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Habitual snoring coexisting with respiratory allergies in children: Prevalence and impact on quality of life extending beyond primary snoring

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ABSTRACT

Background: Children who have respiratory allergies are more likely to experience sleep disturbances. Persistent sleep-disordered breathing directly contributes to poor symptom control for asthma and allergic rhinitis, including deterioration in quality of life. This study aimed to investigate the prevalence, risk factors of habitual snoring, and the correlation between 18-item obstructive sleep apnea (OSA-18) scores and the level of asthma and allergic rhinitis (AR) symptoms control for habitual snorers with respiratory allergies.

Material and methods: A cross-sectional design was conducted on Thai children aged 2 to 15 who were diagnosed with asthma and AR in a respiratory allergy clinic at the Medical Education Center. The Pediatric Sleep Questionnaire was used to determine the prevalence of habitual snoring. Patients with habitual snoring completed the OSA-18 quality of life questionnaire, which was divided into 5 subscales: sleep disturbance, physical symptoms, emotional distress, daytime function, and caregiver concerns. Symptom control for asthma and AR was evaluated according to the Global Initiative for Asthma (GINA) guidelines and the Visual Analog Scales (VAS), respectively. Multivariable logistic regression models and adjusted odds ratios were used to assess associations.

Results: A total of 565 participants were enrolled, and 363 (64.2%) were male. Habitual snoring had the highest prevalence of sleep-disordered breathing in 29.6% of patients with respiratory allergies. Patients with poorly controlled symptoms had a significantly higher risk of habitual snoring than well controlled symptoms for AR (52.0% vs 19.1%, adjusted Odds Ratio: aOR 4.39, 95%CI 2.25–8.58, $p < 0.001$) and for asthma concomitant with AR (54.9% vs. 18.8%, aOR 5.18, 95%CI 2.52–10.68, $p < 0.001$). Habitual snorers with poorly controlled asthma negatively affected their quality of life more than those with well controlled asthma (37.7% vs 13.3%, $p = 0.005$), as did patients with underlying AR (46.2% vs 22.9%, $p = 0.002$). In comparison to habitual snorers with well controlled symptoms, those with poorly controlled symptoms for respiratory allergies had higher mean the OSA-18 scores across all subscales.

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Conclusion: Nearly one-third of children with respiratory allergies develop habitual snoring. Poorly controlled symptoms of asthma and allergic rhinitis raise the possibility of developing habitual snoring. Their quality of life and caregivers were shown to be affected just as negatively as those with obstructive sleep apnea (OSA) syndrome.

Keywords: Asthma, Pediatrics, Prevalence, Rhinitis, Snoring

INTRODUCTION

Habitual snoring is classified as sleep-disordered breathing in patients who experience noisy snoring more than 3 nights a week.[1] Habitual snoring presented with abnormal ventilation is associated with a high risk of developing obstructive sleep apnea syndrome in patients who lack attentive monitoring and improper treatment.[2] Children with habitual snoring have significantly lower cognitive performance than those who never snore,[3] and they have more inattention, hyperactive behavior, and emotional problems.[4] Habitual snoring is associated with risk of stroke,[5] coronary heart disease,[5] and diabetes mellitus[6] from adolescence through adulthood.

Several studies have reported the prevalence of habitual snoring in pediatric populations worldwide, which varies in school-aged children by 4.9%–17.1% in Western countries,[7] 12% in China,[7] 10.9% in Hong Kong,[8] and 6.9% in Thailand.[9] There was a report of atopic young children who had a positive skin-prick test response for both common outdoor and indoor allergens, which found that they had significantly increased the prevalence of habitual snoring by 21.5%.[10] Habitual snoring was identified with an odds ratio of 7.5 among preschool and primary school children who had been diagnosed with asthma, allergic rhinitis, and atopic dermatitis.[11]

Pediatric patients who have sleep-disordered breathing coexisting with respiratory allergies not only tend to have more difficulty controlling allergy symptoms but also experience worsening quality of life.[12] However, a standard checklist for screening patients with sleep-disordered breathing has not been widely used in respiratory allergy clinics in community hospitals in Thailand.[13]

Therefore, the objectives of this study were to ascertain the prevalence and risk factors for habitual snoring in pediatric patients attending our respiratory allergy clinic and the relationship between the 18-item obstructive sleep apnea (OSA-18) scores and the level of symptoms control for respiratory allergies in habitual snorers with underlying diseases asthma or allergic rhinitis.

METHODS

Sample size calculation

We calculated the sample size using the prevalence of patients with habitual snoring who had been diagnosed with allergic rhinitis and asthma in the study by Chng SY et al,[11] who estimated the proportion to be 20.7% with a confidence level of 95%. The degree of precision sought was 3.5% of the estimated proportion. This study assumed that 5% of the data was incomplete, and the required sample size was 545 participants.

Study design and subjects

A cross-sectional design was conducted in pediatric patients aged 2–15 years who had been diagnosed with asthma and moderate-to-severe symptoms of allergic rhinitis by pediatric allergists and pulmonologists in accordance with the clinical diagnostic criteria recommended in the Global Initiative for Asthma (GINA) guidelines and the Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines, respectively.[14,15]

All of them visited the allergy clinic at a tertiary care hospital between March 2021 and September 2023. Patients who had been diagnosed with craniofacial abnormalities, neuromuscular diseases, gastroesophageal reflux disease, Down syndrome, bronchopulmonary dysplasia, cardiovascular diseases, and chronic lung diseases other

than asthma were excluded. In addition, we also excluded patients diagnosed with upper airway infections and rhinosinusitis in the week preceding the follow-up period.

Patients 5 years of age or younger were diagnosed as having asthma if they had at least 3 recurrent wheezing episodes annually, a clear response to bronchodilators as confirmed by a physician, and any of the following symptoms: (1) cough, wheezing, and difficulty breathing for more than 10 days during a respiratory tract infection; (2) symptoms triggered by exercise, laughing, crying, or exposure to air pollution, especially in the apparent absence of respiratory tract infection; (3) recurrent or persistent nonproductive cough, which may worsen at night or at the time of awakening; or (4) risk factors for developing asthma, such as family history of asthma in one or more first-degree relatives or personal history of food allergy or atopic dermatitis.[14,16]

Patients older than 5 years were diagnosed as having asthma if their pulmonary function tests in accordance with the GINA recommendations reliably indicated asthma based on peak expiratory flow measurements or a spirometer to confirm variable expiratory airflow limitation, and they had previously experienced symptoms which responded to bronchodilators, such as wheezing, shortness of breath, chest tightness, and coughing. These symptoms usually get worse at night or at the time of waking up and are triggered by exercise, laughter, allergens, and cold air. They appear or worsen with respiratory tract infections.[14,16]

Patients enrolled in this study will be assessed for their asthma severity after 3–6 months of treatment according to standard asthma management guidelines.[14] The criteria used in our study for assessing asthma severity in children at follow-up are consistent with those recommended by the Global Initiative for Asthma (GINA) guidelines.[14] Asthma is classified as not severe if children can control their symptoms by using low to medium doses of inhaled corticosteroids daily, with or without long-acting beta2-agonists, or if adolescents 12 years of age and older can control their symptoms by using low to medium doses of inhaled corticosteroid-formoterol. In contrast, severe asthma in children refers to uncontrolled asthma symptoms while using high doses of inhaled corticosteroids daily, with or without long-acting beta2-agonists, or high doses of inhaled corticosteroid-formoterol for adolescents 12 years of age and older, or using these medications to prevent the occurrence of uncontrolled asthma.

Patients who had moderate-to-severe allergic rhinitis at diagnosis according to the ARIA recommendations[17] had symptoms that interfered with their ability to function in social situations, at work, or in school. These symptoms included sleep disturbance, impairment of daily activities, leisure and/or sport, impairment of school or work, and troublesome symptoms. Patients who had symptoms of allergic rhinitis, including rhinorrhea, nasal obstruction, nasal itching, and sneezing, that occurred less than 4 days a week or for less than 4 consecutive weeks, were classified as having "intermittent allergic rhinitis", while those with symptoms lasting more than 4 days a week and for more than 4 consecutive weeks were considered having "persistent allergic rhinitis". Regular use of intranasal corticosteroids was the first-line treatment for these participants with moderate-to-severe intermittent or persistent symptoms of allergic rhinitis.[18]

Questionnaire survey and data collection

Caregivers of all patients visiting the asthma clinic were required to complete questionnaires on the day of follow-up. We collected data on patients' demographics, family and perinatal history, and the educational and socioeconomic status of parents or caregivers, including a history of exposure to cigarette smoke. Weight and height are routinely recorded in the electronic hospital information system to calculate the body mass index (BMI; weight/height^2), which were classified by the Centers for Disease Control and Prevention into 4 categories based on age and gender-adjusted standard percentile curves: underweight, BMI $<$5th percentile; healthy weight, BMI 5th–84th percentile; overweight, BMI 85th–94th percentile; obesity, BMI $\geq$95th percentile).[19]

Additionally, each patient was assessed on the level of asthma symptom control within 4 weeks and allergic rhinitis symptom control within 1 week prior to the follow-up period by using the assessment of symptom control criteria of the GINA[14] and the Visual Analog Scales (VAS),[20] respectively. In our study, we defined patients who could achieve good asthma control as "well controlled asthma" while

those who had partly controlled or uncontrolled asthma were defined as "poorly controlled asthma".

Visual Analog Scales (VAS)

We designed the VAS as a horizontal straight line 100 mm long without demarcation. The starting point was labeled "0" (not at all severe) at the left-most end, while the endpoint was labeled "100" (extremely severe) at the right-most end. All patients with allergic rhinitis were to evaluate the VAS by themselves; if self-assessment was not possible, the caregiver was responsible for assessment instead. Our question was, "How severe or how often did you feel your symptoms or your child's symptoms in the past week?" Then, they drew a cross on each straight line at a point indicating the level of disease control for allergic rhinitis. This VAS questionnaire consisted of 5 separate questions, which were used to assess the following overall allergic rhinitis symptoms: 1) nose congestion; 2) sneezing; 3) watery discharge or itchy eyes; 4) the burden of allergic rhinitis on sleep disturbance; and 5) the negative impact on daily activities.[20,21] The VAS was categorized into 3 levels of allergic rhinitis symptom control as follows: VAS <20 (well controlled allergic rhinitis), VAS 20–50 (partly controlled allergic rhinitis), and VAS scores >50 (uncontrolled allergic rhinitis).[22] To be consistent with the asthma control classification for our study, we divided the level of symptom control for allergic rhinitis into two categories: "well controlled allergic rhinitis" (VAS scores <20) and "poorly controlled allergic rhinitis" (VAS scores ≥ 20).

Pediatric Sleep Questionnaire (PSQ)

The Pediatric Sleep Questionnaire, which was used to identify potential cases of pediatric patients at high risk of obstructive sleep apnea, was adapted from the sleep questionnaire developed by Spruyt K et al.[23] In our study, all participants were required to complete the Pediatric Sleep Questionnaire to investigate the prevalence of habitual snoring and symptoms associated with high risk of sleep-disordered breathing.

These questions include whether your child has any of the following conditions, which can position them at a higher risk of developing sleep disordered breathing: 1) habitual snoring; 2) being shaken while sleeping to encourage breathing; 3) apnea during sleep; 4) struggling to breathe when asleep; 5) loud snoring; 6) breathing concerns while asleep; 7) falling asleep easily or being sleepy during the daytime or at school; 8) having behavioral or learning problems (aggression, inattention, hyperactivity, failed grades); 9) bruxism; 10) enuresis; 11) awake at night; 12) nightmare; and 13) morning headache. Patients who experienced noisy snoring more than 3 nights per week were diagnosed with habitual snoring.[1] Then, they were asked to complete the 18-item obstructive sleep apnea quality of life (OSA-18-QOL) questionnaire in order to assess their quality of life and that of their caregivers.

The 18-item obstructive sleep apnea quality of life (OSA-18-QOL) questionnaire

The OSA-18-QOL is a standardized questionnaire that assesses the impact on quality of life for children with obstructive sleep apnea in clinical settings.[24–26] However, we used this questionnaire for our clinical research to evaluate the impact on quality of life involving habitual snoring for patients with respiratory allergies. They underwent quality-of-life assessment where parents or caregivers were asked to answer a questionnaire containing the following questions: "How often have the following problems occurred in the past 4 weeks?" which consists of 18 questions and is divided into 5 subscales as follows: 1) sleep disturbance; 2) physical symptoms; 3) emotional distress; 4) daytime function; and 5) caregiver concerns. This questionnaire applied a Likert-type scoring system with a 7-point scale (1-none of the time, 2-hardly any of the time, 3-a little of the time, 4-some of the time, 5-a good bit of the time, 6-most of the time, 7-all of the time).[24] The total symptom score provides a quantitative measure of the impact on quality of life, with higher scores indicating a more negative impact. It was calculated from 18 (no impact on quality of life) to 126 (the most negative impact). The scores <60 and ≥ 60 are considered to have a minor and moderate to severe impact on quality of life, respectively.[25,27]

Statistical analysis

The raw data were analyzed by using the SPSS software (version 21 for Windows; SPSS Inc., Chicago, IL). Categorical variables were shown as numbers and percentages. The means (standard deviations) were given for the continuous variables. For parameter comparisons between

groups, the Pearson's chi-square test was used for categorical characteristics, and the independent sample *t*-test was used for continuous variables for comparisons between subgroup analyses. Univariate and multivariate logistic regression models were used to assess the odds ratio between the two groups of symptoms after controlling for the significant variable from the univariate logistic regression analysis. The adjusted odds ratio and 95% confidence interval (95% CI) for the two groups were calculated. A p-value <0.05 indicated the outcomes were statistically significant.

RESULTS

Characteristics of the patients with respiratory allergies

A total of 626 participants were diagnosed with respiratory allergies. 61 (9.7%) of them were excluded. The remaining 565 participants were enrolled in this study. They were divided into asthma (37/565, 6.6%), allergic rhinitis (190/565, 33.6%), and asthma concomitant with allergic rhinitis (338/565, 59.8%) groups. 167 participants with respiratory allergies had habitual snoring. They were divided into 2 groups for assessing the quality of life according to their underlying conditions. Of them, 63.5% (106/167) and 96.4% (161/167) of habitual snorers had at least 1 underlying asthma or allergic rhinitis, respectively. (Fig. 1)

Ultimately, a higher proportion of habitual snorers were boys (64.2%) than were girls (35.8%). The majority of patients (57.5%) developed habitual snoring between 5 and 11 years of age. A higher proportion of habitual snorers were overweight or obese than were those who did not habitually snore (43.4% vs. 32.9%, p = 0.044).398 participants with respiratory allergies were non-habitual snorers. Of these, (31/398, 7.8%) had asthma, allergic rhinitis (129/398, 32.4%) had allergic rhinitis, and (238/398, 59.8%) had asthma concomitant with allergic rhinitis. However, no

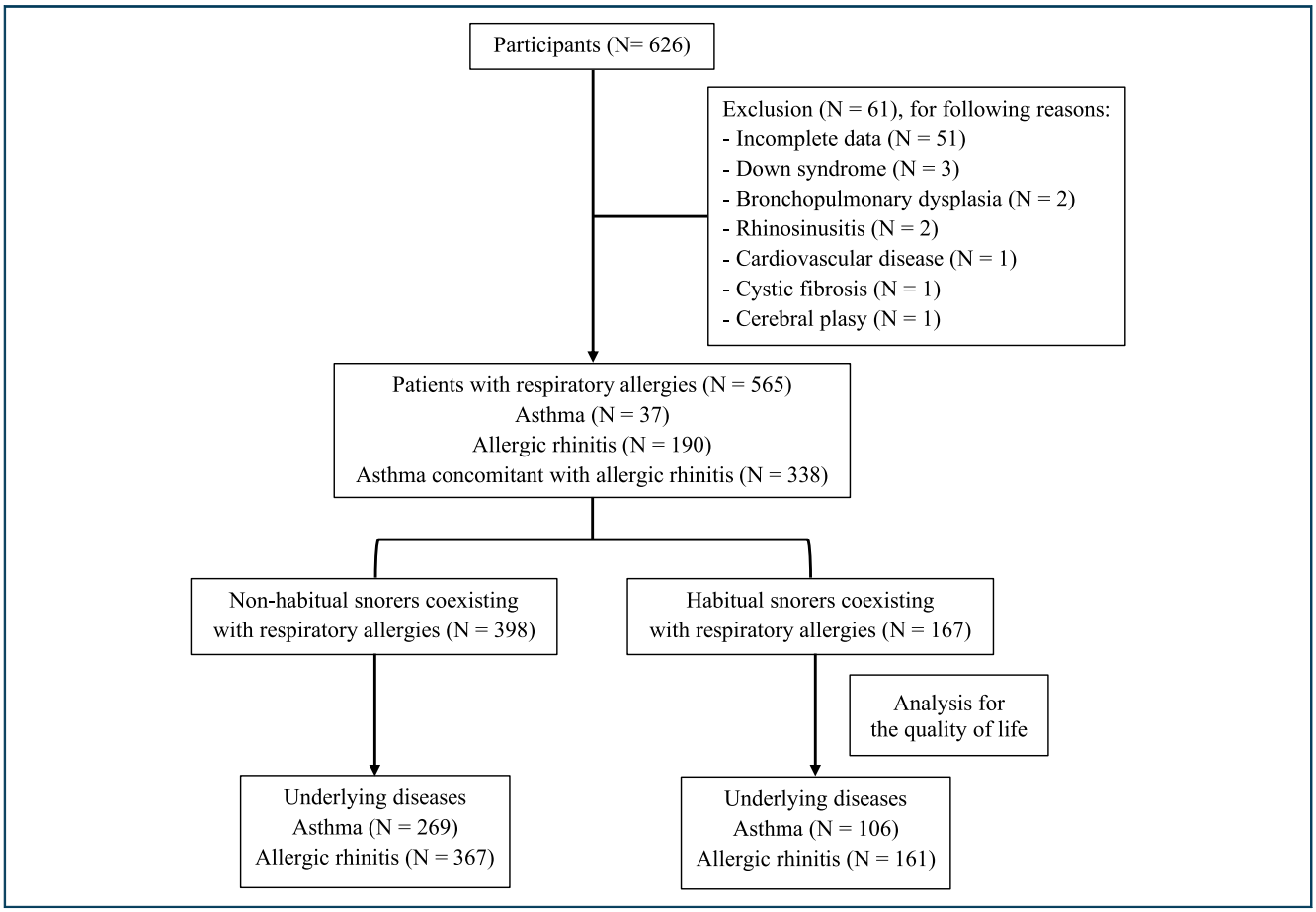

Fig. 1 Study flow diagram.

statistically significant difference was found between the group of patients who do not habitually snore and those who snore habitually when comparing the proportion of patients who were diagnosed with respiratory allergies and the severity of their symptoms. (Table 1)

Prevalence of symptoms related to sleep-disordered breathing and risk factors of habitual snoring

The symptom with the highest prevalence among pediatric patients with respiratory allergies was habitual snoring (29.6%), followed by breathing concerns while asleep (27.8%), struggling to breathe while sleeping (23.0%), and behavioral or learning problems such as aggression, inattention, hyperactivity, and failed grades (16.8%). Morning headaches affected them in the least proportion at 3.4%. (Fig. 2)

The prevalence of habitual snoring was found in patients who were diagnosed with asthma at 16.2%, allergic rhinitis at 32.1%, and asthma with allergic rhinitis at 29.6%. A higher proportion of children who had habitual snoring had poorly controlled allergic rhinitis compared with those who had well controlled symptoms. (52.0% vs. 19.1%, adjusted Odds Ratio: aOR 4.39; 95%CI 2.25–8.58, $p < 0.001$). Similarly, the proportion of habitual snorers who had poorly controlled asthma or allergic rhinitis in the asthma concomitant with allergic rhinitis group was higher than the proportion of patients with well controlled symptoms (33.6% vs. 18.8%, aOR 2.24; 95%CI 1.27–3.94, $p = 0.005$), and in the poorly controlled asthma and allergic rhinitis group it was 54.9% vs. 18.8%, aOR 5.18; 95%CI 2.52–10.68, $p < 0.001$. However, there was no significant association between habitual snoring and the level of symptom control occurring in patients who were diagnosed with asthma only. (Table 2)

The impact on quality-of-life

The patients with poorly controlled symptoms had a significantly higher risk of moderate to severe impact on quality of life than those with well controlled symptoms for asthma (37.7% vs 13.3%, $p = 0.005$) and for allergic rhinitis (46.2% vs 22.9%, $p = 0.002$). (Fig. 3A and B)

The subscales of 18-item obstructive sleep apnea (OSA-18) scores

The mean of composite scores for OSA-18 was significantly higher in patients with poorly controlled asthma (55.25 ± 15.87) than those with well controlled symptoms (38.0 ± 19.52) by mean difference of 17.25, 95% CI = 10.42 to 24.07, $p < 0.001$. Similarly, this is higher in patients with poorly controlled allergic rhinitis (56.27 ± 18.59) than those with well controlled symptoms (46.34 ± 20.37) by mean difference of 9.93, 95% CI = 3.85 to 16.02, $p = 0.002$.

The mean OSA-18 score in patients with poorly controlled asthma was significantly higher than in those with well controlled symptoms for the subscales of sleep disturbance; 10.7 ± 3.70 vs. 7.98 ± 4.05 by mean difference of 2.69, 95% CI = 1.19 to 4.20, $p = 0.001$, physical symptoms; 12.77 ± 4.63 vs. 8.22 ± 4.73 by mean difference of 4.56, 95% CI = 2.74 to 6.39, $p < 0.001$, emotional distress; 8.72 ± 4.64 vs. 5.58 ± 4.12 by mean difference of 3.14, 95% CI = 1.42 to 4.87, $p < 0.001$, daytime function; 8.20 ± 3.60 vs. 5.73 ± 3.66 by mean difference of 2.46, 95% CI = 1.05 to 3.87, $p = 0.001$ and caregiver concerns; 14.87 ± 5.73 vs. 10.49 ± 6.27 by mean difference of 4.38, 95% CI 2.06 to 6.70, $p < 0.001$. (Fig. 4A)

The mean OSA-18 score in patients with poorly controlled allergic rhinitis was significantly higher than those with well controlled symptoms for the subscales of sleep disturbance; 11.73 ± 4.37 vs 9.24 ± 3.96 by mean difference of 2.49, 95% CI = 1.19 to 3.79, $p < 0.001$, physical symptoms; 12.96 ± 5.10 vs 10.06 ± 5.06 by mean difference of 2.90, 95%CI = 1.32 to 4.48, $p < 0.001$, daytime function; 8.29 ± 3.86 vs 6.92 ± 3.99 by mean difference of 1.38, 95%CI = 0.16 to 2.60, $p = 0.017$, and caregiver concerns; 15.26 ± 6.37 vs. 12.90 ± 6.57 by mean difference of 2.35, 95% CI = 0.34 to 4.37, $p = 0.022$. However, there was no significant difference in emotional distress; 8.03 ± 4.68 vs 7.22 ± 5.08 by mean difference of 0.81, 95%CI = 0.71 to 2.33, $p = 0.296$. (Fig. 4B)

DISCUSSION

The prevalence and risk factors of habitual snoring in children who attended a respiratory allergy clinic

Characteristics	Total (N = 565)	%	Non-habitual snoring (N = 398)	%	Habitual snoring (N = 167)	%	p-value
Gender							0.803
Boys	363	64.2	257	64.6	106	63.5	
Girls	202	35.8	141	35.4	61	36.5	
Age groups (years)							0.575
2 to 4	139	24.6	99	24.9	40	23.9	
5 to 11	325	57.5	224	56.3	101	60.5	
12 to 15	101	17.9	75	18.8	26	15.6	
Gestational age at delivery							0.384
Preterm (<37 weeks)	62	11.0	39	9.8	23	13.8	
Term (≥37 weeks)	467	82.6	333	83.7	134	80.2	
Unrecognizable	36	6.4	26	6.5	10	6.0	
Duration of breast feeding							0.414
<6 months	282	49.9	197	49.5	85	50.9	
≥6 months	213	37.7	147	36.9	66	39.5	
Uncertain	70	12.4	54	13.6	16	9.6	
Number of siblings							0.806
0 to 1	265	46.9	187	47.0	78	46.7	
2 to 3	264	46.7	184	46.2	80	47.9	
≥4	36	6.4	27	6.8	9	5.4	
Body mass index (BMI), kg/m^2							**0.044**
Underweight, BMI <5th percentile	73[a]	13.0	51	12.9	22	13.2	
Healthy weight, BMI 5th – 84th percentile	286[a]	51.0	214	54.2	72	43.4	
Overweight and obesity, BMI ≥85th percentile	202[a]	36.0	130	32.9	72	43.4	
Parental education level							0.828
Up to primary school	61	10.8	41	10.3	20	12.0	
Up to secondary school	282	49.9	196	49.2	86	51.5	
Undergraduate or more	168	29.7	122	30.7	46	27.5	
No formal education	54	9.6	39	9.8	15	9.0	
Socio-economic status (US Dollar/month)							0.107
Low (<600)	307	54.4	206	51.7	101	60.5	
Mid (600–1500)	168	29.7	120	30.2	48	28.7	
High (>1500)	43	7.6	33	8.3	10	6.0	

(continued)

Characteristics	Total (N = 565)	%	Non-habitual snoring (N = 398)	%	Habitual snoring (N = 167)	%	p-value
Uncertainty of income	47	8.3	39	9.8	8	4.8	
Household smoking exposure							0.778
No	340	60.2	241	60.6	99	59.3	
Yes	225	39.8	157	39.4	68	40.7	
Diagnosis of respiratory allergies							0.153
Asthma	37	6.6	31	7.8	6	3.6	
AR	190	33.6	129	32.4	61	36.5	
Asthma with AR	338	59.8	238	59.8	100	59.9	
Patients with asthma (N = 37)							0.302
Mild asthma	35	94.6	30	96.8	5	83.3	
Severe asthma	2	5.4	1	3.2	1	16.7	
Patients with AR (N = 190)							0.077
Moderate-to-severe intermittent AR	143	75.3	102	79.1	41	67.2	
Moderate-to-severe persistent AR	47	24.7	27	20.9	20	32.8	
Patients with asthma and AR (N = 338)							0.059
Mild asthma and moderate-to-severe intermittent AR	271	80.2	197	82.8	74	74.0	
Mild asthma and moderate-to-severe persistent AR	32	9.4	19	8.0	13	13.0	
Severe asthma and moderate-to-severe intermittent AR	26	7.7	14	5.9	12	12.0	
Severe asthma and moderate-to-severe persistent AR	9	2.7	8	3.3	1	1.0	

Table 1. (Continued) Comparing the demographic and social characteristics of non-habitual and habitual snorers with respiratory allergies. *Note. p-value in bold font is significant. Abbreviation: AR; Allergic rhinitis. [a]Total of 561 patients had body mass index data available*

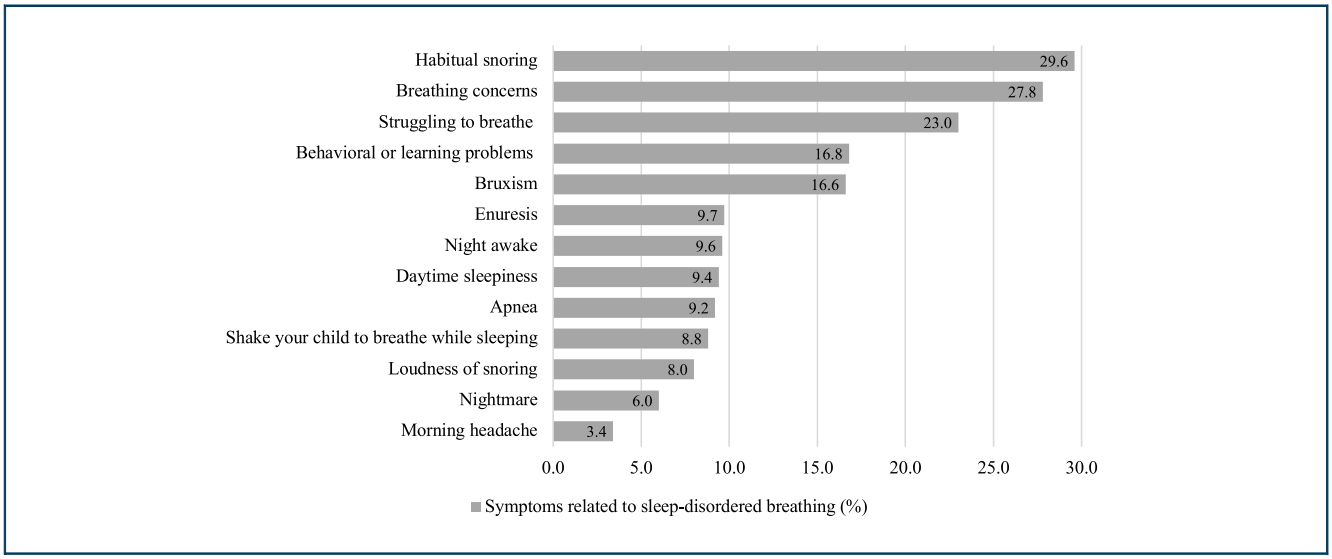

Fig. 2 Prevalence of habitual snoring and symptoms associated with high risk of sleep-disordered breathing (N = 565).

were reported in this study, along with the correlation between the 18-item obstructive sleep apnea scores and the level of asthma or allergic rhinitis symptoms control for those who were underlying these respiratory allergies coexisting with habitual snoring. We found that habitual snoring was the most frequently presented symptom of sleep disturbance in approximately 30% of pediatric patients with respiratory allergies, and poorly controlled symptoms of respiratory allergies were an independent risk factor for habitual snoring.

The overall prevalence of habitual snoring among Thai pediatric population at the age of 5 years was 13%, and this proportion decreased to 10.9% when they were followed up to 8 years of age.[28] However, our study found that the proportion is almost 3 times higher in children with coexisting respiratory allergies. Sogut A et al,[29] studied at primary schools and high schools and reported that the prevalence of habitual snoring in adolescents who had asthma was 2.6% and allergic rhinitis was 7.7%, which is a significant increase in the underlying disease of allergic rhinitis but not asthma when compared with patients with non-habitual snoring. However, this study did not consider pulmonary function tests to confirm a diagnosis of asthma in adolescents. Additionally, our study found that 16% of children with asthma and 32% of those with allergic rhinitis attending a respiratory allergy clinic reported habitual snoring, and the level of asthma control was not significant in determining the independent risk factor of habitual snoring. Similarly, a prospective cohort design by Gunnlaugsson S et al,[30] was conducted on school-age children with persistent asthma. The prevalence of sometime snoring (3–5 nights a week) was found to be as high as 20%. They also reported that the risk of this snoring was not associated with the worsening asthma control of these children when compared with non-snorers.

In contrast to our study, Guo, Y et al,[31] demonstrated that pediatric patients with poorly controlled asthma had almost three times significantly higher rates of sleep-related breathing disorders. This study applied the Pediatric Sleep Questionnaire scores >0.33 to define the high risk of sleep-related breathing disorders in their study population. However, they did not report such results by categorizing the spectrum of sleep disturbance conditions. The majority of studies do not reveal any mechanism that promotes a greater frequency of habitual snoring among patients with uncontrolled asthma. There is only a hypothesis that children with recurrent wheezes or asthma may develop central sleep apnea as a result of chronic systemic inflammation affecting abnormal breathing control of the central nervous system during sleep.[32] Furthermore, they had a significantly higher number of central sleep apnea episodes than children who did not have recurrent wheezes or asthma.[32]

We found that patients with poorly controlled allergic rhinitis have about a five-fold (adjusted odds ratio 4.39) increased risk of habitual snoring

Diagnosis of respiratory allergies	Total	Non-habitual snoring (%)	Habitual snoring (%)	Unadjusted Odds ratio (95% CI)	p-Value	Adjusted Odds ratio[a] (95% CI)	p-value
Asthma	37	31 (83.8)	6 (16.2)	1		1	
Well controlled asthma	29	25 (86.2)	4 (13.8)	2.08 (0.31–14.17)	0.446	2.24 (0.29–17.44)	0.442
Poorly controlled asthma	8	6 (75.0)	2 (25.0)				
Allergic rhinitis	190	129 (67.9)	61 (32.1)				
Well controlled AR	115	93 (80.9)	22 (19.1)	1		1	
Poorly controlled AR	75	36 (48.0)	39 (52.0)	**4.58 (2.39–8.76)**	**<0.001**	**4.39 (2.25–8.58)**	**<0.001**
Asthma with allergic rhinitis	338	238 (70.4)	100 (29.6)				
Well controlled asthma and AR	165	134 (81.2)	31 (18.8)	1		1	
Poorly controlled asthma or AR	122	81 (66.4)	41 (33.6)	**2.19 (1.27–3.76)**	**0.005**	**2.24 (1.27–3.94)**	**0.005**
Poorly controlled asthma and AR	51	23 (45.1)	28 (54.9)	**5.26 (2.68–10.34)**	**<0.001**	**5.18 (2.52–10.68)**	**<0.001**

Table 2. Univariable and multivariate analysis of habitual snoring and symptom control of respiratory allergies. *Note. p-values in bold font are significant. Abbreviations: AR; Allergic rhinitis, 95% CI; Confidence level of 95%.* [a]*Adjusted for body mass index (BMI) and severity of respiratory allergies*

when compared to patients who are effectively controlled. Likewise, a study reported that poorly controlled allergic rhinitis had higher odds of having sleep-related breathing disorders by 3.3.[31] However, they defined poorly controlled symptoms of allergic rhinitis using a visual analog scale ≥5 (or a visual analog scale ≥50 on a 100-mm scale), whereas our study described this condition as a visual analog scale ≥20. Furthermore, the increased severity of symptoms in allergic rhinitis patients appears to be directly related to more intensity of sleep disorders. Pediatric patients with moderate to severe allergic rhinitis had a 10-fold risk of severe obstructive sleep apnea syndrome.[33]

Nasal obstruction is the most common presenting symptom in children and adults with allergic rhinitis, which is a major contributor to upper airway obstruction, affecting sleep quality, and causing daytime sleepiness.[34–36] Another mechanism for explaining the relationship between allergic rhinitis and the consequences of sleep patterns is the secretion of inflammatory mediators that directly lead to exhaustion and abnormal functions of the autonomic nervous system, resulting in difficulty sleeping overnight and daytime tiredness.[34,37]

In a previous study, nearly 80% of patients with severe asthma exacerbations had allergic rhinitis as a major comorbidity.[38] Therefore, the majority (60%) of study participants had a diagnosis of asthma coexisting with allergic rhinitis. Allergic rhinitis was not only a major co-morbid disease of asthma, but it was also a risk factor for increasing the prevalence of sleep-disordered breathing in asthmatic patients.[39] Furthermore, pediatric patients whose asthma symptoms are uncontrollable because their allergic rhinitis symptoms are still persistent have sleep-disordered breathing as a concomitant disease.[39,40] We reported that both respiratory allergy symptoms together poorly controlled had about a five-fold (adjusted odds ratio 5.18) increased risk of developing habitual snoring when compared to these conditions well controlled. It is important for patients with asthma and allergic rhinitis to effectively manage their symptoms to reduce the risk of developing habitual snoring.

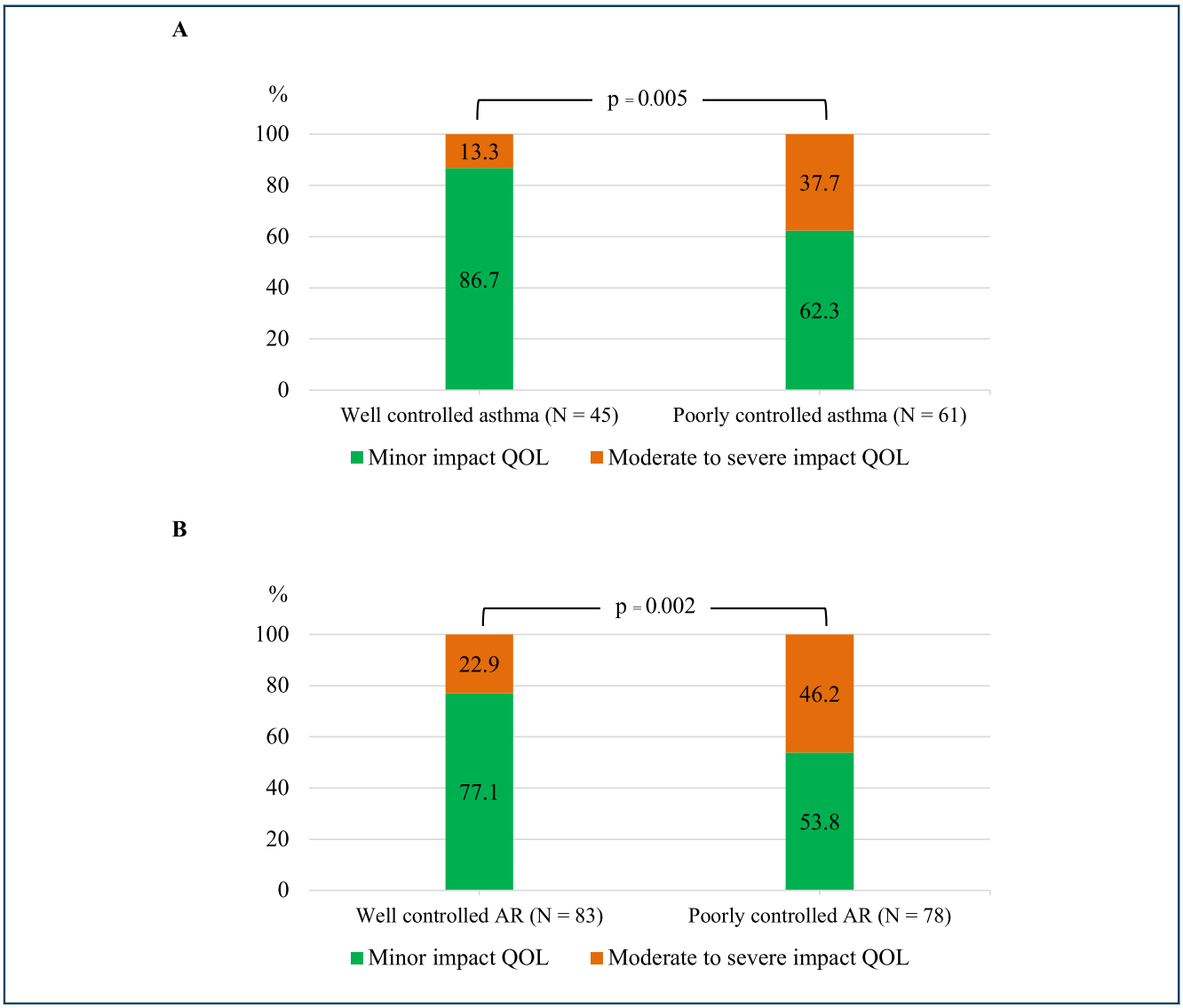

Fig. 3 Comparing the proportion of habitual snorers for impact on quality of life with the level of symptom control according to the underlying diseases of asthma (N = 106) (A) and allergic rhinitis (N = 161) (B). Abbreviations: AR; Allergic rhinitis, QOL; Quality-of-life.

Although the 18-item obstructive sleep apnea quality of life questionnaire was validated for assessing the burden on the quality of life of patients and caregivers with obstructive sleep apnea syndrome,[25] we conducted a study where habitual snorers with respiratory allergies completed this questionnaire to evaluate their impact by calculating the composite score. We have a hypothesis that habitual snoring, which is one of the spectrums of sleep-disordered breathing, may also influence impact on overall quality of life comparable to obstructive sleep apnea syndrome. Our findings revealed that habitual snoring indeed had a significant impact on overall quality of life, similar to obstructive sleep apnea syndrome. This is especially true when patients are unable to control their symptoms of respiratory allergies.

Pediatric patients with asthma or allergic rhinitis who also had sleep-disordered breathing tended to have more difficulty controlling allergy symptoms and they generally experienced a worse quality of life.[12,41,42] This deterioration in quality of life may be due to the progression of severity for allergic diseases, the inability to control a sleep-disordered breathing condition, or the respiratory allergies themselves.[41,42] However, a study of obstructive sleep apnea syndrome in adults demonstrated that the increase in disease severity from the analysis of the apnea-hypopnea

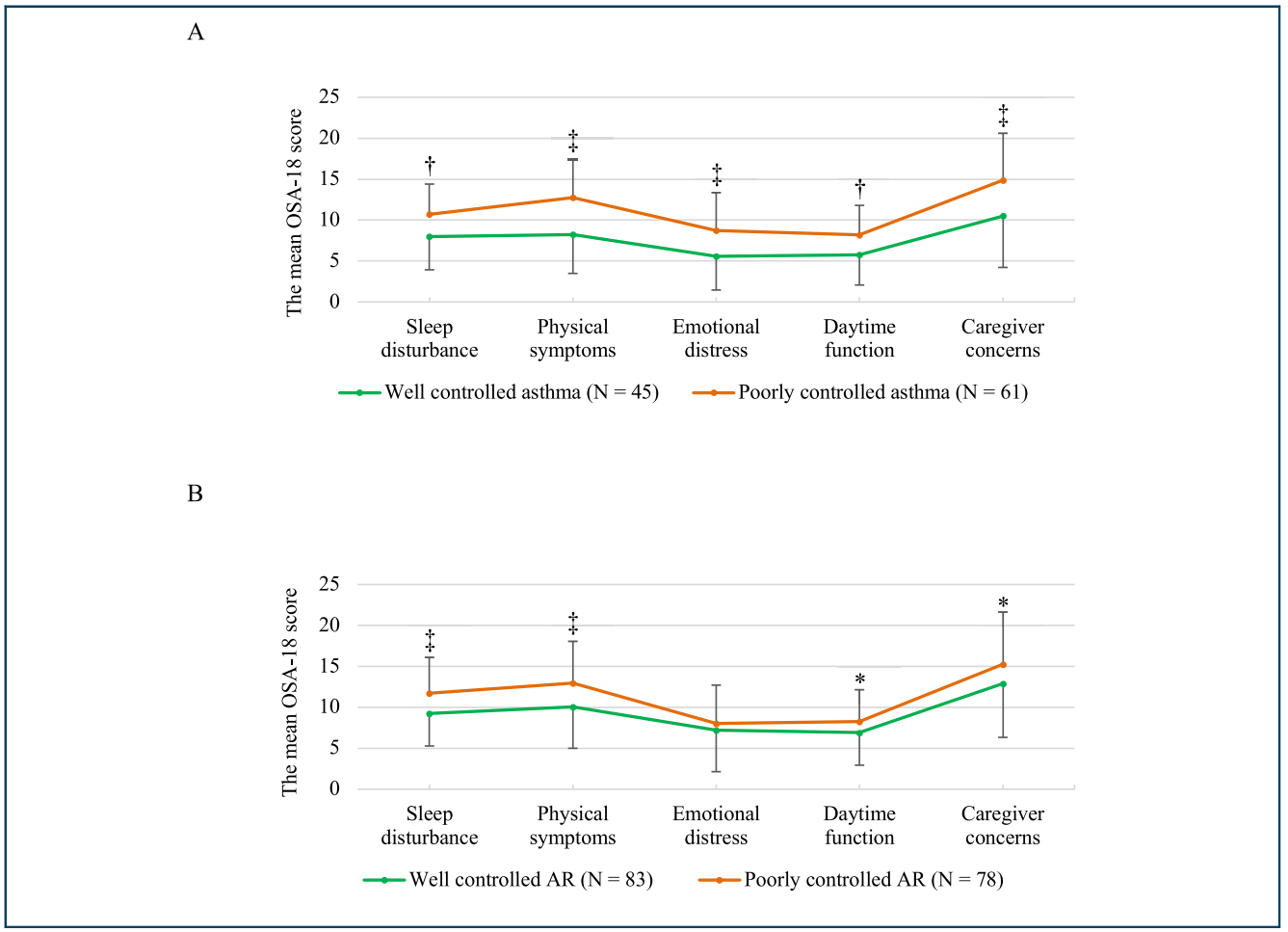

Fig. 4 Comparing the mean OSA-18 score for five subscales with the level of symptom control for the underlying disease of asthma (N = 106) (A) and allergic rhinitis (N = 161) (B). Note. The asterisk (*) indicates a significant ($P < 0.05$), the dagger (†) indicates a significant ($P < 0.01$), and the double dagger (‡) indicates a significant ($P < 0.001$) difference between symptom control. Abbreviations: AR; Allergic rhinitis, OSA-18, 18-item obstructive sleep apnea.

index (AHI) was not related to the deterioration of health-related quality of life. However, this study does not address comorbidities of respiratory allergies related to quality of life in the enrolled patients, which may be an important factor involved in the study endpoints.[43]

Our study demonstrated that habitual snorers with poorly controlled asthma and allergic rhinitis had problems with sleep, physical symptoms, behavioral and emotional disturbances, and deficits in daytime performance for pediatric patients, including increasing the anxiety of caregiver concerns. Furthermore, when management of allergy symptoms was not achieved, the mean 18-item obstructive sleep apnea scores across all modality groups were substantially higher in studied individuals with underlying respiratory allergies, with the exception of the emotional distress subscale for habitual snorers in the group of underlying allergic rhinitis.

In the case of habitual snorers suffering from persistent physical symptoms (mouth breathing, frequent colds or upper respiratory tract infections, rhinorrhea, and dysphagia), there appeared to be the most significant difference in the mean scores between poorly and well controlled symptoms for both groups of underlying diseases. This may be due to those symptoms, which are common in patients with uncontrolled respiratory allergies.[42] Likewise, adult patients diagnosed with obstructive sleep apnea syndrome concomitant with allergic rhinitis had a significant deterioration in the quality of life in terms of daytime sleepiness, physical and mental lethargy, an increased level of stress in daily activities, and also a higher score on the rhinoconjunctivitis

quality of life questionnaire (RQLQ) compared to patients without allergic rhinitis.[44]

A questionnaire for screening sleep-disordered breathing should be contained in the management guidelines for respiratory allergy clinics. In addition to assessment of disease control, this questionnaire should be assessed routinely during the follow-up period for early detection of sleep disturbances. Therefore, healthcare providers should diagnose habitual snoring or obstructive sleep apnea syndrome in order to provide treatment at an early stage, especially for patients who cannot achieve targeted control of symptoms of respiratory allergies and in cases where parents complain of any sleep problems in their children.[30,45,46] However, further studies are required to determine the prevalence of obstructive sleep apnea syndrome for pediatric patients in respiratory allergy clinics and to identify which factors are influencing the progression of disease to obstructive sleep apnea syndrome in habitual snorers suffering from uncontrolled respiratory allergies.

The first limitation of our study was that the pediatric patients visited the respiratory allergy clinic of the Medical Education Center of a provincial hospital, so our results may not be representative of those who attend clinics in other settings of Thailand. Secondly, we did not collect characteristics of patients with confirmed positive risk factors for habitual snoring, such as parents' history of habitual snoring and degree of tonsil enlargement.[29,47] We realized that it is difficult to obtain accurate history from patients who spontaneously snore, and the patency of the nasopharyngeal airway blockage could be ascertained more precisely using the adenoidal-nasopharyngeal ratio from a plain lateral radiograph, which showed a significant correlation with the symptom of snoring.[48,49]

Finally, polysomnography, the gold standard for identifying obstructive sleep apnea syndrome, was not performed on habitual snorers who may have been underdiagnosed with obstructive sleep apnea syndrome.[50] This procedure is expensive and requires specialists for interpretation, which were unavailable in our setting.[30,50] Therefore, the 18-item obstructive sleep apnea scores may be a result of patients with both sleep disturbance conditions. However, only 9% of habitual snorers developed mild to moderate obstructive sleep apnea syndrome over a three-year follow-up period.[9]

CONCLUSION

The prevalence of habitual snoring was approximately 30% in patients with respiratory allergies, and poorly controlled symptoms of respiratory allergies were independent risk factors for habitual snoring. There was a five-fold higher risk of developing habitual snoring in children with poorly controlled asthma and allergic rhinitis symptoms. They suffer in terms of quality of life, as do patients with obstructive sleep apnea syndrome, if their asthma and allergic rhinitis symptoms cannot be controlled. Therefore, screening for habitual snoring should be performed routinely in respiratory allergy clinics to identify and address this circumstance early. Additionally, effective management of respiratory allergies can potentially reduce the frequency of habitual snoring, thereby improving overall sleep quality and well-being in these patients.

Abbreviations

AR, Allergic rhinitis; BMI, Body mass index; OSA-18, 18-item obstructive sleep apnea; QOL, Quality-of-life; SDB, Sleep-disordered breathing; VAS, Visual analog scales.

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Kanlaya Prajongdee: Validation, investigation, project administration, data curation, and editing.

Availability of data and materials
The corresponding author will provide access to the data upon reasonable request, ensuring confidentiality and adherence to any applicable regulations.

Ethics
The study team discussed the questionnaire in great detail at each stage before administering it to participants at the respiratory allergy clinic, and this process was conducted anonymously. Parents or caregivers are allowed to decline their child's participation. Either by responding in writing or expressing a verbal refusal, they can express their preference or rejection of research participation at every follow-up visit. This decision will not affect the continued receipt of medical treatment for any illness by patients and their caregivers. Verbal or written informed consent was obtained from each participant or parent prior to the study, and this study was approved by the ethical committee of Buddhasothorn Hospital (Approval No. BSH-IRB 026/2563). The study was registered at www.clinicaltrials.in.th (Study ID: TCTR20210826003).

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