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The Association between Asthma and Sleep in Urban Adolescents with Undiagnosed Asthma

Daphne Koinis-Mitchell, PhD [Associate Professor, (Research)]

Bradley/Hasbro Children's Research Center, Warren Alpert Medical School of Brown University.
1 Hoppin St, Providence, RI 02903. dkoinismitchell@lifespan.org

Sheryl J. Kopel, MSc [Research Associate]

Bradley/Hasbro Children's Research Center, Warren Alpert Medical School of Brown University.
1 Hoppin St, Providence, RI 02903. Sjkopel@lifespan.org

Barbara N. Jandasek, PhD

Brittney Williams, BA [Research Assistant]

Bradley/Hasbro Children's Research Center, Warren Alpert Medical School of Brown University.
1 Hoppin St, Providence, RI 02903. Bwilliams@lifespan.org

Amarilis Cespedes, MPH [Project Director]

Department of Child and Adolescent Psychiatry, Child Study Center, New York University School of Medicine, NYU School of Medicine, One Park Avenue 7th FL, New York, NY 10016NY.
Amarilis.cespedes@nyumc.org

Jean-Marie Bruzzese, PhD [Associate Professor]

NYU School of Medicine, Child Study Center, One Park Avenue 7th FL, New York, NY 10016

Abstract

BACKGROUND—To examine associations between asthma and sleep in a sample of inner-city adolescents with asthma-like symptoms who are undiagnosed, and to assess the extent to which youth's report of perceived stress moderates this association.

METHODS—A total of 349 adolescents, with a mean age of 15.8 years, 83% female, and their primary caregivers participated. The majority were Latino (46%) or African American (37%). Adolescents reported on asthma - namely rate of night awakenings due to asthma-like symptoms and perceived severity of breathing problems - and sleep, specifically sleep-wake behavior problems and daytime sleepiness during activities. Caregivers provided demographic information by telephone.

RESULTS—Night awakenings and perceived severity of breathing problems were each independently associated with sleep-wake behavior problems and daytime sleepiness during activities. Youth report of perceived stress moderated the association between perceived severity

Correspondence concerning this article should be addressed to Jean-Marie Bruzzese, Ph.D., NYU School of Medicine, Child Study Center, One Park Avenue 7th FL, New York, NY 10016. Electronic mail may be sent to: jean-marie.bruzzese@nyumc.org.

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of breathing problems and sleep-wake behavior problems, and perceived severity of breathing problems and daytime sleepiness during activities.

CONCLUSIONS—Results suggest the importance of interventions that consider undiagnosed asthma and its effects on sleep indicators related to daytime functioning in this high risk group of youth. This study highlights the need for interventions that consider asthma severity, nocturnal asthma, and sleep problems among urban adolescents with no asthma diagnosis.

Keywords

Asthma-like symptoms; Undiagnosed; Adolescents; Urban

Asthma prevalence rates continue to escalate among urban youth,¹ with rates greater than 20% being reported.² African-American and Latino children are disproportionately affected with greater disease prevalence compared to their non-Latino White (NLW) counterparts.³ Urban youth diagnosed with asthma experience greater asthma morbidity, including activity restriction and sleep disruption, and a number of multi-level factors – such as disease severity, poverty, acculturative stress, exposure to allergens and irritants, insurance status – are implicated.^{4–7}

Undiagnosed Asthma among Urban Adolescents: An Understudied Group at Further Risk

Research with 7 to 18 year olds indicates that 28 to 50% of those with asthma-like symptoms lack an asthma diagnosis, and therefore are underdiagnosed or undertreated.^{2,8–10} Undiagnosed and untreated asthma can result in significant activity limitation, loss of school days, and in cases where symptoms are more severe and dangerous, the need for emergent care.^{8,10–12} In fact, among those with moderate to severe persistent symptoms, diagnosed and undiagnosed youth experience equally high rates of daytime and nighttime symptoms and asthma-related activity limitation and school absences.^{8,11,12}

Adolescents are an especially vulnerable group because many have frequent asthma-like symptoms,^{8–10} have greater asthma morbidity due to asthma symptoms,^{8,11} and inconsistently utilize health care services.^{10,11,13} It has also been shown that adolescents are more prone to shorter sleep duration and poor sleep habits.^{14,15} Focusing on adolescent youth is critical as many health-related behavioral patterns that are formed during adolescence continue in adulthood and affect adult health outcomes.^{15,16}

Children's Sleep: An Important Avenue for Intervention in Youth with Asthma-like Symptoms

Children with poorly controlled asthma-like symptoms may have difficulty initiating or maintaining sleep due to nocturnal symptoms which can make them more vulnerable to poor sleep quality.^{17–20} In a study including children with diagnosed asthma and healthy controls, a higher number of night awakenings has been found in children with asthma compared to those without asthma.²¹ Sleep disruption due to nocturnal asthma-like symptoms may also

occur more often in children with persistent asthma than in those with intermittent asthma,²² because their increased severity may increase the frequency of nighttime symptoms.

Frequent night awakenings in youth with diagnosed asthma can result in poor sleep quality and can affect daytime alertness,²³ increased school absences,²⁴ poorer school performance,²⁵ increased risk for behavior problems,²⁶ and poor quality of life.^{27,28} Research to date in this area has included youth either with a physician diagnosis of asthma confirmed directly or by parent report; this relationship has yet to be studied in adolescents with asthma-like symptoms who lack a diagnosis, a highly vulnerable group

Stressors Relevant to Urban Youth with Asthma

Urban ethnic minority children with asthma-like are more vulnerable to neighborhood and family-level stress, and this can affect their susceptibility to asthma symptoms.²⁹ Urban stressors and low-income status are also shown to be associated with poor sleep quality in children in other disease groups.³⁰ Understanding the extent to which perceptions of stress affect the link between asthma and sleep in vulnerable samples, such as urban adolescents with asthma-like symptoms and no diagnosis, may help to identify modifiable factors and provide important opportunities for intervention across multiple settings where students spend the majority of their time, such as at home and/or school.

The Current Study

This study examines the association between asthma and sleep behaviors in a group of urban adolescent students with undiagnosed asthma. Asthma-related indicators include adolescents' report of night awakenings due to breathing problems, and their perceived severity of breathing problems/asthma-like symptoms. Each of these indicators is utilized in the assessment of asthma morbidity in urban children.¹⁷ Sleep-related indicators include the youth's report of their sleep-wake behavior problems and the level of daytime sleepiness during activities. These sleep indicators have been used in several studies assessing sleep in adolescents and have been shown to correlate with indicators of daytime functioning, such as concentration.¹⁴

We hypothesized that more frequent adolescent reported night awakenings and higher levels of perceived severity of breathing problems would each be associated with reports of more sleep-wake behavior problems and daytime sleepiness. In addition, we examined whether perceived stress moderated the association between asthma-like symptoms and sleep indicators in this group. We expected that asthma-like symptoms and sleep behaviors would be more strongly associated in the context of higher levels of perceived stress.

METHODS

Design and Procedures

Data for this cross-sectional analysis are drawn from the baseline visit of a larger, randomized clinical trial examining the efficacy of a school-based intervention, Asthma Self-Management for Adolescents with Undiagnosed Asthma (ASMA-Undx), which aims to assist high school students who meet criteria for moderate to severe persistent asthma, but

who have yet to be diagnosed, obtain a clinical evaluation, and a diagnosis and treatment, if warranted.³¹ Eligible students were drawn from 40 schools in neighborhoods with elevated rates of asthma hospitalizations; schools also needed to have no other on-going asthma interventions. All study procedures were approved by the Institutional Review Boards of the New York University School of Medicine, Columbia University, and the New York City Department of Education.

To determine eligibility for the clinical trial, all students in grades 9 through 11 completed two brief validated asthma case detection surveys,^{2,32} which allowed the investigators to determine whether or not students had probable asthma, the level of severity of their asthma-like symptoms based on NHLBI categories for severity of symptoms,¹⁷ and if they were ever diagnosed with asthma. Trained project staff obtained written assent and informed consent from eligible students, which were those with probable moderate to severe persistent asthma and no diagnosis, to participate in the clinical trial. Exclusion criteria included having other co-morbid diseases that might impact lung functioning and/or highly specialized developmental or learning needs.

The student baseline assessment consisted of surveys that were independently completed by each student, as well as interviews by trained project staff; students' primary caregivers were interviewed by telephone by trained project staff.

Instrumentation

Participant characteristics—Students provided their sex, date of birth, and race/ethnicity. Primary caregivers reported on their highest level of education and employment status.

Asthma-related indicators—Students completed two asthma measures used in prior research examining asthma morbidity in urban youth with diagnosed and undiagnosed asthma.^{17,31,33–35} First, they reported the number of night awakenings due to asthma-like symptoms that they experienced in the prior two weeks. Next, students indicated the perceived severity of their asthma-like symptoms by indicating on a 5-point Likert scale how much they were bothered overall in the last 2 weeks by breathing problems, with 0=Not bothered to 4=Very bothered.

Sleep-related indicators—Students answered several questions related to sleep behaviors and sleepiness from the *School Sleep Habits Survey* (SSHS),^{14,36} a widely used survey with good psychometric properties with urban adolescents. Students completed the Sleep-Wake Behavior Problems Scale, which consists of 15 items regarding the frequency of erratic sleep/wake behaviors over the prior 2 weeks using a 5-point Likert scale, with 0=Never to 4=Every day/night. Sample items include: feeling satisfied with your sleep and falling asleep in a morning or afternoon class. To assess daytime sleepiness, students answered a single question regarding how much of a problem they have with sleepiness during daytime activities, using a 5-point Likert scale, with 0=Not a problem at all, to 4=A very big problem.

Perceived stress—Students completed the 4-item Perceived Stress Scale (PSS-4),^{37,38} which measures the degree to which youth feel their lives were unpredictable, uncontrollable, and overwhelming in the preceding month. Items are scored on a 5-point Likert scale, with 0=Never through 4=Very often. This scale has been widely used with adolescents with adequate reliability reported.³⁹

Data Analysis Plan

Preliminary analyses were conducted to examine associations among demographic variables: child age, ethnicity/race, sex, caregiver employment status and caregiver education; asthma indicators: number of night waking and perceived severity of breathing problems; sleep indicators: sleep-wake behavior problems and daytime sleepiness during activities; and perceived stress. We used Pearson's correlations when both variables were continuous, or analyses of variance (ANOVA) when examining continuous variables across discrete groups, such as sex or race/ethnic group. Chi square analyses were utilized to assess relationships among categorical variables.

We then examined the association between each asthma-related indicator -- the predictor -- and each sleep indicator -- the dependent variable -- in four hierarchical, linear regression analyses. Demographic variables that could represent potential confounds were controlled, when appropriate, as indicated by preliminary analyses.

Next, we examined the moderational role of perceived stress in the association between asthma and sleep. In each hierarchical regression moderation model, the demographic variable was entered into the regression equation in the first step, when appropriate. In the second and third steps, the two variables representing potential main effects -- perceived stress and each asthma indicator, respectively -- were entered. This was followed in the last step by the interaction term of perceived stress and the asthma indicator. We conducted post-hoc probing to clarify interaction terms that were statistically significant or represented statistical trends, as in our previous work.⁴⁰ The relationships between asthma and sleep indicators were tested in the context of high and low levels of perceived stress, as determined by a median split.⁴⁰

Statistical significance was judged at $p < 0.05$, which was used for all statistical tests; trends with $p < .10$ are also reported for descriptive purposes. Effect sizes for analyses of variance were expressed as partial omega squared (ω_p^2), which are interpreted as small (.01), medium (.06) or large (.14).⁴¹ R^2 -adjusted are presented for multiple regression results. Statistical analyses were performed using SPSS version 12.

RESULTS

Table 1 provides a summary of demographic information, baseline clinical characteristics, and the distribution of asthma, sleep and stress variables for the sample.

Preliminary Associations among Demographic Characteristics, Asthma, and Sleep Indicators

Perceived severity of breathing problems ($F=10.9$, $p<.001$, $\omega^2_p=.03$) and daytime sleepiness during activities ($F=7.67$, $p<.01$, $\omega^2_p=.02$) differed by student sex. Compared to males, females reported more severe breathing problems ($M=1.8$, $SD=1.2$ and $M=2.3$, $SD=1.1$, respectively) and more daytime sleepiness ($M=1.3$, $SD=0.9$ and $M=1.7$, $SD=1.1$, respectively). Student race/ethnicity and age, and caregiver education and employment status were not significantly related to asthma or sleep indicators. Based on these analyses, only sex was controlled in the model testing the relationship between perceived severity of breathing problems and daytime sleepiness during activities.

Associations between Asthma and Sleep Indicators—Results from separate hierarchical regression analyses controlling for sex when appropriate revealed that the number of night awakenings significantly predicted sleep-wake behavior problems ($\beta = .18$, $t = 3.44$, $p = .001$; model $R^2_{\text{adjusted}} = .03$) and daytime sleepiness during activities ($\beta = .16$, $t = 2.96$, $p = .003$; model $R^2_{\text{adjusted}} = .02$). Further, perceived severity of breathing problems was a significantly associated with sleep-wake behavior problems ($\beta = .24$, $t = 4.55$, $p<.001$; model $R^2_{\text{adjusted}} = .05$) and daytime sleepiness, controlling for sex ($\beta = .29$, $t = 5.53$, $p < .001$; model $R^2_{\text{adjusted}} = .10$).

Moderational Analyses: Associations among Perceived Stress, Asthma and Sleep-Wake Behavior Problems

Regression analyses examining the moderational role of perceived stress on the association between number of nights awakenings and sleep-wake behavior problems revealed main effects of perceived stress on sleep-wake behavior problems ($\beta = .36$, $t = 7.25$, $p < .001$). Night awakenings remained associated with sleep-wake behavior problems after controlling for perceived stress ($\beta = .13$, $t = 2.58$, $p < .01$; model $R^2_{\text{adjusted}} = .16$). The interaction term between perceived stress and night awakenings was not significant, as indicated in Table 2.

Regression analysis examining the moderational role of perceived stress in the association between perceived severity of breathing problems and sleep-wake behavior problems displayed a significant main effect of perceived stress on sleep-wake behavior problems ($\beta = .34$, $t=6.76$, $p<.001$). Perceived severity of breathing problems remained associated with sleep-wake behavior problems after controlling for perceived stress ($\beta = .15$, $t=3.02$, $p<.01$; model $R^2_{\text{adjusted}} = .16$). A statistical trend in the interaction term (perceived stress $\times$ perceived severity of breathing problems) on sleep-wake behavior problems also emerged ($\beta = .30$, $t=1.67$, $p=.10$, model $R^2_{\text{adjusted}} = .17$; Table 2). Figure 1, Box a depicts a plot reflecting perceived severity of breathing problems by higher and lower levels of perceived stress, determined by median split, indicated that participants in the lower perceived stress group perceived less severe breathing problems ($M = 2.03$, $SD = 1.11$) relative to participants in the higher stress group ($M = 2.32$, $SD = 1.17$), $F = 5.40$, $p=.02$, $\omega^2_p=.01$. Additionally, Figure 1, Box b indicates that participants in the lower stress group had lower sleep-wake behavior problems scores, on average ($M = 15.69$, $SD = 7.76$) relative to their counterparts in the higher stress group ($M = 20.36$, $SD = 6.36$), $F = 38.23$, $p < .001$, $\omega^2_p = .10$.

Moderational Analyses: Associations Among Perceived Stress, Asthma, and Daytime Sleepiness During Activities

In the model testing the moderational role of perceived stress in the association between number of night awakenings and daytime sleepiness during activities, child's perceived level of stress displayed a main effect on daytime sleepiness ($\beta = .24$, $t = 4.57$, $p < .001$). Number of night awakenings remained associated with daytime sleepiness during activities after controlling for perceived stress ($\beta = .12$, $t = 2.34$, $p = .02$; model adjusted $R^2 = .08$). However the interaction term in this model, depicted in Table 3, was not significant.

Analyses investigating the moderational role of perceived stress on the association between perceived severity of breathing problems and daytime sleepiness during activities indicated that, controlling for sex, children's perceived stress displayed a main effect on daytime sleepiness ($\beta = .19$, $t = 3.65$, $p < .001$). Perceived severity of breathing problems remained associated with daytime sleepiness after controlling for perceived stress ($\beta = .24$, $t = 4.63$, $p < .001$; model $R^2_{\text{adjusted}} = .13$). The interaction term was also significant for this model ($\beta = .44$, $t = 2.35$, $p = .02$, model $R^2_{\text{adjusted}} = .14$), indicating the relationship between perceived severity of breathing problems and sleepiness during activities depends upon the child's perceived level of stress (Table 3). As detailed in Figure 1, Box a and Figure 2, Box a, participants in the lower perceived stress group perceived less severe breathing problems relative to participants in the higher stress group. Additionally, participants in the lower stress group less frequently endorsed daytime sleepiness during activities ($M = 1.37$, $SD = 1.07$) relative to their counterparts in the higher stress group ($M = 1.77$, $SD = 1.01$), $F = 12.79$, $p < .001$, $\omega^2_p = .03$; see Figure 2 Box b.

DISCUSSION

We examined associations between asthma-related and sleep indicators in a group of urban adolescents who do not report a diagnosis of asthma, but who present with moderate to severe persistent asthma-like symptoms. Given the important role that perceived stress plays in both asthma and sleep, particularly for urban youth, we also investigated whether adolescents' perceptions of stress moderated the association between these asthma and sleep indicators.

Associations between Asthma-Related and Sleep Indicators

A number of significant direct effects emerged between asthma-related and sleep indicators in our sample. Night waking and perceived severity were independently associated with reports of higher levels of sleep-wake behavior problems and of daytime sleepiness. These results suggest that the rate of night awakenings due to breathing problems and how bothered youth were by their breathing problems, may have affected their sleep behaviors, and more specifically their satisfaction with sleep, whether they obtained a good night sleep and whether they woke up later than their usual wake-up time, items captured by the sleep-wake problem measure utilized in this study. Further, increased night awakenings related to breathing problems and the perceived severity of breathing problems appeared to negatively impact daytime sleepiness in this sample. We focused on these specific asthma-related indicators as they may be more proximally related to sleep-wake problems and daytime

sleepiness because of their link with the nighttime and sleep period. It is important to note that daytime symptoms that are poorly controlled may certainly lead to nighttime symptoms,¹⁷ and as a result, more frequent night awakenings, which in turn, may affect sleep behaviors. The timing and sequence of this pathway needs to be examined in further depth in future research, as it may inform where to prioritize intervention efforts with urban youth.

In our sample, poor asthma control may have played a key role in poor sleep behaviors and subsequent daytime functioning. This sample includes youth with moderate to severe asthma-like symptoms who were undiagnosed. This group may be particularly vulnerable because their symptoms have not been treated yet. In future research with undiagnosed youth, specific avenues by which nocturnal asthma and persistent symptoms influence sleep quality need to be examined, for example is poor sleep quality influenced by poor asthma control, poor sleep hygiene/sleep behaviors, or both? This work is warranted given poor sleep can affect how adolescents function during the day, particularly, their ability to focus at school.

Moderational Role of Perceived Stress

Perceived levels of stress did not interact with self-reported rates of night awakenings in the association with sleep-wake problems. However, adolescents in the sample who perceived their breathing problems to be more problematic tended to report higher levels of daytime sleepiness, and this association was more robust for adolescents who perceived higher levels of stress. In this sample, it may be that adolescents who were experiencing higher levels of stress, perceived more problems with their breathing, and this in turn, may have affected their sleep duration and how tired they were during the day.

Stress is also a trigger for asthma, which may increase breathing problems²⁹ and sleep disruptions in youth.³⁰ Urban ethnic minority youth with asthma are exposed to higher levels of sociocontextual stresses. It may be that heightened levels of perceived stress accentuate how youth perceive the severity of their asthma-like symptoms in comparison to the accuracy with which they report on how often they were awakened because of the symptoms. It is also possible that perceived stress is a marker for poor sleep hygiene and a sleep environment that is not conducive to healthy sleep behaviors. Adolescence is also a period when sleep is restricted, due to hormone-driven changes in circadian rhythms, changes in sleep behaviors, and sleep hygiene, which may be affected by exposure to stress.¹⁴ These potential pathways of influence need to be clarified in future research.

Several limitations to this study bear mention. This study made use of baseline data from larger, randomized trial involving only adolescents with undiagnosed asthma. As such, there were no comparison groups of those with diagnosed and/or well-controlled asthma. In addition, the study only included adolescent-report measurements, which could have been influenced by social desirability and poor recall. Further, assessments focused on a restricted period of time. Asthma-like symptoms or breathing problems can be affected by seasonal changes and environmental triggers,¹⁷ which were not considered. Future research should utilize objective assessments of both lung function and sleep quality, and examine these processes over time in urban adolescents. Attention to environmental allergens and irritants

in the home should also be considered. Finally, this study involved cross-sectional associations; thus, the directionality of the associations between the asthma and sleep indicators require further examination in studies employing longitudinal designs.

The results of this study suggest several avenues for future research and intervention with this group. This is a group experiencing untreated, persistent asthma-like symptoms, which can affect night waking, daytime sleepiness and sleep and wake patterns and behaviors. This work builds on the results of previous studies, which showed that adolescents with undiagnosed asthma and persistent symptoms may face a greater risk for asthma burden due to being untreated or undertreated.¹⁰ This work highlights the need for increased understanding of why this group is undertreated and undiagnosed -- specifically what health care system factors, family and social factors, illness stigma may be implicated-- and underscores the need for targeted identification and treatment.

IMPLICATIONS FOR SCHOOL HEALTH

Our results show the potential impact of untreated asthma on sleep problems and daytime functioning of urban adolescents; their increased risk for sleep disruption and poor quality sleep may negatively affect daytime and behavioral functioning and academic learning. High schools serve as important settings where screening and appropriate referral of children at risk for untreated asthma and sleep problems may occur. School personnel would also benefit from knowing which students have asthma, to refer students to the school nurse and/or connect with their caregivers to encourage the connection with the student's health care provider, and to begin to discuss how uncontrolled asthma may affect attention levels, fatigue and academic performance. In addition, school personnel would benefit from asthma education to enhance knowledge of the impact of asthma on daytime functioning and how to support student's asthma control in school. Adolescents with asthma may benefit from during-the-day, school-based interventions to enhance their response to asthma in the school setting and how to improve nighttime asthma control.

School nurse teachers can refer students who present with asthma-like symptoms and who appear groggy and sleepy to receive a comprehensive sleep evaluation. This evaluation may identify specific sleep behavior problems, such as inconsistent bedtime and wake time, inconsistent sleep location, as well as problems with the sleep environment, and sleep hygiene issues, including noise, sleep disruptions in the child's sleep location, that affect sleep quality and duration. Finally, school-based and family interventions for adolescents addressing asthma and sleep may need to consider behavioral strategies that decrease perceived levels of stress, to minimize the potential for nocturnal asthma symptoms and increased sleep-onset latency. Thus, a more integrated, multi-disciplinary asthma and sleep assessment in the home and school setting may be needed for youth vulnerable to poor quality sleep. Improving asthma control and enhancing sleep behaviors and hygiene are important intervention targets for all adolescent students who present with persistent asthma symptoms. Sleep should be considered when working with adolescent students with undiagnosed asthma, given this group's high risk for poor quality sleep, asthma morbidity, and associated difficulties with learning and behavior problems.

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Figure 1.
Perceived Severity of Breathing Problems and Sleep Behavior Problems Score by Perceived Stress (Median Split)

Figure 2. Perceived Severity of Breathing Problems and Daytime Sleepiness during Activities Scores by Perceived Stress (Median Split).

Table 1

Demographic and Clinical Characteristics of Student Participants and Caregivers, and Distribution of Predictors and Dependent Variables

Demographic and Clinical Characteristics (N = 349)	n (%)
Student Characteristics	
Female	289 (83)
Age in years [M (SD)]	15.8 (1.1)
Ethnicity	
Latino	160 (46)
African American	130 (37)
Other	59 (17)
Severity of Asthma-Like Symptoms	
Moderate Persistent	186 (53)
Severe Persistent	163 (47)
Primary Caregiver Characteristics (N=240)	
Education	
Less than high school education	88 (37)
Completed high school education	60 (25)
Beyond high school education	92 (38)
Employment Status (n=239)	
Full time	109 (46)
Part time	44 (18)
Home maker	25 (11)
Unemployed or laid off	43 (18)
Not employed (i.e., leave of absence, retired, disability, full-time student)	18 (8)
Predictors and Dependent Variables	M (SD) Range
# Night Wakenings, past 2 weeks	2.5 (3.5) 0–14
Perceived Severity of Breathing Problems	2.2 (1.2) 0–4
Sleep-Wake Behavior Problems Total Score	18.3 (7.4) 0–37
Daytime Sleepiness During Activities	1.6 (1.1) 0–4
Perceived Stress Total Score	7.5 (2.7) 0–16

Table 2

Moderational Model: Predictors of Sleep-Wake Behavior Problems

	Model R ² adj	β	t	p value
Night Wakenings				
Perceived Stress	.16	.36	7.25	<.001
Number of Night Wakenings		.13	2.58	.01
Perceived Stress $\times$ Number of Night Wakenings	.15	.00	.03	.97
Perceived Severity of Breathing Problems				
Perceived Stress	.16	.34	6.76	<.001
Perceived Severity of Breathing Problems		.15	3.02	<.01
Perceived Stress $\times$ Perceived Severity	.17	.30	1.67	.10

Table 3

Moderational Model: Predictors of Daytime Sleepiness During Activities

	Model R ² adj	β	t	p value
Night Wakenings				
Perceived Stress	.08	.24	4.57	<.001
Number of Night Wakenings		.12	2.34	.02
Perceived Stress $\times$ Number of Night Wakenings	.08	-.15	-.96	.34
Perceived Severity of Breathing Problems				
Perceived Stress	.13	.19	3.65	<.001
Perceived Severity of Breathing Problems		.24	4.63	<.001
Perceived Stress $\times$ Perceived Severity	.14	.44	2.35	.02