic dermatitis and asthma, will be required. Finally, we did not discuss the association between sleep duration and allergic rhinitis, the most typical allergic disease. Of note, we examined this association however, no significant association was found. The present study focuses on the statistically significant association between sleep duration and asthma and atopic dermatitis, and negative data are not presented.

## Conclusions

Our results show a U-shaped association between sleep duration and the prevalence of atopic dermatitis and asthma in a nationally representative sample of young adult women from the KNHANES survey. The lowest prevalence of atopic dermatitis and asthma were associated with a sleep duration of 7 hours. When assessing the risk of allergic diseases, such as atopic dermatitis and asthma, short (≤5 hours) and long (≥9 hours) sleep duration may be a useful clinical indicator in the young female adult population.

## Acknowledgments

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2016R1C1B2015652). This study was supported by the Soonchunhyang University Research Fund.

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