

Association between allergic rhinitis and poor sleep parameters in U.S. adults

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Background: Evidence suggests relationships between allergic rhinitis (AR) and poor sleep parameters, but population-based studies in the United States are lacking. This study investigates the relationship between AR and sleep parameters in a representative sample of U.S. adults.

Methods: Cross-sectional study of 5563 participants ≥ 18 years old from the 2005–2006 National Health and Nutrition Examination Survey who participated in the allergy and sleep questionnaires. The predictor variable was AR (self-reported hay fever and/or nasal symptoms in the past 12 months). The outcome variables were individual sleep parameters (sleep latency, sleep duration, sleep disorders, sleep habits, sleep medication use, daytime dysfunction). Covariates included age, gender, race, and obesity.

Results: The population-weighted prevalence of AR was 36.5%. Adjusting for covariates, subjects with AR had higher odds of sleep latency ≥ 30 minutes (OR 1.24; 95% CI, 1.01 to 1.51; $p = 0.04$), sleep apnea (OR 1.86; 95% CI, 1.22 to 2.82; $p < 0.01$), insomnia (OR 1.85; 95% CI, 1.04 to 3.32; $p = 0.04$), trouble falling asleep (OR 1.43; 95% CI, 1.17 to 1.75; $p < 0.01$), waking up during the night (OR 1.49; 95% CI, 1.11 to 1.99; $p = 0.01$), waking up too early in the morning (OR 1.46; 95% CI, 1.20 to 1.79; $p < 0.01$), feeling unrested during the day (OR 1.76, 95% CI, 1.43 to 2.16; $p < 0.01$), feeling

overly sleeping during the day (OR 1.54; 95% CI, 1.25 to 1.90; $p < 0.01$), not getting enough sleep (OR 1.68; 95% CI, 1.41 to 1.99; $p < 0.01$), using sleep medication (OR 1.69; 95% CI, 1.23 to 2.33; $p < 0.01$), difficulty concentrating (OR 1.93; 95% CI, 1.30 to 2.88; $p < 0.01$), remembering (OR 1.91; 95% CI, 1.22 to 2.97; $p < 0.01$), managing finances (OR 1.68; 95% CI, 1.09 to 2.56; $p = 0.02$), working (OR 2.16; 95% CI, 1.45 to 3.22; $p < 0.01$), and getting things done (OR 2.35; 95% CI, 1.36 to 4.06; $p < 0.01$) due to daytime sleepiness.

Conclusion: This analysis of a representative sample of U.S. adults revealed associations between AR and poor sleep parameters including prolonged sleep latency, insomnia, sleep apnea, sleep disturbances, sleep medication use, and daytime dysfunction. These findings reinforce the need to assess sleep quality in patients undergoing evaluation for AR. © 2018 ARS-AAOA, LLC.

Key Words:

allergic rhinitis; patient reported outcome measure; quality of life; aeroallergen; sleep

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Allergic rhinitis (AR) is a type 1 hypersensitivity reaction of the nasal mucosa mediated by immunoglobulin-E

(IgE) and T helper 2 (TH2) cells in response to inhaled environmental allergens.¹ AR is estimated to affect 10% to 20% of U.S. adults.^{2,3} The most commonly reported symptom of AR is nasal obstruction, which results from mucosal edema and may lead to sleep impairment in affected individuals.^{4,5} Nasal obstruction has also been shown to increase upper airway resistance and play a role in obstructive sleep apnea syndrome (OSAS).⁶ In addition to nasal obstruction, systemic release of mediators of AR such as inflammatory cytokines and histamine may lead to decreased cognition and arousal, as well as daytime somnolence.^{7,8}

While the literature suggests an association between AR and sleep disordered breathing (SDB) in children,⁹ the literature assessing specific sleep disturbances associated with AR in adults is inconsistent. One previous study reported that up to 57% of adult AR sufferers report sleep

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difficulty,¹⁰ and a survey of 3831 AR sufferers revealed that only 3.6% experienced 100% sleep adequacy, with significantly reduced work and school productivity.¹¹ Another survey revealed that 38% of allergy sufferers reported difficulty falling asleep and 42% reported lack of a good night's sleep.¹² Conversely, a German study of 119 patients presenting with OSAS symptoms reported no differences in sleeping behavior or polysomnography (PSG) parameters between allergic and nonallergic patients,¹³ and a Turkish study of 150 patients presenting with OSAS symptoms reported no association between sleep latency or PSG findings and perennial AR.¹⁴

However, there remains a paucity of evidence about the relationship between AR, sleep disturbances, and OSAS in the U.S. adult population. The National Health and Nutrition Examination Survey (NHANES) is an ongoing population-based survey conducted by the U.S. Centers for Disease Control and Prevention, with the purpose of estimating disease prevalence.¹⁵ The purpose of this study is to investigate the relationship between AR and sleep disturbances in a representative sample of U.S. adults.

Subjects and methods

The primary institution for this work was Johns Hopkins University, Baltimore, MD.

Data source

The NHANES uses a complex stratified multistage sampling design to select a nationally representative sample of non-institutionalized U.S. civilians to participate in a series of comprehensive health-related interviews and examinations every 2 years. Recruitment and testing are performed across the United States, with 15 different counties visited yearly. NHANES purposefully oversamples larger numbers of certain subgroups of particular public health interest including Mexican Americans, African Americans, and persons 60 years of age or older, in order to increase the reliability and precision of the health-related information gathered about these demographic groups. The NHANES protocols were approved by the National Center for Health Statistics research ethics review board and informed consent was obtained from all participants.

Demographics

Participating subjects' age, gender, and race were collected in a demographic questionnaire. NHANES investigators categorized race and ethnicity into 5 categories: Mexican American, Other Hispanic, Non-Hispanic Black, Non-Hispanic White, and Non-Hispanic Other or Multi-Racial. For this analysis, race was classified as White, Black, Hispanic, and Other. Subjects' body mass indices (BMIs) were obtained from the body measurements examination, and obesity was defined as BMI ≥ 30 kg/m².

Allergy questionnaire

The NHANES allergy component was administered in the 2005–2006 cycle and consisted of 3 parts: (1) collecting self-reported allergic diseases information through household interview questionnaires; (2) analyzing allergen and endotoxin from dust extract; and (3) measuring total and allergen-specific IgE from a blood sample drawn at the NHANES mobile examination site. The laboratory analysis of sensitization to specific serum IgE antigens was performed using the Pharmacia Diagnostics ImmunoCAP 1000 System (Kalamazoo, MI) and included perennial aeroallergens (*Dermatophagoides farinae*, *Dermatophagoides pteronyssinus*, cat, dog, mouse, rat, cockroach, *Alternaria*, and *Aspergillus*), seasonal aeroallergens (ragweed, rye grass, Bermuda grass, oak, birch, thistle), and food allergens (peanut, egg, milk, and shrimp). For each allergen, a positive result was defined as a serum level at or above the detection limit, and a negative result was defined as a serum level below the lower detection limit.

This study included analyses of questionnaire data, but did not include analyses of endotoxin from dust extracts and serum allergen-specific IgE data. The questionnaire included questions about common allergic diseases such as hay fever, allergies, and eczema, as well as symptoms associated with these conditions. For this analysis, allergic rhinitis was defined as an answer of “yes” to either of these 2 questions: “During the past 12 months, have you had an episode of hay fever?” and/or “During the past 12 months, have you had a problem with sneezing, or a runny, or blocked nose when you did not have a cold or the flu?”

Sleep questionnaire

A detailed sleep questionnaire was administered in 2005–2006 and 2007–2008 NHANES cycles to subjects aged 16 years and older and included questions on sleep duration, sleep latency, sleep quality, sleep disturbances, use of sleep medication, and daytime dysfunction.

Participants were asked how many hours of sleep they usually got at night on weekdays or workdays (sleep duration), and their answers ranged from 1 to ≥ 12 hours. For this analysis, subjects reporting 1, 2, or 3 hours of sleep were recategorized as ≤ 3 hours, and subjects reporting 10, 11, or ≥ 12 hours were recategorized as ≥ 10 hours, because this recategorization ensured that all categories were comprised of at least 1% of the total study population. Participants were also asked how long it usually took to fall asleep at bedtime (sleep latency), and their answers ranged from 0 to ≥ 60 minutes. For this analysis, sleep latency was further dichotomized at 0 to 29 minutes and ≥ 30 minutes (quantitative criteria for insomnia).¹⁶

Participants reported whether or not a doctor has told them that they have a sleep disorder. If they answered yes, they were further asked whether the sleep disorder was sleep apnea, insomnia, restless leg syndrome, or other. Subjects were also asked 2 questions to assess for symptoms of

sleep-disordered breathing, which is an umbrella term that encompasses a wide spectrum of sleep-related breathing abnormalities including snoring, upper airway resistance syndrome, and obstructive sleep apnea.¹⁷ For this analysis, the questions “How often in the past month do you snore while sleeping?” and “How often in the past month do you snort, gasp, or stop breathing while you are asleep?” were dichotomized at ≤ 2 nights per week and ≥ 3 nights per week based on other studies in the literature about sleep-disordered breathing using data from NHANES.^{18,19} Sleep-disordered breathing was further categorized as (1) none (no snoring, snorting, gasping, stop breathing, or sleep apnea), (2) snoring (but no snorting, gasping, stop breathing, or sleep apnea), (3) snorting, gasping, stop breathing (but no sleep apnea), (4) sleep apnea, and (5) unknown sleep-disordered breathing status due to incomplete responses on the questionnaire.

Subjects were also asked about their sleep habits in the past month with regard to individual sleep disturbances including trouble falling asleep, waking up during the night, waking up too early in the morning, feeling unrested during the day, feeling overly sleeping during the day, and not getting enough sleep. Patients were also asked whether or not they used sleep medications. These questions were dichotomized at ≤ 4 days per month and ≥ 5 days per month based on other studies in the literature utilizing the NHANES sleep questionnaire.^{18,19}

Subjects were also asked a subscale of questions from the Functional Outcomes of Sleep Questionnaire²⁰ about whether or not they had difficulty with certain daytime activities (concentrating on tasks, remembering things, finishing a meal, working on a hobby, taking care of finances, performing at work, maintaining a phone conversation, getting things done) due to being tired or sleepy. For this analysis, these questions were dichotomized at “no or little difficulty” and “moderate or extreme difficulty.”

Study population

The study population for this analysis included subjects from the 2005–2006 NHANES cycle who were aged 18 years and older at the time of NHANES participation and participated in the allergy and sleep questionnaires. Data from 16-year-old and 17-year old subjects were excluded because this study aimed to investigate AR and sleep in the U.S. adult population.

Data analysis

U.S. population-weighted baseline demographic characteristics and sleep parameters were calculated for the study population and compared across subjects with and without AR using the design-adjusted Rao-Scott Pearson-type χ^2 and Wald tests for categorical and continuous variables, respectively. A series of univariate logistic regression analyses was performed to identify whether or not AR was an independent predictor for each of the sleep outcomes.

Multivariate logistic regression analyses with further adjustment for age, gender, race, and obesity were performed.

A post hoc series of multivariate logistic regressions were performed to further investigate the role of positive serum IgE on sleep parameters. Sleep parameters were compared in patients with positive serum IgE and patients with negative serum IgE, regardless of allergy symptoms. Additionally, multivariate analyses was repeated to investigate whether or not AR was an independent predictor for each of the sleep outcomes, adjusting for age, gender, race, obesity, and positive serum IgE status.

In an effort to most accurately calculate confidence intervals around estimates for the U.S. population, all data analysis was performed using 2-year population-weighted data, calculating standard errors of population estimates using Taylor linearization methods. Analyses were performed using Stata (version 12.0; Stata Statistical Software, College Station, TX)

Results

Population characteristics

The 2005–2006 NHANES included 5563 subjects aged 18 years and older, all of whom were eligible to participate in the sleep and allergy questionnaires. The population-weighted mean age was 45.6 years (95% confidence interval [CI], 44.0 to 47.2 years), the proportion of females was 51.8% (95% CI, 50.7% to 52.9%), the proportion white, black, Hispanic, and other race was 71.4% (95% CI, 65.2% to 76.9%), 11.8% (95% CI, 8.1% to 16.7%), 11.5% (95% CI, 8.9% to 14.7%), and 5.4% (95% CI, 4.3% to 6.8%), respectively (Table 1).

Among the 5563 subjects in the study population, 1797 had AR, 3759 did not have AR, and 7 subjects had unknown AR status because they did not answer the relevant questions in the allergy questionnaire. The population-weighted prevalence of AR was 36.5%. Subjects with AR were more likely to be female (55.2% vs 49.8%, $p = 0.01$), white (78.2% vs 67.5%, $p < 0.01$), and have serum positivity to aeroallergen IgE (21.5% vs 13.8%, $p < 0.01$) compared to subjects without AR (Table 1).

Table 2 describes the sleep characteristics in the total study population as well as the subpopulation of subjects with and without AR. The mean sleep latency was 20.6 minutes, and the mean sleep duration was 6.9 hours per night. The overall population weighted prevalence of snoring, snorting/gasping/stop breathing, and sleep apnea was 31.1%, 8.1%, and 4.3%, respectively, and did not differ between patients with and without AR. Patients with AR were more likely to self-report insomnia compared to patients without AR (1.6% vs 0.9%, $p < 0.05$), and were also more likely to report each of the individual sleep disturbances ($p < 0.01$ for all comparisons), sleep medication use (12.0% vs 7.1%, $p < 0.01$), and difficulty with 6 of 8 of the functional outcomes.

TABLE 1. Demographic characteristics of the study population*

Characteristic	No allergic rhinitis	Allergic rhinitis	Total population	p
Age (years), mean (95% CI)	45.2 (43.7–46.8)	46.2 (44.3–48.2)	45.6 (44.0–47.2)	0.1
Age, % (95% CI)				0.2
18–29 years	23.0 (20.3–26.0)	19.7 (17.3–22.4)	21.8 (19.4–24.4)	
30–39 years	18.5 (15.9–21.4)	18.1 (14.9–21.9)	18.4 (16.0–20.9)	
40–49 years	19.6 (16.9–22.7)	22.3 (20.0–24.8)	20.6 (18.3–23.2)	
50–59 years	16.8 (14.8–19.0)	17.5 (15.3–20.0)	17.1 (15.4–18.9)	
60–69 years	10.7 (9.3–12.4)	10.4 (8.8–12.3)	10.6 (9.2–12.2)	
70–79 years	7.0 (5.7–8.7)	7.9 (5.5–11.2)	7.3 (5.7–9.4)	
≥80 years	4.3 (3.4–5.5)	4.1 (3.0–5.5)	4.2 (3.3–5.4)	
Gender, % (95% CI)				0.01
Male	50.2 (48.0–52.4)	44.8 (42.6–47.0)	48.2 (47.1–49.3)	
Female	49.8 (47.7–52.0)	55.2 (53.0–57.42)	51.8 (50.7–52.9)	
Race, % (95% CI)				<0.01
White	67.5 (60.2–74.0)	78.2 (73.4–82.4)	71.4 (65.2–76.9)	
Black	13.2 (9.0–18.9)	9.2 (6.4–13.1)	11.8 (8.1–16.7)	
Hispanic	13.7 (10.5–17.6)	7.7 (5.9–1.0)	11.5 (8.9–14.7)	
Other	5.7 (4.4–7.3)	4.8 (3.5–6.6)	5.4 (4.3–6.8)	
Obesity, % (95% CI)				0.3
No	66.9 (63.5–70.0)	65.3 (61.4–69.0)	66.3 (63.1–69.3)	
Yes	33.1 (30.0–36.5)	34.8 (31.1–38.6)	33.7 (30.7–36.9)	
All aeroallergen IgE, % (95% CI)				<0.01
Negative	80.2 (77.8–82.3)	72.9 (70.7–74.9)	77.5 (75.8–79.1)	
Positive	13.8 (11.6–16.3)	21.5 (19.5–23.7)	16.6 (14.7–18.7)	
Unknown	6.1 (4.7–7.8)	5.7 (4.0–8.0)	5.9 (4.7–7.5)	

*Values are weighted estimates of U.S. population characteristics, taking into account NHANES' complex sampling design. Allergic rhinitis is defined as an answer of "yes" to either of these 2 questions: "During the past 12 months, have you had an episode of hay fever?" and/or "During the past 12 months, have you had a problem with sneezing, or a runny, or blocked nose when you did not have a cold or the flu?" Obesity was defined as body mass index ≥ 30 kg/m². Positive IgE is defined as serum positivity to any aeroallergen (cat, dog, mouse, rat, cockroach, dust mite, mold, weed, grass, tree). CI = confidence interval; IgE = immunoglobulin E; NHANES = National Health and Nutrition Examination Study.

A series of multivariate logistic regression analyses were performed to investigate the relationship between AR and each of the sleep parameter outcomes (Fig. 1, Table 3). Adjusting for age, gender, race, and obesity, subjects with AR had 24% higher odds of sleep latency ≥ 30 minutes, 86% higher odds of sleep apnea, 85% higher odds of insomnia, 43% higher odds of trouble falling asleep, 49% higher odds of waking up during the night, 46% higher odds of waking up too early in the morning, 76% higher odds of feeling unrested during the day, 54% higher odds of feeling overly sleeping during the day, 68% higher odds of not getting enough sleep, and 69% higher odds of using sleeping pills, compared to subjects without AR. Subjects with AR also had 93% higher odds of difficulty with concentrating on tasks, 91% higher odds of difficulty remembering things,

68% higher odds of difficulty managing finances, 2.2 times higher odds of difficulty performing at work, and 2.4 times higher odds of getting things done due to being too sleepy or tired, compared to patients without AR.

On additional subanalyses, sleep parameters were not poorer in subjects with positive IgE compared to subjects with negative IgE, irrespective of AR symptoms, suggesting that allergen sensitization alone was not a predictor for poor sleep (Table 3). Finally, in a series of post hoc multivariate analyses with further adjustment for serum IgE status, the association between AR symptoms and sleep apnea, insomnia, all of the sleep disturbances, sleep medication use, and 5 of the functional outcomes remained statistically significant (Table 3).

TABLE 2. Sleep characteristics of the study population*

Characteristic	No allergic rhinitis	Allergic rhinitis	Total population	p
Sleep latency (minutes), mean (95% CI)	19.7 (18.6–20.9)	22.2 (20.9–23.5)	20.6 (19.7–21.6)	<0.01
Sleep latency, % (95% CI)				<0.01
<30 minutes	66.8 (63.2–70.2)	62.7 (58.9–66.4)	65.3 (62.4–68.2)	
≥30 minutes	33.2 (29.8–36.8)	37.3 (33.7–41.1)	34.7 (31.8–37.7)	
Sleep duration (hours), mean (95% CI)	6.9 (6.9–7.0)	6.9 (6.8–7.0)	6.9 (6.8–7.0)	0.3
Sleep duration, % (95% CI)				0.5
<7 hours	35.1 (32.6–37.7)	36.4 (32.7–40.4)	35.6 (33.3–38.0)	
≥7 hours	64.9 (62.3–67.4)	63.6 (59.6–67.3)	64.4 (62.0–66.7)	
Sleep disordered breathing, % (95% CI)				0.07
No	44.2 (41.8–46.6)	39.4 (34.7–44.3)	42.4 (39.8–45.1)	
Snoring	30.5 (28.0–33.0)	32.1 (29.1–35.3)	31.1 (28.8–33.5)	
Snorting	7.6 (5.9–9.8)	8.9 (6.7–11.7)	8.1 (6.8–9.6)	
Sleep apnea	3.4 (2.6–4.6)	5.8 (4.6–7.1)	4.3 (3.6–5.1)	
Unknown	14.3 (12.8–15.9)	13.8 (11.1–17.2)	14.1 (12.8–15.6)	
Insomnia, % (95% CI)	0.9 (0.1–1.4)	1.6 (0.1–2.6)	1.2 (0.8–1.7)	0.05
Restless leg syndrome, % (95% CI)	0.3 (0.2–0.7)	0.7 (0.4–1.2)	0.5 (0.3–0.7)	0.15
Sleep habits in past 1 month, % (95% CI)				
Trouble falling asleep	14.1 (12.5–15.8)	19.1 (17.0–21.5)	15.9 (14.7–17.3)	<0.01
Wake up during night	17.5 (15.9–19.4)	24.8 (21.1–28.9)	20.2 (18.9–21.6)	<0.01
Wake up too early	14.9 (13.2–16.9)	20.8 (18.5–23.3)	17.1 (15.6–18.7)	<0.01
Feel unrested	21.8 (20.1–23.7)	33.8 (30.2–37.7)	26.2 (24.5–28.0)	<0.01
Feel overly sleepy	15.9 (14.5–17.3)	22.9 (20.1–26.0)	18.4 (17.2–19.8)	<0.01
Not enough sleep	22.1 (20.5–23.9)	32.1 (28.7–35.8)	25.8 (24.0–27.6)	<0.01
Sleeping pills, % (95% CI)	7.1 (5.5–9.0)	12.0 (9.8–14.7)	8.9 (7.5–10.6)	<0.01
Daytime dysfunction, % (95% CI)				
Concentrating	3.3 (2.5–4.3)	5.8 (5.6–7.2)	4.2 (3.6–4.9)	<0.01
Remembering	2.8 (2.1–3.7)	4.8 (3.6–6.5)	3.5 (2.9–4.3)	0.01
Eating	0.6 (0.4–0.9)	0.8 (0.5–1.2)	0.7 (0.5–0.9)	0.28
Hobby	2.2 (1.6–2.9)	3.3 (2.3–4.6)	2.6 (2.0–3.3)	0.04
Finances	2.0 (1.5–2.6)	3.2 (2.2–4.5)	2.4 (1.9–3.1)	0.02
Working	1.4 (1.1–1.9)	3.0 (2.1–4.4)	2.0 (1.5–2.6)	<0.01
Phone	1.4 (1.0–1.9)	2.0 (1.4–3.0)	1.6 (1.2–2.2)	0.08
Getting things done	1.6 (1.2–2.3)	3.7 (2.4–5.7)	2.4 (1.8–3.2)	<0.01

*Values are weighted estimates of U.S. population characteristics taking into account NHANES' complex sampling design. Snoring, snorting, gasping, and stop breathing were dichotomized at ≤2 nights per week and ≥3 nights per week. Sleep habit and sleeping pill questions were dichotomized at ≤4 days per month and ≥5 days per month. Daytime dysfunction questions were dichotomized at "no or little difficulty" and "moderate or extreme difficulty." CI = confidence interval; NHANES = National Health and Nutrition Examination Study.

Allergic Rhinitis & Sleep Parameters

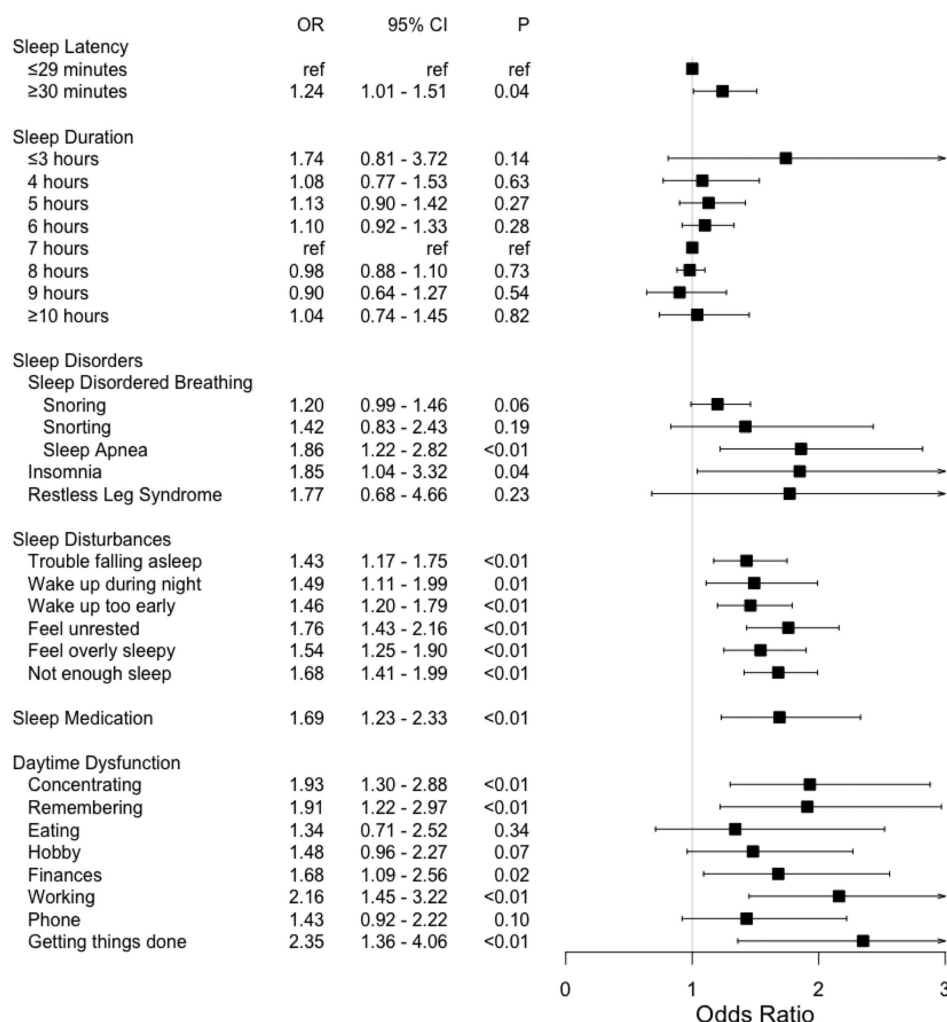


FIGURE 1. Multivariate logistic regression analyses investigating the association between allergic rhinitis and individual sleep parameters. CI = confidence interval; OR = odds ratio.

Discussion

There is a growing body of literature exploring the relationship between AR and sleep in adult patients. However, despite multiple studies assessing this relationship, it is still unclear how AR affects specific sleep parameters. The largest population-level study assessing the affect of AR on sleep quality was performed in 2009.¹¹ This study surveyed 3831 AR sufferers in the United States, specifically with respect to their quality of sleep, cognition, quality of life, and productivity. The authors found that AR sufferers had lower mean sleep adequacy scores and a higher degree of sleep problems, with patients with more severe AR symptoms reporting worse sleep. While this study did show a relationship between poorer sleep and AR at a U.S. population level, and was further able to show an association between poorer quality of life and decreased productivity in these patients, no specific sleep parameters were measured. Namely, the survey did not include data

on specific parameters such as sleep latency, sleep duration, difficulty with waking up at night, and the use of sleeping pills. There was also no assessment of daytime dysfunction, as measured by inability to perform daily tasks due to excessive sleepiness. Moreover, this study did not attempt to define any relationship between AR and SDB or OSAS.

The current study utilizes NHANES data to assess the relationship between AR and specific sleep parameters in U.S. adults on a population level. These data suggest that patients with AR symptoms experience subjectively poorer quality sleep, as evidenced by significant associations between AR and all individual sleep disturbances. Furthermore, patients with AR symptoms and positive confirmatory allergen specific IgE testing also have significant associations with sleep disturbance. However, in the sensitized patient who exhibits positive allergy specific IgE testing, but lacks nasal symptoms of AR, this relationship is not demonstrated.

TABLE 3. Allergic rhinitis as a predictor for sleep parameters*

	Allergic rhinitis vs no allergic rhinitis ^a	Positive IgE vs negative IgE ^a	Allergic rhinitis vs no allergic rhinitis, with adjustment for IgE ^b
Sleep latency			
≥30 minutes	1.24 (1.01–1.51), 0.04	1.04 (0.84–1.29), 0.70	1.22 (0.99–1.49), 0.06
Sleep duration			
≤3 hours	1.74 (0.81–3.73), 0.14	1.27 (0.68–2.39), 0.43	1.82 (0.82–4.04), 0.13
4 hours	1.08 (0.77–1.53), 0.63	1.05 (0.65–1.68), 0.84	1.08 (0.75–1.56), 0.66
5 hours	1.13 (0.90–1.42), 0.27	1.21 (0.91–1.61), 0.17	1.17 (0.93–1.47), 0.18
6 hours	1.10 (0.92–1.33), 0.28	1.05 (0.78–1.40), 0.74	1.06 (0.88–1.29), 0.49
7 hours	Reference	Reference	Reference
8 hours	0.98 (0.88–1.10), 0.73	1.11 (0.94–1.31), 0.22	0.97 (0.86–1.09), 0.55
9 hours	0.90 (0.64–1.27), 0.54	1.42 (0.95–2.11), 0.08	0.89 (0.61–1.31), 0.53
≥10 hours	1.04 (0.74–1.45), 0.82	1.16 (0.62–2.18), 0.61	1.04 (0.68–1.58), 0.85
Sleep disorders			
Sleep disordered breathing			
Snoring	1.20 (0.99–1.46), 0.06	0.95 (0.72–1.27), 0.73	1.21 (0.98–1.49), 0.07
Snorting	1.42 (0.83–2.43), 0.19	1.20 (0.79–1.83), 0.36	1.50 (0.87–2.58), 0.14
Sleep apnea	1.86 (1.22–2.82), <0.01	1.36 (0.77–2.42), 0.27	1.92 (1.22–3.02), <0.01
Insomnia	1.85 (1.04–3.32), 0.04	0.35 (0.13–0.94), 0.04	1.84 (1.07–3.15), 0.03
Restless leg syndrome	1.77 (0.68–4.66), 0.23	0.10 (0.01–0.92), 0.04	1.82 (0.68–4.85), 0.22
Sleep habits			
Trouble falling asleep	1.43 (1.17–1.75), <0.01	0.94 (0.72–1.22), 0.62	1.43 (1.16–1.75), <0.01
Wake up during night	1.49 (1.11–1.99), 0.01	1.03 (0.81–1.29), 0.82	1.51 (0.12–2.03), 0.01
Wake up too early	1.46 (1.20–1.79), <0.01	1.18 (0.95–1.47), 0.13	1.45 (1.19–1.78), <0.01
Feel unrested	1.76 (1.43–2.16), <0.01	0.94 (0.74–1.19), 0.57	1.70 (1.39–2.08), <0.01
Feel overly sleepy	1.54 (1.25–1.90), <0.01	0.95 (0.73–1.24), 0.70	1.49 (1.20–1.85), <0.01
Not enough sleep	1.68 (1.41–1.99), <0.01	1.00 (0.79–1.25), 0.99	1.66 (1.37–2.02), <0.01
Sleep medication	1.69 (1.23–2.33), <0.01	0.91 (0.63–1.33), 0.61	1.69 (1.20–2.37), <0.01
Daytime dysfunction			
Concentrating	1.93 (1.30–2.88), <0.01	1.01 (0.66–1.53), 0.97	1.85 (1.24–2.75), <0.01
Remembering	1.91 (1.22–2.97), <0.01	0.57 (0.37–0.89), 0.02	2.02 (1.30–3.11), <0.01
Eating	1.34 (0.71–2.52), 0.34	0.54 (0.20–1.47), 0.21	1.40 (0.72–2.73), 0.30
Hobby	1.48 (0.96–2.27), 0.07	1.00 (0.63–1.57), 0.99	1.47 (0.97–2.22), 0.07
Finances	1.68 (1.09–2.56), 0.02	0.84 (0.51–1.39), 0.48	1.79 (1.17–2.72), 0.01
Working	2.16 (1.45–3.22), <0.01	0.92 (0.57–1.51), 0.74	2.33 (1.41–3.85), <0.01

Continued

TABLE 3. Continued

	Allergic rhinitis vs no allergic rhinitis ^a	Positive IgE vs negative IgE ^a	Allergic rhinitis vs no allergic rhinitis, with adjustment for IgE ^b
Phone	1.43 (0.92–2.22), 0.10	1.28 (0.66–2.48), 0.44	1.51 (0.92–2.47), 0.09
Getting things done	2.35 (1.36–4.06), <0.01	0.90 (0.59–1.36), 0.59	2.38 (1.33–4.26), <0.01

*All values are OR (95% CI), *p*. Allergic rhinitis is defined as an answer of “yes” to either of these 2 questions: “During the past 12 months, have you had an episode of hay fever?” and/or “During the past 12 months, have you had a problem with sneezing, or a runny, or blocked nose when you did not have a cold or the flu?” Positive IgE is defined as serum positivity to any aeroallergen (cat, dog, mouse, rat, cockroach, dust mite, mold, weed, grass, tree). Snoring, snorting, gasping, and stop breathing were dichotomized at ≤ 2 nights per week and ≥ 3 nights per week. Sleep habit and sleeping pill questions were dichotomized at ≤ 4 days per month and ≥ 5 days per month. Daytime dysfunction questions were dichotomized at “no or little difficulty” and “moderate or extreme difficulty.”

^aMultivariate logistic regression adjusting for age, gender, race, and obesity.

^bMultivariate logistic regression adjusting for age, gender, race, obesity, and IgE.

CI = confidence interval; IgE = immunoglobulin E; OR = odds ratio.

Moreover, this analysis revealed that sufferers of AR symptoms are 43% more likely to report difficulty falling asleep than patients without AR, which is consistent with literature suggesting that patients with AR have more trouble falling asleep than patients without AR.^{11,12,14,21,22} However, there is a paucity of objective evidence about sleep latency in AR sufferers. In this study, the mean sleep latency for the NHANES study population was approximately 20 minutes, which is similar to what is reported in the literature for normal subjects.²³ However, patients with AR were significantly more likely to report an abnormally long sleep latency of ≥ 30 minutes. A sleep latency of ≥ 30 minutes is clinically consistent with insomnia, and may be associated with an increased risk of depression and decreased health-related quality of life.^{24–27}

This study also revealed that patients with self-reported AR were nearly twice as likely to self-report a diagnosis of OSAS, confirming an association between AR and OSAS. Previous studies have failed to show a consistent association between AR and changes in PSG parameters such as apnea-hypopnea index or respiratory disturbance index,^{13,14,28} and while some studies suggest that pharmacotherapy for AR may improve sleep quality,^{21,29,30} there is no evidence to date that treatment of AR improves OSAS. However, these results demonstrating a population level association between AR and OSAS suggest that further studies assessing the effects of AR pharmacotherapy and immunotherapy on OSAS in AR sufferers are warranted.

Furthermore, this analysis revealed that patients with AR symptoms were significantly more likely to suffer from daytime dysfunction, including difficulty concentrating on tasks, remembering things, managing finances, performing at work, and getting things done, due to excessive sleepiness. These results add to a growing body of literature suggesting that AR symptoms negatively impact patients' quality of life by causing stress, fatigue, daytime somnolence, impaired performance, productivity, and social functioning.^{11,12,31}

There are several limitations to the current study. The NHANES is a cross-sectional database without any longitudinal follow-up, so it is not possible to draw conclusions

about the direction of causation or the mechanism of the hypothesized association. Since AR was defined by self-reported symptoms, it is possible that some subjects with self-reported sneezing and/or runny nose may have been misclassified as having AR when they actually had a different type of rhinitis, such as vasomotor or nonallergic rhinitis. Furthermore, nasal endoscopy was not performed, so there was no objective measurement of the severity of nasal inflammation in this study population. Similarly, the sleep questionnaire consisted of self-reported data, so this study could not objectively assess the relationship between AR and PSG parameters. Additionally, while the NHANES does oversample racial groups such as blacks and Hispanics, these may not be generalizable to individuals belonging to smaller ethnic groups such as Asians and other minorities that were not oversampled in NHANES.

Despite these limitations, these population level data show a strong association between AR and prolonged sleep latency, OSAS, sleep disturbances, sleep medication use, and daytime dysfunction even with adjustment for age, gender, race, and obesity. These associations provide a basis for future large-scale and prospective studies assessing AR, severity of sleep disturbances, and OSAS. Furthermore, future studies assessing the impact of specific allergen sensitization may help to target which allergy sufferers at higher risk for sleep disturbances.

Conclusion

AR is a common inflammatory condition that leads to nasal obstruction and the release of systemic inflammatory mediators that may affect sleep quality. While this relationship has been extensively studied in the literature, few studies have assessed the specific impact of AR on sleep in U.S. adults on a population level. This study revealed associations between AR symptoms and poor sleep quality, as measured by individual prolonged sleep latency, insomnia, OSAS, sleep disturbances, sleep medication use, and daytime dysfunction in U.S. adults. These findings reinforce the need to assess sleep quality in patients undergoing evaluation for AR. 

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