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Allergic sensitization and objective measures of sleep in urban school-aged children with asthma

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ABSTRACT

Background: Allergic sensitization is associated with increased child asthma morbidity and decreased pulmonary function. Nocturnal symptoms and/or awakenings typically are measured by self-report from diary data, whereas objective assessments of sleep in child asthma studies are lacking.
Objective: To investigate the association between increased allergic sensitization (number of positive allergy test results measured by skin prick test or specific immunoglobulin E) and sleep outcomes (sleep efficiency, sleep duration, and mean number of awakenings measured by actigraphy) in urban schoolchildren with persistent asthma.
Methods: One hundred ninety-six children with persistent asthma (7–9 years old) attending public school in 1 of 4 large urban school districts completed allergy testing during a study clinic visit. Forced expiratory volume in 1 second was monitored at home using a handheld spirometer. Sleep outcomes were measured with a wrist Actiwatch during a 1-month period in the fall and winter seasons.
Results: Number of positive allergy test results significantly predicted mean sleep efficiency ($P = .02$), such that children with more positive test results experienced less efficient sleep. Number of positive allergy test results significantly predicted mean number of night awakenings ($P = .05$), such that children with more positive allergy test results experienced more night awakenings. Variability in forced expiratory volume in 1 second was a significant moderator in the association between number of positive allergy test results and variability in sleep efficiency ($P = .04$). Racial and ethnic differences in allergic sensitization and sleep outcomes were found between African Americans and Latinos.
Conclusion: More positive allergy test results were associated with poorer sleep outcomes measured objectively in this sample of urban children. Implications for environmental control interventions and asthma treatments in different racial and ethnic groups are discussed.

Introduction

Allergic Sensitization, Asthma, and Sleep

Associations among allergic sensitization, decreased pulmonary function, and increased asthma morbidity in children have been demonstrated consistently across studies.[1–3] Specific allergic sensitivities to dog, cat, *Alternaria* species, but especially to cockroach and rodents, have been associated with increased bronchial responsiveness,[4] increased risk of emergency department visits for asthma,[5] and higher asthma morbidity.[3,6–10]

Sleep is an important outcome to evaluate when considering allergen sensitization in asthma, because it can be a vulnerable time for children with asthma for various physiologic reasons.[11,12] To date, most studies of allergic asthma and sleep in children are based on self-report assessments using diary data,[13,14] which are subject to poor recall and bias. More objective assessments of sleep quality in asthma are needed.[11]

Urban minority children appear to be at greater risk. Children from African American and Latino, predominantly Puerto Rican, backgrounds have poor asthma outcomes.[15,16] In particular, African Americans are 2 times more likely to report nocturnal asthma compared with non-Latino whites (NLWs) in genetic studies.[17] African Americans, at as young as 2 years old, also are disproportionately affected by higher allergic sensitization compared with

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NLWs of the same age.[18] Our previous work showed that urban African Americans and Latinos with asthma had higher total sleep problem scores compared with NLWs,[19] and that well-controlled asthma and better lung function were more likely in children with "good" sleep health.[20] We have yet to study the contribution of allergic sensitization to objective measurements of sleep quality in urban children with asthma. Addressing this gap in the literature has important implications for environmental and behavioral interventions to promote good sleep health in urban minority groups.

Present Study

First, this study investigated the association between increased allergic sensitization (number of positive allergy test results measured by skin prick test or specific immunoglobulin E [sIgE]) and children's sleep outcomes (measured objectively using actigraphy; sleep quality or efficiency, variability in sleep efficiency, mean number of awakenings, and sleep duration) in a carefully evaluated urban sample of children with persistent asthma. We expected that greater allergic sensitization would be associated with poorer sleep quality and duration. Given higher levels of morbidity in minority groups,[21] we expected this association would be more pronounced in children from African American and Latino backgrounds compared with NLW children. Second, we determined whether sleep outcomes differed across sensitization to specific indoor perennial allergens (dust mite, cat, dog, cockroach, and mouse) potentially relevant to the bedroom environment. Based on prior literature in urban environments, we expected that children with cockroach and mouse sensitization would have poorer sleep outcomes. Third, we sought to determine whether asthma status indicators (forced expiratory volume in 1 second [FEV_1], FEV_1 variability, and asthma control) moderated associations between allergic sensitization and sleep outcomes and expected these associations to be more robust in the context of lower FEV_1, greater FEV_1 variability, and poor asthma control.

Methods

Data for this study were collected from a larger study, Project NAPS (Nocturnal Asthma and Performance in School; R01 HD057220, D.K.-M., principal investigator), that examines the co-occurrence of asthma and allergic rhinitis symptoms, sleep quality, and academic function in urban children with persistent asthma (7–9 years of age) across 1 academic year. Data presented in this sub-study include the 196 participants who completed allergy testing at the clinic study visit that occurred during the fall and early winter monitoring period. The institutional review board at Rhode Island Hospital (Providence, Rhode Island) approved the study protocol.

Participants were recruited from the 4 largest school districts in an urban Northeastern US city, from hospital and ambulatory pediatric clinics, and from a hospital-based asthma educational program by convenience sampling. Inclusion criteria specified child age 7 to 9 years, child's legal guardian was willing to participate, caregiver race and ethnicity was self-identified as black or African American, Latino (Dominican or Puerto Rican), or NLW, and the child attended public school in 1 of the targeted school districts in the greater Providence area. Children needed to meet criteria for persistent asthma by prescription for asthma controller medication or recurrent asthma symptoms (eg, daytime symptoms >2 days a week, nocturnal symptoms >2 times a month, short-acting β-agonist use >2 days a week, at least some limitation in normal activity, and/or ≥2 oral steroid bursts per year).[22] Exclusion criteria were moderate to severe cognitive impairment as determined by school placement, use of stimulant medication for attention-deficit/hyperactivity disorder, additional pulmonary disease or chronic health condition, or a diagnosed sleep disorder (eg, restless leg syndrome) that would confound the primary hypotheses of the larger study. Children with sleep disordered breathing (SDB) were not excluded because this is highly comorbid in this population.

Table 1
Sample Characteristics (N = 196)

Demographic variable	
Child age (y), mean (SD)	8.31 (0.87)
Boys, %	53
Caregiver race and ethnicity, %	
Black	34
Latino	51
Non-Latino white	15
At or below poverty threshold, %	70
People in household, mean (SD)	4.70 (1.76)
Asthma severity, %	
Mild persistent	56
Moderate persistent	33
Severe persistent	11
Asthma poorly controlled, %	44
Asthma medications, %	
Inhaled corticosteroid	70
Long-acting β-agonists	5
AR medications, %	
Intranasal steroid	11
Antihistamine use, %	
First-generation antihistamine	18
Second-generation antihistamine	26
FEV_1% predicted, mean (SD)	83.9 (12.80)
Variability in FEV_1% predicted, mean (SD)	14.97 (5.96)
Risk for sleep disordered breathing, %	49
BMI percentile for age, mean (SD)	74.32 (25.22)
Sleep health indicators	
Sleep efficiency (%), mean (SD)	86.54 (3.48)
Variability in sleep efficiency, mean (SD)	4.17 (1.87)
Sleep duration (min), mean (SD)	554.49 (35.04)
Number of awakenings per night, mean (SD)	5.35 (2.42)

Abbreviations: AR, allergic rhinitis; BMI, body mass index; FEV_1%, forced expiratory volume in 1 second percentage.

Data for the present study were collected during the fall and early winter period of each study year (August 15 through December 31 from 2010 to 2014). At the initial study visit, demographic information and medication use were collected, followed by a second session at the hospital-based clinic at least 2 weeks later, when asthma severity and allergy status were evaluated. The clinic visit was followed by a 1-month home-monitoring period in which children wore an ActiGraph to assess sleep quality and used a handheld device to assess FEV_1. Midway through the monitoring period, study staff conducted a home visit to download and review electronic sleep and pulmonary function data. At the end of the monitoring period, asthma control was assessed.

Standardized training procedures for device use were provided throughout to encourage protocol adherence and ensure appropriate use of the devices.[20] Assessments were administered in English or Spanish according to participants' preference, and standardized procedures were used for the translation of measures.[23]

Measures

Demographic and descriptive information

Primary caregivers provided demographic information (Table 1). Poverty status was determined by dividing the family's annual income by the federal per-capita poverty threshold for a family of that size.[24]

Asthma severity

The clinic study visit consisted of a medical history, physical examination, allergy testing, pulmonary function testing, and review of medications to confirm the diagnosis of asthma and classify