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Sleep Duration, Sleep Hygiene, and Insomnia in Adolescents with Asthma

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Abstract

Background—There is a need to understand more about modifiable health behaviors that may be related to asthma control. Sleep is one such health behavior that has received little attention in pediatric asthma research.

Objective—To examine sleep duration, sleep hygiene, and insomnia in adolescents with and without asthma.

Methods—Adolescents (n=298, 51% male, 12–17 years, 48% with asthma) from the general community completed an on-line survey that included the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire, the Children's Report of Sleep Patterns, and the Insomnia Severity Index.

Results—Sleep duration did not differ between asthma groups, yet more adolescents with severe asthma reported insufficient weekday sleep (44%) versus adolescents without asthma (31%). Significant asthma group differences were found for sleep hygiene, with adolescents with severe asthma reporting poorer sleep hygiene. Almost twice as many adolescents with severe asthma reported clinically significant insomnia than adolescents with mild or no asthma. Sleep hygiene variables were correlated with insomnia, although these associations did not differ between adolescents with and without severe asthma. Finally, both insomnia severity and asthma severity were significant predictors of daytime sleepiness, however asthma severity accounted for only 2% of the variance, compared to 28% of the variance accounted for by insomnia severity.

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Conclusions—Many adolescents with severe asthma regularly obtain insufficient sleep, have poor sleep hygiene, and experience clinically significant insomnia. It is important to ask adolescents with asthma about sleep duration, sleep hygiene, and insomnia as there are effective interventions that can improve sleep for these youth.

Keywords

Sleep; sleep disorders; sleep deprivation; adolescents; asthma

Introduction

Asthma is the most common chronic disease among youth.(1) In spite of medical advances in the diagnosis and treatment of asthma, asthma prevalence has increased from 8.7% to 9.6% over the past decade.(2) The economic burden of asthma in the United States is approximately \$56 billion, with 33% of children and adolescents with asthma reporting an emergency department or urgent care visit in 2008 and 8% of youth hospitalized for asthma.(2;3) Beyond required medical care, youth with asthma miss an estimated 14.4 million school days annually because of asthma related illness or exacerbation,(2;4;5) highlighting a major functional consequence of this disease.

Nocturnal asthma symptoms are a marker of asthma severity.(6;7) Mechanisms of inflammation and cytokine production have been shown to be under circadian control and involved in nocturnal asthma.(8–10) Further, sleep may play a direct role in the worsening of asthma via a variety of factors, including the supine posture, nocturnal increase in airway inflammation and bronchial responsiveness, and greater airway resistance.(9;10) For youth with asthma, sleep problems are common,(11) including prolonged sleep onset latency, frequent night wakings, and daytime sleepiness, even when asthma symptoms are well controlled.(12–16) Further, when nocturnal asthma symptoms improve, an improvement in sleep and daytime functioning has also been found.(11)

While it is well known that asthma affects sleep there is also evidence that sleep affects asthma expression. One study found that youth who reported lower sleep quality had more severe asthma symptoms the following day; yet asthma symptoms did not significantly predict sleep the following night.(17) Given that sleep may affect asthma symptoms, sleep habits are a possible target for intervention for youth with asthma.

In general, adolescents are known to be chronically sleep deprived, with decreased total sleep time, delayed sleep onset, and increased daytime sleepiness.(18) This is due to a variety of factors including decreased parental involvement, increased school and work obligations, and the misalignment of biological circadian rhythms and early school start times.(19) However, there are a number of other factors under the control of adolescents that also may contribute to insufficient sleep, including inconsistent bedtimes and poor sleep hygiene (e.g., caffeine use late in the day, technology in the bedroom). Recent studies have demonstrated that brief interventions are effective in improving sleep patterns and sleep hygiene in adolescents.(20;21)

Insomnia also impacts a significant number of adolescents, with rates ranging from 7 to 36% depending on definition used and data collection methods.(22;23). Recently, cognitive-behavioral therapy for insomnia (CBT-I), an empirically validated treatment for insomnia, and the frontline treatment for insomnia in adults (24), has also been shown to be effective for adolescents.(25;26)

Based on the current literature, the purpose of this exploratory study was to examine sleep duration, sleep hygiene, and insomnia in adolescents with and without asthma with the following three questions: (1) Do sleep duration, sleep hygiene, and insomnia differ between adolescents with and without asthma? (2) Is sleep hygiene related to sleep duration and insomnia, and does this differ between adolescents with and without severe asthma? (3) Does daytime sleepiness differ in adolescents with and without severe asthma, and if so, is this a result of asthma or insomnia?

Methods

Participants were 298 adolescents aged 12–17 years, (51% male, 48% with asthma). Adolescents with and without asthma were recruited using a national online research panel with approximately 3 million members (Zoompanel) who have opted-in to participate in surveys. The demographics of panel members is similar to US Census data, including race, household income, and region. Members receive points for completing each survey (worth approximately \$1–3 per survey), which can later be exchanged for prizes (e.g., movies, music, gift cards). In September 2012, approximately 2600 members received an email invitation to participate in the study, with 1532 (~59%) responding to and viewing the survey (see Figure 1 for flow diagram). Quotas were established to prevent an oversampling of any age, sex, or asthma status (“Do you have asthma?”). The use of online survey panels has been shown to be reliable and valid compared to telephone and household surveys (27;28), and has been used in multiple studies.(29–32) This study was approved by the Institutional Review Board at National Jewish Health.

Measures

The International Study of Asthma and Allergies in Childhood (ISAAC)

Questionnaire—This 8-item measure was developed as a core questionnaire to assess the prevalence and severity of asthma in a large international epidemiological study.(33) Following the guidelines of the ISAAC Phase 3 Study Group (34) the ISAAC questionnaire was used to create our groups of adolescents with and without asthma using the question “Have you ever had asthma?” (Asthma Ever). For those with asthma, we further distinguished those with Current Wheeze (“Have you ever had wheezing or whistling in the chest at any time in the past?”) and “Have you had wheezing or whistling in the chest in the past 12 months?”) and those with Severe Asthma (positive response to Current Wheeze and whether the adolescent in the past 12 months had (1) >4 attacks of wheeze or (2) >1 night per week sleep disturbance from wheeze or (3) wheeze affecting speech).

Children’s Report of Sleep Patterns (CRSP)—The CRSP is a 52-item self-report measure of sleep that includes modules for sleep patterns, sleep hygiene, sleep disturbances, and daytime sleepiness, and has been validated in children and adolescents with and without

chronic illnesses (35–38). From this measure we obtained sleep duration (calculated as hours from bedtime to wake time, less sleep onset latency and wake after sleep onset), as well as sleep hygiene and daytime sleepiness modules. The sleep hygiene indices included Caffeine Use, Stimulating Activities in the hour Before Bed (e.g., video games), Electronics Use at Sleep Onset (e.g., television), Sleep Location (i.e., falling asleep or waking up somewhere other than the child's bed), and Negative Bedtime Cognitions (e.g., worries about the next day that prevent sleep onset). Higher scores indicate poorer sleep hygiene and more daytime sleepiness. Categories of insufficient sleep duration (<7 hours), borderline sleep duration (7–9 hours), and optimal sleep duration (≥9 hours) were created based on CDC criteria.(39)

Insomnia Severity Index (ISI)—The ISI has 7 items that evaluate the severity of insomnia symptoms (e.g., difficulties initiating and maintaining sleep) and the consequences of sleep problems/disruptions.(40) Cutoff scores have been established to identify insomnia severity (no clinically significant insomnia [ISI score of 0–7], subthreshold clinically significant insomnia [ISI score of 8–14], clinically significant insomnia – moderate/severe [ISI score greater than or equal to 15]). Minimally important differences (MID) for the ISI have recently been identified in adult populations, with a reduction in ISI score by 6 points associated with improved health related quality of life in one study (41) and a reduction in ISI score by 7 points associated with moderately improved insomnia in another trial (42).

Data Analysis

Outcome variables (sleep duration, sleep hygiene, insomnia severity, and daytime sleepiness) were examined for normality, and square root and logarithm transformations were conducted for non-normal variables. Preliminary analyses were conducted to examine demographic differences between groups, using one-way ANOVA for continuous variables and chi-square for categorical variables.

Question 1: Do sleep duration, sleep hygiene, and insomnia differ between adolescents with and without asthma?—One-way ANOVA was used to compare group differences for continuous data, with Tukey's Honestly Significant Difference used for post-hoc analyses. Chi-square analysis was used to compare frequency differences for categorical variables.

Question 2: Is sleep hygiene related to sleep duration and insomnia, and does this differ between adolescents with and without severe asthma?—Pearson bivariate correlation was used to examine the relationship between sleep hygiene, sleep duration, and insomnia, with correlations run separately for those with and without severe asthma (severe vs. no asthma/ever asthma/current wheeze). Fisher's *r*-to-*z* transformation (transforming the correlation coefficient to a *z*-score, then comparing the *z*-scores making use of the sample size using formula 2.8.5 from Cohen and Cohen (43)) was used to determine whether the correlations significantly differed between the two groups (with and without severe asthma)(44). A *z*-score ≥2.58 is considered significant at a *p*-value of 0.01.

Question 3: Does daytime sleepiness differ in adolescents with and without severe asthma, and if so, is this a result of asthma or insomnia?—One-way

ANOVA was used to examine differences in daytime sleepiness for those with and without asthma, with Tukey's Honestly Significant Difference used for post-hoc analyses. Hierarchical multiple regression was used to examine whether asthma (severe vs. no asthma/ever asthma/current wheeze) or insomnia severity was more predictive of daytime sleepiness.

Results

Demographic data for the four asthma groups are presented in Table 1. No significant differences were found between the four ISAAC asthma categories for any demographic variables (see Table 1 for complete demographic data).

Question 1: Do sleep duration, sleep hygiene, and insomnia differ between adolescents with and without asthma?

Sleep duration—Age was found to be significantly correlated with weekday sleep duration, thus age was controlled for in the weekday total sleep time ANCOVA. No significant difference between asthma severity groups was found for weekday total sleep time, $F(3,293)=.14$, $p=.93$. No significant difference was found between asthma severity groups for weekend total sleep time, $F(3,294)=.31$, $p=.82$ (see Table 1 for means and SE).

Although not significantly different, 44% of adolescents with Severe Asthma reported regularly obtaining insufficient sleep (<7 hours)(39) on weekdays compared to only 31% of adolescents with No Asthma, $\chi^2(6)=4.48$, $p=.61$ (Figure 2).

Sleep hygiene—Significant racial differences were found for Electronics Use at Sleep Onset and Negative Bedtime Cognitions, thus race was controlled for in analyses that included these variables. Significant asthma severity group differences were found for Stimulating Activities in the Hour Before Bed, $F(3,294)=2.78$, $p=.04$, Sleep Location, $F(3,294)=3.69$, $p=.01$, and Negative Bedtime Cognitions, $F(3,293)=2.81$, $p=.04$ (see Table 1 for means and SE). Significant post-hoc analyses suggest that adolescents with Severe Asthma more frequently slept somewhere other than their own bed (parent bed, sibling bed, couch) compared to both adolescents with No Asthma or Ever Asthma, and adolescents with Severe Asthma had more negative bedtime cognitions that interfere with sleep onset compared to adolescents with No Asthma.

Insomnia—Because girls reported more insomnia symptoms than boys, insomnia analyses controlled for gender. Adolescents with Severe Asthma reported more severe insomnia than adolescents with No Asthma or Asthma Ever, $F(3,293)=7.67$, $p<.001$, (see Table 1 for means and SE).

Notably, 39.5% of adolescents with Severe Asthma reported moderate to severe clinical insomnia, more than twice that of the other three asthma groups, and only 23.3% of adolescents with Severe Asthma reported no insomnia compared to 62.3% of adolescents with No Asthma, $\chi^2(6)=27.2$, $p<.001$ (Figure 3).

Question 2: Is sleep hygiene related to sleep duration and insomnia, and does this differ between adolescents with and without severe asthma? (Table 2)

Sleep hygiene and weekday sleep duration—For adolescents with Severe Asthma, weekday sleep duration was not significantly correlated with any sleep hygiene variables. For adolescents Without Severe Asthma, weekday sleep duration was significantly correlated with Stimulating Activities in the Hour Before Bed and Electronics Use at Sleep Onset, with coefficients suggesting that shorter sleep duration on weekdays was associated with more activities in the hour before bed and greater electronics use at bedtime. The relationship between the sleep hygiene variables and weekday sleep duration did not differ between adolescents with and without severe asthma.

Sleep hygiene and weekend sleep duration—For adolescents with Severe Asthma, weekend sleep duration was not significantly correlated with any sleep hygiene variables. For adolescents Without Severe Asthma, weekend sleep duration was significantly correlated with Electronics Use at Sleep Onset, with the coefficient suggesting that shorter sleep duration on weekends was associated with greater electronics use at bedtime. The relationship between the sleep hygiene variables and weekend sleep duration did not differ between adolescents with and without severe asthma.

Sleep hygiene and insomnia—For adolescents with Severe Asthma, Sleep Location, Electronics Use at Sleep Onset, and Negative Bedtime Cognitions were all significantly correlated with insomnia, suggesting that adolescents with Severe Asthma who sleep somewhere other than their own bed, use more electronics at bedtime, and have more negative cognitions at bedtime also report more insomnia. For adolescents Without Severe Asthma, all sleep hygiene variables were positively correlated with insomnia, suggesting that poorer sleep hygiene is associated with more insomnia in these youth. The relationship between the sleep hygiene variables and insomnia did not differ between adolescents with and without severe asthma.

Question 3: Does daytime sleepiness differ in adolescents with and without severe asthma, and if so, is this a result of asthma or insomnia?

Adolescents with Severe Asthma had significantly greater daytime sleepiness ($M=2.11$, $SD=1.5$) than adolescents with No Asthma ($M=1.54$, $SD=1.5$), Asthma Ever ($M=1.50$, $SD=1.5$), and Current Wheeze ($M=1.66$, $SD=1.5$), $F(3,294)=8.12$, $p<.001$. In the final regression model, both asthma severity and insomnia severity were significant predictors of daytime sleepiness (Table 3). However, asthma severity only accounted for an additional 2% of the variance above insomnia severity (which accounted for 28% of the variance).

Discussion

This exploratory study extends previous reports that many adolescents obtain insufficient sleep (18;39;45) to adolescents with asthma, demonstrating that more adolescents with asthma reported insufficient sleep than adolescents without asthma. While the impact of insufficient sleep on asthma remains to be determined, a recent study demonstrated that adolescents were able to successfully extend sleep duration with sleep hygiene education

and gradually moving their bedtime earlier.(46) This simple intervention would also likely be beneficial for adolescents with asthma.

It was notable that almost 40% of adolescents with severe asthma reported clinically significant insomnia. Not only is this more than twice as much as adolescents with mild or no asthma, it is higher than previously reported adolescent insomnia prevalence rates in the United States and around the world.(22;23;47) As insomnia has been shown to be effectively treated with cognitive-behavioral therapy for insomnia (CBT-I),(24–26) it is important to screen for insomnia in adolescents with asthma.

Sleep hygiene was also found to differ between adolescents with and without asthma, providing another area for clinical intervention.(20;21) In particular, adolescents with severe asthma were found to sleep somewhere other than their own bed. While more information is needed about why adolescents were not sleeping in their own beds, anecdotally we see a number of families who like to have their child close by during an asthma exacerbation to monitor breathing and provide treatment if needed. This may lead to the development of a sleep onset association in the youth, who then need to have a parent nearby to facilitate sleep onset and sleep maintenance. Alternatively, parents may be hesitant to have a child return to their own sleeping environment after an exacerbation due to concerns about a reoccurrence.

Another area of sleep hygiene that may respond to intervention is the negative bedtime cognitions that were greater in adolescents with severe asthma. This aspect of sleep hygiene inquires about whether adolescents are scared, upset, or worried when they are trying to fall asleep. Although this study does not elucidate why adolescents with more severe asthma had more negative bedtime cognitions, it may be possible this is a result of worries or fears about nocturnal asthma. However, the unintended consequence of these fears may be delayed sleep onset and shorter sleep duration. Not surprisingly negative bedtime cognitions were significantly associated with insomnia severity. One component of CBT-I focuses solely on changing negative cognitions around sleep,(48) which could easily be applied to adolescents with severe asthma.

Daytime sleepiness was also found to be greater in adolescents with Severe Asthma compared to the other three groups. However, it was notable that in our sample, daytime sleepiness was better accounted for by insomnia severity than asthma severity. This again speaks to the importance of screening adolescents with asthma for insomnia, and referring these youth for treatment of the insomnia.

There are several methodological limitations in this study that must be noted. First, although adolescents have been shown to be accurate reporters of their sleep,(49) this study only included self-reported data collected via the internet. Studies using an objective measure of sleep (e.g., actigraphy) are needed. Second, the use of an internet survey without clear tracking of those who responded and those who didn't may have introduced sample bias. However, the demographics of our sample were similar to other reports of youth with asthma, including race (50) and the frequency of asthma severity.(34) Third, we only collected data at one point asking about typical sleep in the past two weeks. Longitudinal studies are needed as asthma and sleep patterns may change throughout the school year.

Finally, the cross-sectional design precludes conclusions on the directional relationship between sleep duration, sleep hygiene, insomnia, and severe asthma in adolescents, further supporting the need for longitudinal research in this area.

Despite these limitations, the results of this study are important for clinical practice. Sleep quality has received limited attention in terms of asthma management, and the discussion of nocturnal asthma has received significantly less attention in the recent past. With a significant number of adolescents with severe asthma in this study reporting insufficient sleep, poor sleep hygiene, and insomnia, it may be time for renewed attention to these issues. In particular, a careful evaluation of sleep issues by clinicians is needed, especially for those patients with severe asthma. Further research is also needed to help understand the mechanisms and additional outcomes that may be related to deficient sleep and insomnia in adolescents with asthma.

Acknowledgments

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Abbreviations

ANOVA	Analysis of Variance
CBT-I	Cognitive-Behavioral Therapy for Insomnia
CRSP	Children's Report of Sleep Patterns
ISAAC	International Study of Asthma and Allergies in Childhood
ISI	Insomnia Severity Index

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Highlights Box

1. What is already known on this topic?
 - Sleep disruption due to nocturnal asthma symptoms is common.
 - Poor sleep quality and short sleep duration may contribute to increased daytime asthma symptoms.
2. What does this article add to our knowledge?
 - Compared to adolescents with mild or no asthma, more adolescents with severe asthma have insufficient sleep, poorer sleep hygiene, more symptoms of insomnia, and more daytime sleepiness.
3. How does this study impact current management guidelines?
 - Clinical providers should inquire about adolescent sleep habits, encourage good sleep hygiene and increased sleep duration, and refer when necessary for the treatment of insomnia.

Figure 1.

Flow diagram of participant recruitment. ISAAC definitions(34): ^a*Asthma Ever*: Positive response to question “Have you ever had asthma?” ^b*Current Wheeze*: Positive response to “Have you ever had wheezing or whistling in the chest at any time in the past?” and “Have you had wheezing or whistling in the chest in the past 12 months?” ^c*Severe Asthma*: Positive response to Current Wheeze and in the past 12 months had (1) >4 attacks of wheeze or (2) >1 night per week sleep disturbance from wheeze or (3) wheeze affecting speech

Figure 2.

Percent of adolescents with and without asthma meeting CDC criteria for insufficient (< 7 hours), borderline (7 to 9 hours), and optimal (≥ 9 hours) sleep duration on weekdays.

Figure 3.

Frequency of adolescents with and without asthma reporting no insomnia (ISI score 0 to 7), subthreshold clinical insomnia (ISI score 8 to 14), or moderate/severe clinical insomnia (ISI score 15).

Table 1

Group differences for demographic and sleep variables (mean and standard error unless specified)

	Severe Asthma (n=43)	Current Wheeze (n=41)	Asthma Ever (n=44)	No Asthma (n=170)	p
Male [% (n)]	46.5 (20)	58.5 (24)	45.5 (25)	52.2 (83)	.56
Race [% (n)]					.74
White	72.1 (31)	78.0 (32)	78.2 (43)	83.6 (133)	
Black	14.0 (6)	9.8 (4)	10.9 (6)	6.9 (11)	
Other	14.0 (6)	12.2 (5)	10.9 (6)	9.4 (15)	
Age	14.7 (.27)	15.0 (.30)	14.1 (.22)	14.5 (.13)	.10
Weekday Total Sleep Time (hrs) ^d	7.7 (.16)	7.8 (.16)	7.8 (.14)	7.8 (.08)	.93
Weekend Total Sleep Time (hrs)	9.0 (.22)	8.8 (.21)	9.1 (.18)	9.0 (.10)	.82
Caffeine Use ^b	8.9 (.09)	8.4 (.08)	8.2 (.07)	8.1 (.04)	.51
Stimulating Activities in the Hour Before Bed	18.6 (.46)	18.9 (.43)	18.2 (.38)	17.6 (.24)	.04
Sleep Location ^b	10.1 (.03) ^c	8.6 (.02)	8.0 (.02)	8.3 (.03)	.01
Electronics Use at Sleep Onset	7.6 (.45)	7.4 (.46)	6.6 (.40)	6.5 (.23)	.08
Negative Bedtime Cognitions ^{b,e}	3.7 (.03) ^d	3.5 (.3)	3.3 (.03)	3.0 (.02)	.04
Insomnia Severity Index ^{b,f}	10.6 (.02) ^c	8.0 (.04)	7.4 (.04)	6.5 (.04)	<.001

^aEstimated marginal means controlling for age

^bGeometric means

^cTukey HSD post-hoc significant differences between Severe Asthma and both Ever Asthma and No Asthma

^dTukey HSD post-hoc significant differences between Severe Asthma and No Asthma

^eEstimated marginal means controlling for race

^fEstimated marginal means controlling for gender

Table 2

Pearson bivariate correlations between sleep hygiene, sleep duration, and insomnia for adolescents with and without severe asthma

	Severe Asthma (n=43)	No Asthma (n=255)	z-score
Weekday Sleep Duration			
Caffeine Use	-.002	-.002	0
Stimulating Activities in the Hour Before Bed	.185	-.202*	2.30
Sleep Location	.096	-.077	1.02
Electronics Use at Sleep Onset	-.135	-.269*	0.82
Negative Bedtime Cognitions	.007	-.069	0.45
Weekend Sleep Duration			
Caffeine Use	-.234	-.124	0.67
Stimulating Activities in the Hour Before Bed	.057	-.03	0.51
Sleep Location	-.120	-.095	-0.15
Electronics Use at Sleep Onset	-.307	-.209*	0.62
Negative Bedtime Cognitions	-.195	-.106	-0.54
Insomnia (controlling for sex)			
Caffeine Use	.328	.321*	0.05
Stimulating Activities in the Hour Before Bed	-.026	.174*	-1.19
Sleep Location	.505*	.404*	0.75
Electronics Use at Sleep Onset	.418*	.408*	0.07
Negative Bedtime Cognitions	.636*	.453*	1.55

* Significant correlation ($p < .006$) between sleep hygiene variable and sleep duration or insomnia

Table 3

Hierarchical multiple regression predicting daytime sleepiness

	B	SE	β	R²
Daytime Sleepiness				
Insomnia Severity	0.31	0.03	0.49**	.280
Asthma	0.07	0.03	0.15*	.021

Note. B, SE, and β values for final model, with insomnia severity entered as Step 1 and asthma severity as Step 2.

**
 p .001,

*
 p .01