

The prevalence of sleepiness and the risk of sleep-disordered breathing in children with positive allergy test

Stacey L. Ishman, MD, MPH, David F. Smith, MD, PhD, James R. Benke, BS, Mai-Tien Nguyen, BA, Sandra Y. Lin, MD

Background: We evaluated the prevalence of sleep-disordered breathing (SDB) and sleepiness in children with allergy and compared sleep-specific quality of life measures to those of children without allergy.

Methods: A prospective case-control study was done at a tertiary care academic center. The parents of 21 pediatric patients with positive environmental allergy testing completed questionnaires including the Obstructive Sleep Apnea-18 (OSA18), the Pediatric Sleep Questionnaire (PSQ), and the Pediatric Daytime Sleepiness Scale (PDSS). Comparisons were made to 113 children without allergy who had undergone cochlear implantation (CI) who served as controls.

Results: SDB was suggested in 19% of children with allergy using the OSA18 and in 29% using the PSQ vs 6% and 7% of controls ($p = 0.029$; $p = 0.003$), respectively. In addition, daytime sleepiness was suggested in 45% to 48% of children with allergy using the PSQ and PDSS vs 17% to 25% of controls ($p = 0.015$; $p = 0.025$), respectively. Patients with allergy had SDB and sleepiness scores

higher than population normal values: OSA-18 of 41.7 vs 34.0, PSQ-SDB of 0.25 vs 0.14, PSQ-Sleepy of 0.34 vs 0.15, and PDSS of 14.2 vs 11.4. The difference between cases and controls was significant for all measures of sleepiness and SDB.

Conclusion: Children with allergy have higher SDB and sleepiness scores than controls. This suggests that children with allergic rhinitis are at increased risk for SDB and screening should be considered in this population. In addition, studies with a larger sample size are important to fully understand this relationship. © 2011 ARS-AAOA, LLC.

Key Words:

allergy; allergic rhinitis; sleep disordered breathing; obstructive sleep apnea; quality of life

How to Cite this Article:

Ishman SL, Smith DF, Benke JR, Nguyen M-T, Lin SY. The prevalence of sleepiness and the risk of sleep-disordered breathing in children testing positive for allergy. *Int Forum Allergy Rhinol*, 2011; 00:X-XX

Allergy and sleep-disordered breathing (SDB) are both common conditions of childhood. Allergic rhinitis affects an estimated 20% of the U.S. population, and snoring is estimated to occur in up to 30% of children. SDB encompasses a range of problems including primary snoring, upper-airway resistance syndrome, and in the most severe form, obstructive sleep apnea (OSA).

Primary snoring is snoring with the absence of apneas, ventilation/oxygenation deficiencies, and daytime symptoms. Upper-airway resistance syndrome manifests with increased airway resistance without apneas or desaturations, leading to increased sleep disruption in the form of arousals with daytime symptoms. The hallmarks of frank OSA can include a combination of obstructive apnea, hypopnea, and hypoxemia.

The estimates of the prevalence of OSA in children range from 1% to 4%.¹ Previous studies have examined whether SDB is related to allergic rhinitis. Chng et al.² found in their survey of children in Singapore that habitual snoring was associated with allergic rhinitis. McColley et al.³ showed that children with habitual snoring and positive allergy test are more likely to have OSA. One possible mechanism behind this association is related to the hypothesis that allergy can lead to lymphoid hypertrophy, increasing tonsil and adenoid size, and therefore causes obstruction of the upper airway; this airway obstruction may further manifest as SDB.⁴

Department of Otolaryngology–Head and Neck Surgery, Johns Hopkins School of Medicine, Baltimore, MD

Correspondence to: Sandra Y. Lin, MD, Department of Otolaryngology–Head Neck Surgery, 601 N. Caroline St., #6254, Baltimore, MD 21287; e-mail: slin30@jhmi.edu

Presented at the 69th Annual Meeting American Academy of Otolaryngic Allergy, September 24–25, 2010, Boston, MA.
Potential conflict of interest: None provided.

Received: 16 May 2011; Revised: 28 September 2011; Accepted: 2 October 2011

DOI: 10.1002/alr.20104

View this article online at wileyonlinelibrary.com.

The ability to identify risk factors for SDB and OSA in children is of great clinical utility. This is particularly true because a pediatric sleep study continues to be the gold standard for diagnosis, despite the fact that pediatric sleep studies may not be widely available in many areas of the United States. Based on previous studies, it appears that allergy may be a risk factor for SDB. Therefore, we hypothesize that children with allergy are more likely to exhibit symptoms of SDB, and to suffer poorer disease-specific quality of life than children without allergy.

The purpose of our study is to examine children with skin-prick test–positive allergic rhinitis in comparison to a control group without allergy, and evaluate the effects of allergy on disease-specific quality of life measures of sleep and SDB using validated questionnaires, the Pediatric Sleep Questionnaire (PSQ),⁵ the OSA-18 Quality of Life Survey (OSA-18),⁶ and the Pediatric Daytime Sleepiness Scale (PDSS).⁷ The PSQ is a 5-question multiple-choice-format instrument shown to identify SDB symptoms in a clinical research setting; the OSA-18 is an 18-question disease-specific quality of life survey, and the PDSS is an 8-item scale of sleepiness in children.

Patients and methods

After institutional review board approval was obtained for this study, subjects were recruited from the Johns Hopkins Otolaryngology clinics. Pediatric patients, aged 0 to 18 years, who had undergone environmental allergy skin-prick testing or in vitro allergy testing were eligible, and subjects/caregivers were asked to complete the PSQ, PDSS, and OSA18. Questionnaires were administered at the time of clinic visit/allergy testing or sent to the subject/caregiver to complete after the visit (if the questionnaires were not completed while at the clinic). Non-English-speaking, hearing-impaired, or language-impaired subjects were not eligible for this study. Patients with cystic fibrosis, ciliary disorders, craniofacial abnormalities, neuromuscular disease, or known immunodeficiency were excluded from this study. Control subjects included children with no history of allergic rhinitis (by parental report) who had undergone cochlear implantation (CI).

Subjects were considered allergic based on positive results on either skin-prick or in vitro testing (radioallergosorbent test [RAST]). Subjects were considered to be allergic based on in vitro testing of Class II sensitivity or greater. For this study skin-prick testing was considered positive when the resulting wheal was greater than or equal to 3 mm when compared to negative controls after 15 minutes. Controls used for skin-prick testing included glycerin (negative) and histamine (positive). Subjects were tested with a battery of 14 to 30 allergens selected to reflect local, endemic allergens specific to the geographic site of the study.

Sleep questionnaires

A score of 60 or greater was considered suggestive of SDB on the OSA18 because validation studies have shown that

scores over 60 correlate with moderate to severe OSA.⁶ The PSQ can be divided into a number of subscales; in this study we evaluated the sleepiness and SDB subscales separately.⁵ Scores greater than 0.33 are considered suggestive of sleepiness and SDB, respectively. A score greater than 15 on the PDSS is suggestive of sleepiness in children.⁷

Statistical analysis

Standard statistical analysis, including descriptive statistics and the Mann-Whitney *U* test, was used to evaluate outcome instrument score differences between the allergy patients evaluated and normal values derived from a cohort of 113 patients who had previously undergone CI (Graph Pad Instat, GraphPad Software, San Diego, CA). Values of $p < 0.05$ were used to determine significance throughout the analysis.

Results

Overall, 21 patients with allergy were evaluated and compared to 113 children who had previously undergone CI who served as controls. Demographic information is found in Table 1.

SDB

SDB was suggested in 19% (4/21) of children with allergy by the OSA18, but in only 6% of the children having undergone CI ($p = 0.029$). In addition, the PSQ-SDB score suggested SDB in 29% (6/21) of the allergy patients vs 7% of the children having undergone CI ($p = 0.003$). Patients with allergy had SDB and sleepiness scores higher than population normal values and controls: OSA-18 of 41.7 vs 34.0, PSQ-SDB of 0.25 vs 0.14 (Table 2). The difference between cases and controls was significant for all measures of sleepiness and SDB (Fig. 1).

Sleepiness

Daytime sleepiness was suggested in 48% of children using the PSQ-sleepiness scale vs 17% of children having undergone CI ($p = 0.015$). Additionally, sleepiness

TABLE 1. Baseline demographics

	Allergy patients (n = 21)	Control patients (n = 113)	<i>p</i>
Sex, n (%)			0.116
Male	14 (67.7)	53 (46.9)	
Female	7 (33.3)	60 (53.1)	
Race, n (%)			0.299
White	13 (61.9)	83 (73.4)	
Black	4 (19.0)	13 (11.5)	
Other	4 (19.0)	17 (15.0)	
Age, mean (SD)	9.45 (4.43)	9.95 (4.69)	0.741

SD = standard deviation.

Sleepiness and SDB in Children with Allergies versus Controls

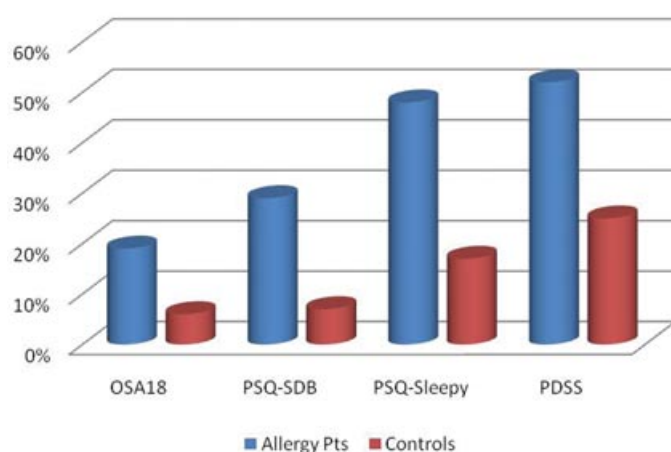


FIGURE 1. Sleepiness and SDB in children with allergy vs controls. SDB = sleep-disordered breathing.

screening using the PDSS found that 45% of allergy patients are sleepy vs 25% of controls ($p = 0.025$). Patients with allergy had sleepiness scores significantly higher than controls and population normal values (Table 2).

Discussion

Allergy and SDB are common childhood illnesses in the United States, and a vast number of resources are used for their diagnosis and treatment. Allergic rhinitis occurs in approximately 7% of the pediatric population.^{8,9} OSA affects approximately 2% to 4% of children and, left untreated, can result in serious behavioral and health problems, such as poor school performance, hyperactivity, hypertension, arrhythmias, cor pulmonale, and failure to thrive.^{10,11} In addition, snoring alone has been associated with nocturnal blood pressure elevation and decreased neurocognitive issues.^{12,13} Given the significant health consequences of untreated SDB, it is important to identify risk factors for and symptoms of OSA and SDB. This study was designed to examine the association between allergic rhinitis and SDB using validated questionnaires.

Previous work has focused on uncovering the link between allergic rhinitis and sleep disorders, especially SDB. Chng et al.² sought to identify both the prevalence and risk factors of snoring in a pediatric population. This large, questionnaire-based study of over 11,000 Asian schoolchildren found snoring in 28.1% and habitual snoring in 6.0%. On multivariate logistic regression analysis, habitual snoring was found to be significantly associated with obesity, allergic rhinitis, atopic dermatitis, maternal smoking, and breastfeeding. However, atopy was the risk factor most strongly associated with habitual snoring. Another study of Asian schoolchildren by Anuntaseree et al.¹⁴ examined a sample of 1142 first-grade schoolchildren at randomly

selected schools in Southern Thailand. In that study, 8.5% were found to be habitual snorers, and there was a significant association between snoring and allergic rhinitis. A subsequent study by Kalra et al.¹⁵ of habitual snorers under the age of 1 year also found a significant association between positive atopic status and habitual snoring. Taking this theory further, McColley et al.³ performed a prospective study of 39 children with habitual snoring referred for polysomnography. In vitro allergy testing studies were performed on patients prior to the administration of polysomnographic tests. In this study, 36% of the patients had sensitivity to allergens, which is higher than expected for the general pediatric population. The frequency of OSA was significantly increased in those patients with positive RASTs compared to those with negative tests.³ The authors concluded that patients with OSA who have features of allergic disease should be assessed for allergy.

There are several theories on the pathophysiologic link between allergic rhinitis and SDB. One possible mechanism for the relationship between allergic rhinitis and SDB is that allergies may stimulate adenotonsillar hypertrophy. Modrynski and Zawisza¹⁶ studied adenoid hypertrophy in children with atopy ($n = 436$) with any or all of the following: allergic rhinitis, asthma, and atopic dermatitis. In comparison to controls ($n = 229$), the children with allergic rhinitis were found to have significantly increased the probability of adenoid hypertrophy. In the allergic group with adenoid hypertrophy, the most common allergens were to pollen and molds. Further study by Huang and Giannoni¹⁷ also found a significantly higher prevalence of positive reactivity to mold in those subjects with allergy and with adenoid hypertrophy.

Another hypothesis concerning the relationship between allergic rhinitis and SDB is that increased nasal resistance, resulting from allergic rhinitis, contributes to the formation of upper airway obstruction. Prior studies have shown nasal congestion to be an independent risk factor for SDB, as detailed in a review and analysis of the literature on this topic¹⁸; the authors of that review concluded that SDB can both result from and be worsened by nasal obstruction. Persistent mouth-breathing in childhood can lead to the classic "adenoid facies," with elongation of the mid-face and retrognathia.¹⁹ These changes in facial growth may potentially further predispose children with increased nasal resistance to SDB. In addition, insomnia has been associated with allergic rhinitis²⁰; however, no questions specific to insomnia were investigated in this study.

The current study demonstrates that children with allergic rhinitis are at an increased risk of SDB when compared to those without allergic rhinitis. This suggests that a high degree of suspicion for SDB should be applied to children with allergic rhinitis, and that these children with allergy and features of disruptive sleep or snoring should undergo further evaluation for OSA.

Limitations in this study include the small sample size, as the parents of only 21 pediatric patients with positive skin-prick allergy testing submitted the validated sleep

TABLE 2. Individual sleep screening questionnaire results for allergic patients*

Patient ID	Age	Sex	Race	OSA18	PSQ				PDSS
					Snore	Behavior	SDB	Sleepy	
1	10.7	F	A	18	0.00	0.33	0.09	0.00	9
2	17.9	M	W	19	0.00	0.00	0.00	0.00	12
3	12.1	M	W	23	0.50	0.50	0.32	0.25	14
4	4.8	M	W	24	0.00	0.00	0.00	0.00	5
5	6.2	F	W	25	0.00	0.17	0.05	0.00	10
6	5.3	M	W	33	0.00	0.33	0.14	0.25	16
7	4.8	M	O	34	0.25	0.00	0.23	0.50	NR
8	5.4	M	W	42	0.00	0.50	0.32	0.75	16
9	6.2	M	B	46	0.25	0.17	0.18	0.25	19
10	8.8	F	W	47	0.50	0.33	0.27	0.00	11
11	15.3	F	W	47	0.00	0.67	0.36	0.75	17
12	9.3	M	B	48	0.75	0.33	0.41	0.50	18
13	11.6	F	W	53	0.00	0.00	0.18	0.50	NR
14	13.2	M	W	54	0.25	0.83	0.50	0.75	21
15	5.8	M	W	59	1.00	1.00	0.73	0.75	17
16	14.9	M	W	83	1.00	0.67	0.73	0.50	24
17	9.3	M	B	48	0.75	0.33	0.41	0.50	18
18	13.2	M	W	54	0.25	0.83	0.50	0.75	22
19	9.5	M	B	60	0.75	0.33	0.55	0.75	28
20	5.8	M	W	59	1.00	1.00	0.73	0.75	14
21	14.9	M	W	83	1.00	0.67	0.73	0.50	25
Mean	9.5			41.7	0.21	0.30	0.25	0.34	14.2
SD	4.3			18.7	0.35	0.29	0.21	0.32	7.0
Criteria				≥60	>0.33	>0.33	>0.33	>0.33	>15
Positive				19%	29%	29%	29%	48%	45%
Control mean				34.04	0.06	0.25	0.14	0.15	11.35

A = Asian; B = Black; F = female; M = male; NR =; O = other; OSA18 = Obstructive Sleep Apnea-18; PDSS = Pediatric Daytime Sleepiness Scale; PSQ = Pediatric Sleep Questionnaire; SD = standard deviation; SDB = sleep-disordered breathing; W = White.

questionnaires. In addition, all pediatric questionnaire-based studies are limited by the fact that caregivers, not the patients themselves, complete the evaluations. In addition, data on height, weight, and oral-nasopharyngeal examination were not captured. While control patients were negative for allergic symptoms by report, they did not undergo formal allergy testing for confirmation. However, the presence of allergies in this population would actually minimize the difference between populations and would therefore be expected to decrease the likelihood of significantly different findings between groups. Ideally, further studies will have larger sample sizes and include patients from multiple institutions. In addition, measurement of sleep disorders, and specifically SDB, would ideally be carried out with confirmation by polysomnography and completion of sleep questionnaires specifically designed to evaluate disorders such

as insomnia. Despite these limitations, the data presented here do support the hypothesis that there is a relationship between AR and SDB.

Conclusion

Children testing positive for allergy have significantly higher SDB and sleepiness scores when compared to controls. These findings support the hypothesis that children with allergy determined by skin-prick testing are more likely to have SDB. Given the increased risk of SDB in these children, screening should be considered in patients with atopy and patients with allergic rhinitis. In addition, further study is recommended to better understand the link between allergic rhinitis and SDB.

References

1. Lumeng JC, Chervin RD. Epidemiology of pediatric obstructive sleep apnea. *Proc Am Thorac Soc*. 2008;5:242–252.
2. Chng SY, Goh DY, Wang XS, Tan TN, Ong NB. Snoring and atopic disease: a strong association. *Pediatr Pulmonol*. 2004;38:210–216.
3. McColley SA, Carroll JL, Curtis S, Loughlin GM, Sampson HA. High prevalence of allergic sensitization in children with habitual snoring and obstructive sleep apnea. *Chest*. 1997;111:170–173.
4. Carr E, Obholzer R, Caulfield H. A prospective study to determine the incidence of atopy in children undergoing adenotonsillectomy of obstructive sleep apnea. *Int J Pediatr Otorhinolaryngol*. 2007;71:19–22.
5. Chervin RD, Hedger K, Dillon JE, Pituch KJ. Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Med*. 2000;1:21–31.
6. Franco RA Jr, Rosenfeld RM, Rao M. First place—resident clinical science award 1999. Quality of life for children with obstructive sleep apnea. *Otolaryngol Head Neck Surg*. 2000;123(1 Pt 1):9–16.
7. Drake C, Nickel C, Rothe T, Jefferson C, Pietro B. The pediatric daytime sleepiness scale (PDSS): sleep habits and school outcome in middle-school children. *Sleep*. 2003;26:455–458.
8. Sampson HA, Eggleston PA. Allergy. In: Oski FA, DeAngelis CD, Feigin RD, et al., eds. *Principles and Practice of Pediatrics*. Philadelphia: JB Lippincott; 1990:195–201.
9. Luoma R, Koivikko A, Viander M. Development of asthma, allergic rhinitis, and atopic dermatitis by the age of 5 years. *Allergy*. 1983;38:339–346.
10. Ali NJ, Pitson DJ, Stradling JR. Snoring, sleep disturbance and behavior in 4–5 year olds. *Arch Dis Child*. 1993;68:360–366.
11. Marcus CL, Carroll JL. Obstructive sleep apnea syndrome. In: Loughlin GM, Eigen H, eds. *Respiratory Disease in Children: Diagnosis and Management*. Baltimore, MD: Williams and Wilkins; 1993:475–499.
12. Kohler MJ, Lushington K, van den Heuvel CJ, Martin J, Pamula Y, Kennedy D. Adenotonsillectomy and neurocognitive deficits in children with sleep disordered breathing. *PLoS One*. 2009;4:e7343.
13. Li AM, Au CT, Ho C, Fok TF, Wing YK. Blood pressure is elevated in children with primary snoring. *J Pediatr*. 2009;155:362–368.e1.
14. Anuntaseree W, Rookkapan K, Kuasirikul S, Thongsuksai P. Snoring and obstructive sleep apnea in Thai school-age children: prevalence and predisposing factors. *Pediatr Pulmonol*. 2001;32:222–227.
15. Kalra M, Lemasters G, Bernstein D, et al. Atopy as a risk factor for habitual snoring at age 1 year. *Chest*. 2006;129:942–946.
16. Modrzynski M, Zawisza E. An analysis of the incidence of adenoid hypertrophy in allergic children. *Int J Pediatr Otorhinolaryngol*. 2007;71:713–719.
17. Huang SW, Giannoni C. The risk of adenoid hypertrophy in children with allergic rhinitis. *Ann Allergy Asthma Immunol*. 2001;87:350–355.
18. Rappai M, Collop N, Kemp S, deShazo R. The nose and sleep-disordered breathing, what we know and what we do not know. *Chest*. 2003;124:2309–2323.
19. Bresolin D, Shapiro PA, Shapiro GG, Chapko MK, Dassel S. Mouth breathing in allergic children: its relationship to dentofacial development. *Am J Orthod*. 1983;83:334–340.
20. Ferguson BJ. Influences of allergic rhinitis on sleep. *Otolaryngol Head Neck Surg*. 2004;130:617–629.