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Association of asthma and sleep insufficiency among South Korean adolescents: analysis of web-based self-reported data from the Korean youth risk behavior web-based survey

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ABSTRACT

Objectives: Weekend oversleep or catch-up sleep is common among adolescents, but relatively few data are available with regard to its effects on asthma. Our aim was to investigate whether weekend oversleep is associated with ever having asthma among Korean adolescents. **Methods:** We analyzed web-based self-reported data from the Korean Youth Risk Behavior Web-based Survey in 25,927 physician-diagnosed adolescent asthma cases and 266,160 non-asthma cases. Self-report questionnaires were used to assess socioeconomic status, health behaviors, psychological factors and sleep patterns. Multiple logistic regression after adjusting for factors was used to determine the association between sleep and asthma. **Results:** The asthma group slept less (≤ 5 hours: 23.9% vs. 22.8%) had a later weekend bedtime ($\geq 1:00$ AM: 58.1% vs. 57.8%), and an earlier weekend wake time ($\leq 7:00$ AM: 18.1% vs. 17.0%) compared to the non-asthma group. After multiple logistic regression, a sleep duration ≤ 5 hours (odds ratio (OR), 1.09; 95% confidence interval (CI), 1.04–1.14) and weekend “early bird” (weekend wake time $\leq 7:00$ AM: OR, 1.03; 95% CI, 1.00–1.07) were significantly associated with an increased frequency of asthma. Long weekend catch-up sleep (weekend sleep duration minus weekday sleep duration ≥ 2 hours) was significantly associated with a decreased frequency of asthma (OR, 0.98; 95% CI, 0.94–0.99). **Conclusion:** Long weekend catch-up sleep, as an indicator of insufficient weekday sleep, is associated with a decreased frequency of asthma in Korean adolescents.

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Introduction

Asthma is associated with sleep problems including decreased sleep time, reduced stage 4 sleep, more frequent nighttime awakenings due to night asthma attacks and sleep-disordered breathing [1,2]. Asthma symptoms frequently worsen at night due to physiological changes (e.g. airway inflammation and resistance, episodic coughing, wheezing and shortness of breath). Although asthma can have a negative effect on sleep, few studies have explored whether sleep affects asthma. Both asthma symptoms and pulmonary function can be affected by inadequate sleep [3], and smoking status [4], but few studies have yielded any significant conclusions on the effects of sleep on asthma, in contrast to the effects of asthma on sleep. Adult patients with nocturnal asthma symptoms showed that bronchoconstriction developed in both nights spent asleep and those spent awake. However,

the peak expiratory flow rate (PEFR) fell to lower values on nights when patients were asleep, as compared to nights when they were awake [5]. The study by Meltzer et al. was a pilot study involving 10 patients and demonstrated the feasibility of a crossover sleep manipulation protocol in adolescents with asthma [6]. They showed that an overnight decrease in PEFR was associated with shortened sleep duration. Although sufficient sleep is important for the mental and physical health of adolescents, Korean adolescents face strong psychosocial pressure to attain sufficient grades for entrance to university and therefore spend considerable time studying at the cost of sufficient sleep [7].

Weekend catch-up sleep can be defined as sleep time on weekends that exceeds sleep time on weekdays. Adolescents tend to sleep less during school days and sleep more on weekends to compensate for sleep deprivation during school days [8]. Because

individual sleep needs vary, weekend catch-up sleep can reflect the degree of sleep insufficiency better than sleep duration. Weekend catch-up sleep has been associated with hypertension in adults [9] but not with adolescents [10], obesity [11] or suicidal attempts [12]. Although sleep is important for adolescent asthma, very few studies have explored the possible associations between asthma and sleep. Sleep disturbances in asthma are well known, but there have been few studies on whether sleep increases the incidence of asthma. In the case of adolescents, weekday sleeping is insufficient due to the pressure of school work, while sleeping on weekends is needed to compensate for insufficient weekday sleep over the entire week. So far, the research has mainly identified a relationship between asthma and sleep, and there has been no study of the relationship between weekend catch-up sleep and asthma in asthma adolescents. Therefore, this study was conducted to investigate the relationship between weekend catch-up sleep and asthma (including asthma adolescent who currently had no symptoms of asthma) in a school-based nationally representative Korean adolescent dataset.

Methods

Study participants

The nationwide survey data for this study, which was conducted jointly by the Korea Centers for Disease Control and Prevention and approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention, were obtained from the Korea Youth Risk Behavior Web-based Survey (KYRBWS) 2013–17 and included adolescents aged 12–18 years. The study population was stratified according to 43 regional and school-type variables, and samples were then selected using two sets of school and class variables. After the survey had been fully explained and all adolescent participants had provided written informed consent (both directly and from their parents or legal guardians), participants completed an online survey using a self-report questionnaire in a school computer room. Asthma was defined by answering “yes” to the following question: “Have you ever been diagnosed with asthma by a doctor?” Participants who did not have available sleep records, age, height or weight were excluded, leaving a total of 25,927 adolescent asthma and 266,160 non-asthma participants in the final analysis.

Socioeconomic and demographic factors

Weight and height data were used to calculate body mass index (BMI; weight in kilograms divided by the square of height in meters). Weight status was classified into overweight (BMI $\geq$ 85th percentile), normal ($5^{\text{th}} \leq$ BMI $<$ 85th percentile) and underweight (BMI $<$ 5th percentile) based on sex- and age-specific references according to the 2007 Korean National Growth Chart [13]. The self-administered questionnaires were used to provide information on socioeconomic factors [age, sex, school type (middle, high, or vocational school; southern, girls only, or coeducation school), family income, residence area, family structure and academic achievement], health behavior factors (smoking status, alcohol drinking, regular exercise, sexual experience and illicit drug use) and psychological factors (self-rated health status, self-rated stress status, depression, suicidal ideation, suicidal plan, suicidal attempt). Family income status was re-categorized into three categories: high, middle and low income. Residential area was divided into urban and rural. Smoking status was determined by the following question: “Have you ever smoked cigarettes, even once?” If the answer was “yes,” another question was asked: “On how many days did you smoke cigarettes during the last month?” Those who responded “more than 1 day” were defined as the smoking group [14]. Alcohol drinking was determined by the following question: “Have you ever consumed alcohol, even once?” If the answer was “yes,” the following question was asked: “On how many days did you drink alcohol during the last month?” Those who responded “more than 1 day” were defined as the alcohol group [14]. Academic performance was assessed by the following question: “During the last year, how would you rate your academic achievement?” Possible responses included “high,” “middle-high,” “middle,” “middle-low” and “low.” Family income was assessed by the following question: “How would you rate your family’s socioeconomic status?” Academic achievement and family income were categorized into three groups: high (middle-high), middle and low (middle-low and low).

Regular exercise was determined by the following question: “On how many days have you engaged in intense activity that caused an increase in breathing or heart rate for at least 60 min per day over the past 7 days?” Responses were categorized as <3 times/week or ≥ 3 times/week [15]. Sexual experience was defined by “yes” to the question “Have you ever had sexual intercourse with either the same or different sex partner(s)?”, or “no.” Illicit drug use was determined

by the following question: “Have you ever inhaled/taken substances such as glue, stimulants, hallucinogens, marijuana, butane gas, amphetamine, heroin, high-dose cold medicine or anxiolytics for mood elevation or excessive dieting?” Drug experience was categorized as “never experienced” or “ever experienced” [16].

The participants were asked the following question as an index of stress level: “Do you feel stress in your life?” Responses were classified into five categories: none, some stress, moderate, high stress and very high stress. The stress level was reclassified as low stress (none or mild stress) or high stress (moderate or severe stress). Self-rated health status was determined by the following question: “In general, how do you feel about your health?” Self-rated health status was classified into five categories: very good, good, fair, poor or very poor. Health status was recategorized as good (including very good), fair or poor (including very poor).

Depression was assessed using the Korean version of the World Health Organization Composite International Diagnostic Interview – Short Form, which has been validated as a cost-effective screening method for health surveys [17]. The following question was used to assess depression: “In the last year, did you have more than 2 weeks where you felt sad, blue, or depressed?” Responses were categorized as “yes” or “no.” Suicidal ideation was determined by the following question: “In the last year, did you think about committing suicide?” Responses were categorized as “yes” or “no.” This indicator is a well-validated predictor of suicide attempts that has been used in other surveys [18]. Suicidal plan was determined by the following question: “In the last year, did you ever plan to commit suicide?” Responses were categorized as “yes” or “no.” Suicide attempts were assessed by the following question: “In the last year, did you try to commit suicide?” Responses were categorized as “yes” or “no.”

Sleep

Self-reported waking time and bedtime were investigated for each participant and weekday and weekend sleep durations were calculated from responses to the following questions: “What time did you usually fall asleep during the week (on school days) over the last week?” “what time did you usually fall asleep on the weekend over the last weekend?” “what time did you usually wake on weekday mornings over the last week?” and “what time did you usually wake on

weekend mornings over the last weekend?” The responses for wake time were categorized as $\leq 5:00$, 6:00, 7:00, 8:00 and $\geq 9:00$ AM and bedtime responses were categorized as $\leq 9:00$, 10:00, 11:00 PM, 12:00, 1:00 and $\geq 2:00$ AM. Average sleep duration was calculated as $(5 \times \text{weekday sleep duration} + 2 \times \text{weekend sleep duration})/7$. Sleep time was divided into five subcategories: ≤ 5 , 6, 7, 8 and ≥ 9 h. The International Classification of Sleep Disorders 2nd edition definitions were used for a sleep duration of less than 5 h (“short sleep”) and sleep of more than 9 h (“long sleep”) [19]. Weekend catch-up sleep was calculated from the weekend sleep duration minus weekday sleep duration. Bedtime delay was calculated from weekday bedtimes minus weekend bedtimes. Wake-up delay was calculated using the same method. Long weekend catch-up sleep was defined as weekend sleep duration minus weekday sleep duration of more than 2 h [20,21].

Sleep satisfaction (quality of sleep) was assessed by the response to the following question: “In the last week, do you feel you have had enough sleep to recover from fatigue?” using a five-point Likert scale. The answer options were more than enough, enough, moderate, not enough and less than enough. We recategorized sleep quality into three groups: enough (more than enough and enough), moderate and not enough (less than enough and not enough).

Data analysis

Statistical analyses were performed for both asthma and non-asthma subjects. Descriptive statistical methods including the chi-square test were used to describe the basic characteristics of the study population, and numbers and percentages were reported for each variable. The associations between sleep and asthma were analyzed using the following methods: multiple logistic regression analysis with complex sampling adjusted for age and sex (model 1), and multiple logistic regression analysis with complex sampling adjusted for age, sex, BMI, current smoking status, current alcohol use, regular physical activity, household income, residence, school type, sexual experience, drug experience, academic achievement and family structure (model 2); and multiple logistic regression analysis with complex sampling adjusted for age, sex, BMI, current smoking status, current alcohol use, regular physical activity, household income, residence, school type, sexual experience, drug experience, academic achievement, family structure, stress, health status, happiness, depression, suicidal idea, suicidal plan and suicidal attempt (model

Table 1. General characteristic of participants according to history of asthma.

	Asthma (<i>n</i> = 25927)	No asthma (<i>n</i> = 266160)	<i>p</i> value
Sex			<0.001
Girl	11165 (43.1)	134255 (50.4)	
Boy	14762 (56.9)	131905 (49.6)	
Age	14.9 ± 1.7	15.0 ± 1.7	<0.001
BMI	20.9 ± 3.2	21.2 ± 3.3	<0.001
School			<0.001
Middle school	13227 (51.0)	129353 (48.6)	
Academic high school	10491 (40.6)	112589 (42.3)	
Vocational high school	2199 (8.5)	24488 (9.2)	<0.001
School type			<0.001
Southern school	5222 (20.1)	46662 (17.5)	
Girl school	3931 (15.2)	49329 (18.5)	
Coeducation	16774 (64.7)	170169 (63.9)	
Residence			<0.001
Rural	2031 (7.8)	23089 (8.7)	
Urban	23896 (92.2)	243071 (91.3)	0.035
Living			0.035
Living without parents	1267 (4.9)	12236 (4.6)	
Living with parents	24660 (95.1)	253924 (95.4)	<0.001
Family income			<0.001
Low	4718 (18.2)	44943 (16.9)	
Medium	11642 (44.9)	127586 (47.9)	
High	9567 (36.9)	93631 (35.2)	
Subjective academic achievement			<0.001
Low	8490 (32.7)	89590 (33.7)	
Middle	7067 (27.3)	75664 (28.4)	
High	10370 (40.0)	100906 (37.9)	
Smoking	2199 (8.5)	18848 (7.1)	<0.001
Alcohol	4345 (16.8)	40904 (15.4)	<0.001
Regular exercise	1582 (6.1)	14187 (5.3)	<0.001
Sexual Experience	1140 (4.4)	9314 (3.5)	<0.001
Substance use	311 (1.2)	1863 (0.7)	<0.001
Perceived Stress			<0.001
Severe	10703 (41.3)	99523 (37.4)	
Moderate	10733 (41.4)	114416 (43.0)	
None to mild	4491 (17.3)	52221 (19.6)	
Perceived health status			<0.001
Not bad	16541 (63.8)	1921117 (72.2)	
Moderate	6897 (26.6)	58543 (22.0)	
Bad	2489 (9.6)	15500 (5.8)	
Perceived happiness			<0.001
Happy	16153 (62.3)	172538 (64.8)	
Moderate	7027 (27.1)	71372 (26.8)	
Unhappy	2747 (10.6)	22250 (8.4)	
Experiences of depressive mood for 2 or more continuous weeks	7897 (30.5)	67639 (25.4)	<0.001
Suicidal idea	4123 (15.9)	33004 (12.4)	<0.001
Suicidal plan	1478 (5.7)	10380 (3.9)	<0.001
Suicidal attempt	1011 (3.9)	6654 (2.5)	<0.001

Data are presented as *n* (percent) or mean ± SD.

3). *p* values < 0.05 were considered statistically significant. All data were analyzed using SPSS for Windows (version 20.0; SPSS Inc., Chicago, IL, USA).

Results

Table 1 summarizes the demographic characteristics and questionnaire data of Korean adolescents aged 12–18 years enrolled in the KYRBWS. Female gender, co-education school type, urban living, living without parents, high family income and high subjective academic achievements were associated with higher rates of asthma. Smoking, alcohol intake, substance use and sexual experience statuses were significantly higher among those with asthma. Psychosomatic differences

were also explored between those with and without asthma: Rates of poor self-rated health, perceived stress, perceived unhappiness, depressive mood, suicidal ideation and suicide attempts were higher in the asthma group.

Table 2 shows the sleep parameters between the asthma and non-asthma groups. The non-asthma group was significantly different from the asthma group in terms of every variable except bedtime delay. The asthma group slept less (≤5 h: 23.9% vs. 22.8%) had a later weekend bedtime (≥1:00 AM: 58.1% vs. 57.8%), and earlier weekend wake time (≤7:00 AM: 18.1% vs. 17.0%) compared to the non-asthma group. Mean weekday sleep duration (394 ± 97 vs. 396 ± 95 min; *p* = 0.001), weekend sleep duration

Table 2. Descriptive statistics of sleep variables.

	Asthma (n = 25927)	No asthma (n = 266160)	p value
Sleep time			<0.001
≤5hr	6198 (23.9)	60759 (22.8)	
6hr	5915 (22.8)	60180 (22.6)	
7hr	5635 (21.7)	58839 (22.1)	
8hr	4562 (17.6)	49055 (18.4)	
≥9hr	3617 (14.0)	27327 (14.0)	
Week day			
Sleep duration, min	394 ±97	396 ±95	0.001
Bed time			0.001
≤21:00	353 (1.4)	3692 (1.4)	
22:00	1964 (7.6)	20073 (7.5)	
23:00	5687 (25.3)	59738 (22.4)	
24:00	6567 (25.3)	68601 (25.8)	
1:00	6485 (25.0)	66970 (25.2)	
≥2:00	4871 (18.8)	47086 (17.7)	
Wake time			<0.001
≤5:00	1321 (5.1)	12160 (4.6)	
6:00	10397 (40.1)	109410 (41.1)	
7:00	13085 (50.5)	134511 (50.5)	
8:00	1124 (4.3)	10079 (3.8)	
≥9:00	0 (0)	0 (0)	
Weekend day			
Sleep duration, min	527 ±184	533 ±181	<0.001
Bed time			0.004
≤21:00	435 (1.7)	4438 (1.7)	
22:00	1247 (4.8)	12047 (4.5)	
23:00	3539 (13.6)	37181 (14.0)	
24:00	5622 (21.7)	58663 (22.0)	
1:00	5325 (20.5)	56244 (21.1)	
≥2:00	9759 (37.6)	97587 (36.7)	
Wake time			<0.001
≤5:00	357 (1.4)	2922 (1.1)	
6:00	1171 (4.5)	11200 (4.2)	
7:00	3160 (12.2)	31135 (11.7)	
8:00	5704 (22.0)	57954 (21.8)	
≥9:00	15535 (59.9)	162949 (71.2)	
Weekend-weekday difference			
Sleep time difference	133 ± 176	137 ± 174	0.003
Weekend catchup sleep, ≥2hr	13701 (52.8)	144300 (54.2)	<0.001
Bedtime delay	44.4 ± 129.1	43.7 ± 128.8	0.444
Wake time delay	156.7 ± 137.4	158.6 ± 134.6	0.030
Sleep satisfaction			<0.001
Enough	6552 (25.3)	69523 (26.1)	
Moderate	8196 (31.6)	86472 (32.5)	
Unenough	11179 (43.1)	110165 (41.4)	

Data are presented as n (percent) or mean ± SD.

(527 ± 184 vs. 533 ± 181 min; $p < 0.001$) and weekend catch-up sleep duration (133 ± 176 vs. 137 ± 174 min; $p < 0.001$) were significantly lower in the asthma group compared to the non-asthma group. Even weekday sleep was lower, and weekend catch-up sleep significantly lower (52.8% vs. 54.2%; $p < 0.001$) in the asthma group. Consequently, sleep satisfaction was significantly poorer (sleep satisfaction not enough: 43.1% vs. 41.4%) in the asthma group compared to the non-asthma group. Table 3 lists the adjusted OR for asthma according to sleep duration in the adolescent population. After adjusting for age and sex (model 1), the OR of asthma frequency with a short (≤5 h) sleep duration was 1.17 (95% CI, 1.13–1.22) times higher than those with a sleep duration of 7 h. After adjusting for model 1 plus sociodemographic

factors (BMI, current smoking status, current alcohol use, regular physical activity, household income, residence, school type, sexual experience, drug experience, academic achievement, and family structure; model 2), a sleep duration ≤5 h was significantly associated with an increased frequency of asthma (OR, 1.15; 95% CI, 1.10–1.20) compared to a sleep duration of 7 h. After adjusting for model 2 plus psychosomatic factors (stress, health status, happiness, depression, suicidal ideation, suicidal plan and suicidal attempt; model 3), a sleep duration ≤5 h was significantly associated with an increased frequency of asthma (OR, 1.09; 95% CI, 1.04–1.14) compared to a sleep duration of 7 h. After adjusting for model 3, long weekend catch-up sleep was significantly associated with a decreased frequency of asthma (OR, 0.98; 95% CI, 0.94–0.99), and weekend

Table 3. Adjusted odds ratio for asthma according to sleep duration in a young adult population.

Sleep duration	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
≤5hr	1.17 (1.13–1.22)	1.15 (1.10–1.20)	1.09 (1.04–1.14)
6hr	1.08 (1.04–1.12)	1.07 (1.03–1.12)	1.05 (1.00–1.10)
7hr	1	1	1
8hr	0.93 (0.89–0.97)	0.95 (0.91–0.99)	0.97 (0.92–1.02)
≥9hr	0.94 (0.90–0.98)	0.98 (0.93–1.03)	0.99 (0.95–1.05)
Long weekend catch-up sleep	0.95 (0.90–0.99)	0.97 (0.93–0.98)	0.98 (0.94–0.99)
Weekend sleep time, ≥1:00	1.08 (1.06–1.11)	1.05 (1.02–1.09)	1.01 (0.98–1.04)
Weekend wake time, ≤7:00	1.05 (1.02–1.09)	1.04 (1.00–1.08)	1.03 (1.00–1.07)

Data are presented as odds ratios (OR) and 95% confidence intervals (CI).

Model 1: adjusted for age, sex. Model 2: adjusted for age, sex, BMI, current smoking status, current alcohol use, regular physical activity, household income, residence, school type, sexual experience, drug experience, academic achievement and family structure. Model 3: adjusted for age, sex, BMI, current smoking status, current alcohol use, regular physical activity, household income, residence, school type, sexual experience, drug experience, academic achievement, family structure, stress, health status, happiness, depression, suicidal idea, suicidal plan and suicidal attempt.

“early bird” (weekend wake time ≤7:00 AM) was significantly associated with an increased frequency of asthma (OR, 1.03; 95% CI, 1.00–1.07).

Discussion

We found that long weekend catch-up sleep, as an indicator of insufficient weekday sleep, is associated with a decreased frequency of asthma in Korean adolescents. To the best of our knowledge, this is the first study to investigate the relationship between weekend catch-up sleep and asthma in the adolescent population after adjusting for multiple potential confounding factors.

Our results indicate that short sleep duration is significantly associated with asthma, which is consistent with the results of other studies [1,2]. Bakour et al. [2], using data from the Florida Youth Risk Behavior Survey (2009–13) in the United States, found that overweight adolescents who slept for less than 7 h were more at risk of currently having asthma (OR, 1.75; 95% CI, 1.45–2.11) than normal weight adolescents who slept for 7–8 h. Although the link between a short sleep duration and asthma has not yet been clearly established, there are several possible explanations for this association. First, a habitually short sleep duration may be associated with decreased immune function and an elevated inflammatory response by means of detrimental immunologic [22], endocrine [23] and metabolic processes [24]. Sleep deprivation is considered to be a stress-causing factor and is associated with impaired immune activity [22], while sleep duration is associated with obesity and diabetes [23]. This decreased immune function and elevated inflammatory response due to sleep disturbance might eventually lead to asthma exacerbation. Second, sleep insufficiency is also associated with low-grade systemic inflammation [25]. In particular, sleep insufficiency

leads to a functional change in monocyte proinflammatory cytokine responses and may result in severe inflammatory consequences [26]. It is widely accepted that allergic diseases such as asthma can develop due to diverse responses via IgE-mediated allergic reactions or inflammation. Third, immune modulators such as interleukin 6 and tumor necrosis factor α may enhance non-rapid eye movement sleep [27]. Furthermore, immune modulators during allergic reactions may be linked to shorter sleep duration [27]. Corticosteroids, which are commonly used to control asthma, are another explanation for short sleep duration in patients with asthma. Although inhaled corticosteroids are the first line of therapy for patients with asthma who require daily treatment, and systemic corticosteroids are recommended only for the treatment of acute exacerbations and not for long-term treatment, children and adolescents receiving oral glucocorticoid therapy can experience serious and persistent sleep disturbances [28,29].

Our results revealed a significant difference between weekday sleep duration and weekend sleep duration among Korean adolescents. We hypothesized that weekend catch-up sleep might be a factor when assessing the association between a short sleep duration and asthma. As a result, we found that long weekend catch-up sleep was significantly associated with adolescent asthma. Thus, our results suggest that sufficient weekend sleep times to compensate for insufficient weekday sleep times are associated with adolescent asthma. Korean adolescents have been shown to have shorter sleep durations and longer weekend catch-up sleeps, compared to other countries [7]. In Korea, middle- and high-school students usually go to school at 7:00 to 8:30 AM. Additionally, most Korean adolescents attend private academic institutions or go to night school for after-school extra tuition, usually late at night. Furthermore, because

Korean adolescents are under strong psychosocial pressure to obtain good grades for university entrance, they spend a lot of time studying at the cost of sufficient sleep [7].

Our results also revealed that being a weekend “night owl” (a weekend bedtime of 1:00 AM or later), a weekend “early bird” (weekend wake time of 7:00 AM or earlier) and having a short sleep time (≤ 5 h) were associated with Korean adolescent asthma. Few studies have investigated sleep patterns in terms of bedtime and wake-up time with asthma. Spilsbury et al. [30] found that adolescent asthma patients were more likely to have a bedtime of 11:00 PM or later.

By sleeping late on weekends, adolescent students may suffer from a five-hour “jet lag” when it is time to get up on Monday morning [31]. The alarm clock may indicate 6:00 a.m., but the student’s inner clock reads 1:00 a.m. This will make it much harder for them to concentrate at school. When this becomes a regular pattern, it can also have a significant effect on mood. Although our study did not investigate students’ concentration in class, the above sleep pattern interferes with students’ concentration and can eventually have a significant effect on psychosocial and physical health such as asthma.

Our study had several limitations. First, it used web-based self-reported data only, so the reliability of the exact sleep time may be questionable, despite adolescents having been shown to correctly report their sleep [32]. Studies using an objective measure of sleep such as actigraphy are needed to resolve this limitation. Second, the cross-sectional study design did not allow determination of an accurate cause-and-effect relationship between sleep and asthma. Future research is needed to determine the relationship between sleep and asthma prevalence or sleep and current asthma symptoms. Third, not enough asthma-related information such as the use of asthma medication, spirometry data or asthma control scores was collected from the participants; for example, there were no data on the amount of steroids used or asthma severity, both of which might affect sleep disturbance. Fourth, our study had a large sample size that resulted in statistical significance, but clinical significance of this study is unknown. Fifth, this study was based on self-report of ever having a diagnosis of asthma and not related to current asthma symptoms. Therefore, any association between having asthma and current sleep disturbances must be evaluated with caution. Finally, in spite of multiple other confounding variables adjusted for in this study, nocturnal gastroesophageal reflux [33], snoring [34] and oral

glucocorticoid use have been associated with poor sleep quality, but our study did not adjust for these variables.

Despite these limitations, our study had many strengths. The KYRBWS data were obtained from a nationwide population-based sample featuring weighted sampling, and the analysis can therefore represent the entire Korean adolescent population. Almost all participants had the same ethnic background, which minimizes other possible confounding factors. Sleep has received little attention in the treatment of asthma. Our results revealed that a significant number of adolescents with asthma suffer from insufficient sleep, so more attention to this problem is needed. Further prospective studies are needed to help identify the relationship between sleep and adolescent asthma.

In conclusion, long weekend catch-up sleep, as an indicator of insufficient weekday sleep, is associated with a decreased frequency of asthma in Korean adolescents. Additional large prospective studies are required to elucidate sleep issues in adolescents with asthma.

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Author contributions

All authors contributed conception, analysis, interpretation, revising and final approval of the manuscript. JH Chung served as a principal investigator and had full access to all of the data in the study. CH Han take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosure statement

The authors declare no conflict of interest.

References

- Dean BB, Calimlim BC, Sacco P, Aguilar D, Maykut R, Tinkelman D. Uncontrolled asthma among children: impairment in social functioning and sleep. *J Asthma* 2010;47:539–544. doi:10.3109/02770900903580868.
- Bakour C, O'Rourke K, Schwartz S, Wang W, Sappenfield W, Couluris M. Sleep duration, obesity, and asthma, in Florida adolescents: analysis of data from the Florida Youth Risk Behavior Survey (2009–2013). *Sleep Breathing* 2017;21:1039–1045. doi:10.1007/s11325-017-1460-2.
- Shin YS, Liu JN, Kim JH, Nam YH, Choi GS, Park HS. The impact of asthma control on salivary cortisol level in adult asthmatics. *Allergy Asthma Immunol Res* 2014;6:463–466. doi:10.4168/aa.2014.6.5.463.
- Miadich SA, Everhart RS, Heron KE, Cobb CO. Medication use, sleep, and caregiver smoking status among urban children with asthma. *J Asthma* 2018; 55:588–595. doi:10.1080/02770903.2017.1350969.
- Catterall JR, Rhind GB, Stewart IC, Whyte KF, Shapiro CM, Douglas NJ. Effect of sleep deprivation on overnight bronchoconstriction in nocturnal asthma. *Thorax* 1986;41:676–680.
- Meltzer LJ, Faino A, Szeffler SJ, Strand M, Gelfand EW, Beebe DW. Experimentally manipulated sleep duration in adolescents with asthma: Feasibility and preliminary findings. *Pediatr Pulmonology* 2015;50: 1360–1367. doi:10.1002/ppul.23179.
- Yang CK, Kim JK, Patel SR, Lee JH. Age-related changes in sleep/wake patterns among Korean teenagers. *Pediatrics* 2005;115:250–256.
- Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Med* 2007;8:602–612.
- Hwangbo Y, Kim WJ, Chu MK, Yun CH, Yang KI. Association between weekend catch-up sleep duration and hypertension in Korean adults. *Sleep Med* 2013; 14:549–554. doi:10.1016/j.sleep.2013.02.009.
- Quan SF, Combs D, Parthasarathy S. Impact of Sleep Duration and Weekend Oversleep on Body Weight and Blood Pressure in Adolescents. *Southwest J Pulm Crit Care* 2018;16:31–41. doi:10.13175/swjpc.150-17.
- Im HJ, Baek SH, Chu MK, Yang KI, Kim WJ, Park SH, et al. Association Between Weekend Catch-up Sleep and Lower Body Mass: Population-Based Study. *Sleep* 2017;40:
- Kang S-G, Lee YJ, Kim SJ, Lim W, Lee H-J, Park Y-M, Cho IH, et al. Weekend catch-up sleep is independently associated with suicide attempts and self-injury in Korean adolescents. *Compr Psychiatry* 2014; 55:319–325.
- The Korean Pediatric Society. Korean children and adolescents growth standard. Seoul SK, Prevention; KCfDCaPKCfDCa, 2007.
- Lim MK, Kim HJ, Yun EH, Oh J-K, Park EY, Shin SH, Jung BY, et al. Role of quit supporters and other factors associated with smoking abstinence in adolescent smokers: a prospective study on Quitline users in the Republic of Korea. *Addict Behav* 2012;37:342–345. doi:10.1016/j.addbeh.2011.11.007.
- US Department of Health and Human Services. 2008 Physical activity guidelines for Americans: be active h, and happy!. Available from: http://fitprogram.ucla.edu/workfiles/Documents/Fit%20for%20residents%20curriculum/Step_5/2008_Physical_Activity_Guidelines_for_Americans.pdf [cited 20 Jul 2016].
- Park S, Kim Y. Prevalence, correlates, and associated psychological problems of substance use in Korean adolescents. *BMC Public Health* 2016;16:79.
- Gigantesco A, Morosini P. Development, reliability and factor analysis of a self-administered questionnaire which originates from the World Health Organization's Composite International Diagnostic Interview - Short Form (CIDI-SF) for assessing mental disorders. *Clin Pract Epidemiol Mental Health: CP & EMH* 2008;4:8. doi:10.1186/1745-0179-4-8.
- Gaynes BN, West SL, Ford CA, Frame P, Klein J, Lohr KN. Screening for suicide risk in adults: a summary of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med* 2004;140:822–835.
- International classification of sleep disorders: Diagnostic and coding manual, American Academy of Sleep Medicine, Westchester, IL 2005.
- Pallesen S, Saxvig IW, Molde H, Sorensen E, Wilhelmsen-Langeland A, Bjorvatn B. Brief report: behaviorally induced insufficient sleep syndrome in older adolescents: prevalence and correlates. *J Adolescence* 2011;34:391–395. doi:10.1016/j.adolescence.2010.02.005.
- Komada Y, Inoue Y, Hayashida K, Nakajima T, Honda M, Takahashi K. Clinical significance and correlates of behaviorally induced insufficient sleep

- syndrome. *Sleep Med* 2008;9:851–856. doi:[10.1016/j.sleep.2007.08.018](https://doi.org/10.1016/j.sleep.2007.08.018).
22. De Lorenzo BHP, Novaes EBRR, Paslar Leal T, Piqueira Garcia N, Martins Dos Santos RM, Alvares-Saraiva AM, et al. Chronic sleep restriction impairs the antitumor immune response in mice. *Neuroimmunomodulation* 2018;25:59–67. doi:[10.1159/000490352](https://doi.org/10.1159/000490352).
23. Charlier CM, Barr ML. Correlations of self-reported androgen deficiency in ageing males (adam) with stress and sleep among young adult males. *Healthcare* 2018;6:121.
24. Rosique-Esteban N, Papandreou C, Romaguera D, Warnberg J, Corella D, Martinez-Gonzalez MA, et al. Cross-sectional associations of objectively-measured sleep characteristics with obesity and type 2 diabetes in the PREDIMED-Plus trial. *Sleep*. 2018;41. doi:[10.1093/sleep/zsy190](https://doi.org/10.1093/sleep/zsy190)
25. Atienza M, Zientz J, Cantero JL. Low-grade inflammation in the relationship between sleep disruption, dysfunctional adiposity, and cognitive decline in aging. *Sleep Med Rev* 2018;42:171–183.
26. Irwin MR, Carrillo C, Olmstead R. Sleep loss activates cellular markers of inflammation: sex differences. *Brain Behav Immun* 2010;24:54–57. doi:[10.1016/j.bbi.2009.06.001](https://doi.org/10.1016/j.bbi.2009.06.001).
27. Kapsimalis F, Richardson G, Opp MR, Kryger M. Cytokines and normal sleep. *Curr Opin Pulmon Med* 2005;11:481–484.
28. Drigan R, Spirito A, Gelber RD. Behavioral effects of corticosteroids in children with acute lymphoblastic leukemia. *Med Pediatr Oncol* 1992;20:13–21.
29. Hinds PS, Hockenberry MJ, Gattuso JS, Srivastava DK, Tong X, Jones H, West N, et al. Dexamethasone alters sleep and fatigue in pediatric patients with acute lymphoblastic leukemia. *Cancer* 2007;110:2321–2330.
30. Spilsbury JC, Storfer-Isser A, Drotar D, Rosen CL, Kirchner LH, Benham H, et al. Sleep behavior in an urban US sample of school-aged children. *Arch Pediatr Adolesc Med* 2004;158:988–994. doi:[10.1001/archpedi.158.10.988](https://doi.org/10.1001/archpedi.158.10.988).
31. Boivin DB, James FO. Phase-dependent effect of room light exposure in a 5-h advance of the sleep-wake cycle: implications for jet lag. *J Biol Rhythms* 2002;17:266–276. doi:[10.1177/074873040201700310](https://doi.org/10.1177/074873040201700310).
32. Wolfson AR, Carskadon MA, Acebo C, Seifer R, Fallone G, Lubyak SE, Martin JL, et al. Evidence for the validity of a sleep habits survey for adolescents. *Sleep* 2003;26:213–216.
33. Lim KG, Morgenthaler TI, Katzka DA. Sleep and nocturnal gastroesophageal reflux: an update. *Chest* 2018; 154:963–971.
34. Sakamoto N, Gozal D, Smith DL, Yang L, Morimoto N, Wada H, et al. Sleep duration, snoring prevalence, obesity, and behavioral problems in a large cohort of primary school students in Japan. *Sleep* 2017;40. doi:[10.1093/sleep/zsy190](https://doi.org/10.1093/sleep/zsy190)