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Natural History of Snoring and Obstructive Sleep Apnea in Thai School-Age Children

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Summary. In 1999, a survey was carried out in 1,008 Thai children aged 7 years, which found that 85 (8.5%) children were habitual snorers, and 7 (0.69%) children had mild obstructive sleep apnea syndrome (OSAS). Since the natural history of snoring and untreated mild OSAS is still largely unknown, this study was undertaken in 2002 in the same group of children to determine the natural history of snoring and OSAS. Questionnaires, consisting of questions about snoring, were sent to the parents of the 1,008 children. Polysomnography was performed in 1) the 7 children who had OSAS in the previous survey, and 2) other habitual snorers who had sleep-related symptoms in this survey. Seventy-five percent of the questionnaires were returned. The prevalence of habitual snoring had decreased slightly, from 8.5% in 1999 to 6.9% in 2002. Sixty-five percent of the children who had snored habitually in the previous survey no longer did so, whereas 4.5% of the children who previously never snored or snored sometimes had become habitual snorers. Of the 7 children who had OSAS previously, 5 had persistent snoring, and polysomnographic studies revealed more severe OSAS, with an apnea-hypopnea index (AHI) of 1.5–9.2 per hour of sleep. Five children were newly diagnosed with OSAS in this survey, with an AHI of 1.5–7.5. The overall prevalence of OSAS in this survey was 10/755 (1.3%). In conclusion, 65% of children who snored habitually no longer did so when they got older, while 9% of children had developed OSAS. We suggest that regular follow-up in children with habitual snoring may be needed, and additional research is required to determine the indications for polysomnography and neurobehavioral and cardiovascular assessment. We also showed that children with mild OSAS could develop more severe disease if left untreated, suggesting that deferment of treatment may have negative consequences. **Pediatr Pulmonol. 2005; 39:415–420.** © 2005 Wiley-Liss, Inc.

Key words: snoring; sleep; obstructive sleep apnea; polysomnography; children; natural history.

INTRODUCTION

Recent studies demonstrated that snoring is a common symptom in the pediatric population, and it is one of the primary signs of obstructive sleep apnea syndrome (OSAS).[1] In a previous study in 1,008 children (mean age, 7.25 years) to determine the prevalence of snoring in Thai school-age children by using a sample survey and recording predisposing factors, we found that 8.5% of children were habitual snorers. The risk factors significantly and independently associated with snoring were tonsillar size and allergic rhinitis. Snoring children who had at least one sleep-related symptom underwent polysomnography, following which 7 children were diagnosed with mild OSAS, with an apnea-hypopnea index of 1.2–4.7/hr of sleep. The parents of all of these children decided to have their children followed up rather than undergo surgical treatment.[2] Very few studies have been published about the natural history of habitual snoring and mild OSAS. Ali et al.[3] reported that after a 2-year follow-up, snoring resolved in half of the children but commenced in a similar proportion of children without previous snoring. In Marcus et al.,[4] only 10% of children with primary snoring showed evidence of mild OSAS after a 1–3-year follow-up. This was also found by Topol and Brooks,[5] who evaluated children with primary snoring 3 years after their original polysomnographys, and found that these children were not likely to develop OSAS. Since the actual natural history of snoring and untreated mild OSAS is still unclear, we undertook a repeat survey in the same cohort of children to examine the natural history of snoring and OSAS.

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MATERIALS AND METHODS

Subjects

The original survey in 1999[2] was conducted to determine the prevalence of snoring in Thai school-age children, and to record predisposing factors. The study population was first-grade schoolchildren in the area of Hat Yai municipality in southern Thailand. Using stratified cluster sampling, 1,142 children were enrolled in the study. Sleep and breathing questionnaires were sent to the parents or guardians. To determine predisposing factors, we identified two subgroups: 1) 85 children who snored on most nights, and 2) 170 children who never snored. The children were examined at their schools. Body weight, tonsillar size, and nasal patency were recorded. Because of limitations in our facility, we were unable to perform polysomnography on all snoring children. The selection procedure for those we tested was as follows: the parents of the children who replied on the questionnaire that their child snored "most nights" were asked for the child's sleep-related symptoms by telephone or by hospital visit if a telephone was not available. An interview was conducted, using specific questions about sleep-related symptoms, following which snoring children who had at least one sleep-related symptom underwent polysomnography to determine the prevalence of OSAS. The apnea-hypopnea index (AHI) was counted as total amount of apneas and hypopneas per total sleeping time. Obstructive sleep apnea syndrome was diagnosed when the AHI was at least once per hour. The parents of 1,008/1,142 (88.3%) children responded to the original questionnaire in 1999, and we found that the prevalence of habitual snoring was 8.5%; 7 children had mild OSAS. These children then constituted the study group for the second survey in 2002, at which time they were fourth-grade schoolchildren. We excluded 3 children who suffered from mental problems that had delayed their study. The delayed children had an age range of 14–16 years, which was older than the rest of the study population. Therefore, 1,005 children constituted the final study group.

Questionnaire Survey

The questionnaire used in this 2002 study was based on the questionnaire in the original survey, and contained the following information: age; gender; who the child slept with; snoring; sleep-related symptoms, and specific questions about adenotonsillectomy. The questionnaire included questions such as: 1) Does your child snore at night? 2) Does your child have difficulty breathing during sleep? 3) Does your child stop breathing at night? 4) Does your child have restless sleeping and frequent awakening? 5) Does your child sleep with the head tipped back? 6) Does your child tend to breathe through the mouth rather than the nose? 7) Does your child fall asleep during the day, particularly when not active (for example, watching TV or reading)? 8) Has your child had their tonsils removed? and 9) Has your child had their adenoid removed? The reply choices for the first question were formulated as 1) never; 2) only with colds; 3) occasionally; and 4) most nights. For the remaining questions, the choices were yes or no.

A letter explaining our continuing interest in children's sleep together with the questionnaire were sent to the parents or guardians of the 1,005 children, who were asked to observe their child's sleep for 1 week before answering the questionnaire.

Patient Selection for Polysomnographic Study

Because of the limitations of the facility, polysomnography could not be performed on all snoring children. The selection procedure was the same as previously done for the 1999 survey, which was as follows: parents of children who reported snoring on most nights were asked for the child's sleep-related symptoms by telephone or during a hospital visit. An interview was conducted, using questions 2–7 in the questionnaire to confirm the presence of sleep-related symptoms (see above). The snoring children who answered "yes" to at least one of these questions in this survey, and all of the OSAS children ($n = 7$) from the original survey, were selected for the polysomnographic study. In the current study, children who reported on the questionnaire that they snored occasionally, or never snored but reported other sleep-related symptoms, were also contacted for a further interview to determine a diagnosis.

Polysomnography

Overnight polysomnography was performed on the selected children under the supervision of a trained nurse. A 12-channel polysomnograph (Alice 4, MIC) was obtained for each subject. Sleep stages were measured using electroencephalograms, electrooculograms, and submental electromyograms. The remaining channels were EKG, oxygen saturation, thoracoabdominal movement, and nasal-oral airflow measurement with a thermistor. The respiratory events were manually edited by one of the authors, who is an accredited polysomnographer. He is the same person who scored the polysomnography in the previous 1999 study.

Sleep staging was scored by standard criteria.[6] Obstructive apnea was defined as a reduction of 80% or more in nasal-oral airflow with continued respiratory efforts, lasting for at least two respiratory cycles; hypopnea was defined as a reduction of 50% or more in airflow signal associated with arousal and/or desaturation of more than 4%.[7] Obstructive and mixed apneas and hypopneas were taken into account, and the AHI was

counted as total amount of apneas and hypopneas per total sleeping time. Obstructive sleep apnea syndrome was diagnosed when the AHI was at least once per hour.[8]

Statistical Analysis

All data for the current survey as well as the previous survey were analyzed together, using SPSS version 10. To compare the results of both surveys for those who did, and those who did not, reply to the current survey, the chi-square test was used to establish if there were significant differences between them.

Comparison of individual responses in the present survey with those from the original survey was done by calculating values of weighted kappa to express the amount of agreement between the two surveys for the snoring questions.

RESULTS

Seven-hundred and fifty-five (755/1,005; 75.1%) of the questionnaires were returned. Of these, 371/755 (49.1%) were boys. The mean age was 10.2 ± 0.48 years (range, 9.1–12.9 years). There was no significant difference between the 755 who replied to the present survey and the 250 who did not as regards age, gender, allergic rhinitis, smoking in the household, and their responses to the snoring questions of the previous survey (Table 1). Thus the 755 respondents to the present survey were representative of our study group of 1,005 children. Most children (74.6%) slept in the same room as their parents; 13.4% slept alone. When compared to the previous study, 502/638 (78.7%) who shared a bedroom with their parents in the previous study continued to do so in this survey. Two children had had their adenoids and tonsils removed within the past 3 years.

Changes in Symptoms

Fifty-two (52/755; 6.9%) of the children were reported as snoring on most nights; 22.0% snored sometimes even without colds; 8.9% snored only with colds; and the remaining 62.2% never snored (Table 1). The overall prevalence of habitual snoring decreased slightly between the two surveys, from 8.5% to 6.9%. The prevalence of habitual snoring was statistically significantly higher in boys than in girls, at 9.4% vs. 4.7% ($P = 0.003$). Of 61 habitual snorers from the previous survey, 21 (34.4%) continued to snore habitually, while 40 (65.6%) changed to never snoring or snoring sometimes. Twelve (12/409; 2.9%) of the children who had never snored, had become habitual snorers in this survey. Of 694 children who had never snored or had snored occasionally, 31 (4.5%) had became habitual snorers (Table 2). These 31 new habitual snorers had a mean age of 10.2 ± 0.36 years (range, 9.4–10.8 years). The prevalence of new habitual snorers was significantly higher in boys than in girls (21/339 or 6.5% vs. 10/355 or 2.8%, respectively; $P = 0.031$).

Clinical and Polysomnographic Features of Children With Mild OSAS

Of 7 children who had mild obstructive sleep apnea in the previous study, 6 could be contacted. Five still snored habitually, and only the least severe individual had stopped snoring. Of 5 children who continued to snore habitually, 2 showed no change in sleep-related symptoms, 2 showed more severe symptoms, and the remaining child had no further symptoms.

In the previous study, one subject had been determined to be obese, with an ideal body weight for height greater than 120%. On follow-up evaluation, there was an increase in percent ideal body weight for height in all 6 children, and 3 were determined to be obese. On follow-up

TABLE 1—Gender and Prevalence of Snoring in 1999 Survey for 755 Children Who Responded and 250 Children Who Did Not Respond to 2002 Survey[1]

	1999 survey			
	Nonresponders (n = 250)	Responders (n = 755)	*P*	2002 survey (n = 755)
Mean age ± SD (years)	10.3 ± 0.57	10.2 ± 0.48	0.31	10.2 ± 0.48
Gender				
Male (%)	56.0	49.1		49.1
Female (%)	44.0	50.9	0.06	50.9
Allergic rhinitis (%)	6.1	8.0	0.32	
Smoking in household (%)	50.4	48.6	0.62	
Snoring				
Never (%)	50.0	54.0		62.2
Only with colds (%)	15.6	13.3		8.9
Occasionally (%)	24.8	24.6		22.0
Most nights (%)	9.6	8.1	0.6	6.9

[1]Also shown are results of 2002 survey.

TABLE 2—Relationship Between Responses to Snoring Questions in 2002 and 1999 Surveys[1]

	2002		
1999	Never snored or snored sometimes	Most nights	Total
Never snored or snored sometimes	663 (95.5)	31 (4.5)	694
Most nights	40 (65.6)	21 (34.4)	61
Total	703 (93.1)	52 (6.9)	755

[1]Values are presented as number (%). Agreement between results of two surveys was 55.8%, with kappa 0.25.

polysomnography in the 5 children who continued to snore habitually, the mean total sleep time was 469.8 ± 38.0 min, with a range of 410–514 min. The lowest oxygen saturation was 82–92%. The AHI was in the range of 1.5–9.2 per hour of sleep time. When compared to the previous study, all 5 children had developed more severe OSAS (Table 3).

Clinical and Polysomnographic Features of Children Newly Diagnosed With OSAS

Of 61 children who were habitual snorers in the previous survey, 6 were diagnosed with mild OSAS previously, and 6 had newly developed at least one sleep-related symptom. Five of these 6 children had undergone polysomnography, while one had not, due to moving to another part of the country. Two of the 5 children were determined to be obese. Polysomnographic studies revealed a mean total sleep time of 409.4 ± 85.2 min, with a range of 249–501 min. The lowest oxygen saturation was between 59–91%, and the AHI ranged from 1.5–7.5 per hour of sleep time. Therefore, 5 children were newly diagnosed with OSA (Table 4).

Of 755 children, 10 were reported on the questionnaire to have sleep-related symptoms without associated snoring, while 6 had difficulty breathing, and the remaining 4 had mouth breathing. After interviewing in detail, we found that such symptoms occurred only with colds, and a diagnosis could be made of asthma and allergic rhinitis in 3 and 2 children, respectively. The remaining 5 children had resolved their symptoms after 1-month follow-up. This group of children had not undergone a polysomnographic study.

TABLE 4—Characteristics and Polysomnographic Studies in Children Newly Diagnosed With OSAS in 2002 Survey[1]

Case no./ gender	Age (years)	% weight for height	Lowest O_2 saturation (%)	AHI
1/M	10.0	94.0	73	1.5
2/M	10.8	89.2	59	4.3
3/M	11.0	88.9	91	2.1
4/M	11.2	208.6	89	7.5
5/F	11.0	184.8	85	5.1

[1]Abbreviations as in Table 3.

The overall results of the survey of the natural history of snoring and mild OSAS are summarized in Table 5. Of 409 nonsnorers, 12 (2.9%) became habitual snorers, and none of these children had OSAS. Most (40/55; 72.7%) habitual snorers improved or resolved their symptoms over time, while 10 (18.2%) continued to snore, and 5 (9.1%) children developed OSAS. Of 6 children who had had mild OSAS, 5 (83.3%) had more severe OSAS, and 1 subject had stopped exhibiting all symptoms.

DISCUSSION

This study was performed to determine the natural history of snoring and mild OSAS in a cohort of 1,008 children in southern Thailand. These children were randomly selected using stratified cluster sampling when they were first-grade schoolchildren, with a mean age of 7.25 ± 0.58 years (range, 6.1–13.1 years) in 1999. The study population had a wide age range because some children suffered from social or mental problems that delayed their school attendance. However, most children had an age of around 7 years old, because the standard deviation is only 0.58. As age and abnormalities are the

TABLE 3—Initial and Follow-Up Patient Characteristics, Sleep-Related Symptoms, and Results of Polysomnographic Studies[1]

Case no./ gender	Age (years)	Snoring	Sleep-related symptoms	% weight for height in survey		Lowest O_2 saturation (%)/AHI in survey	
				I	II	I	II
1/M	10.5	Yes	2, 5	95.2	122.4	86/2.2	85/7
2/M	10.6	Lost to follow-up		93.2		84/4.7	Not done
3/M	10.6	Yes	1, 5	98.7	112.4	94/2.8	82/3.6
4/M	10.3	Yes	5	131.5	161.9	92/3.3	88/9.2
5/M	10.3	Yes	1, 2, 5	95.4	99.2	89/1.4	88/1.5
6/M	10.9	Yes	4, 5	107.4	164.7	95/2.0	92/8
7/M	10.0	No	None	94.9	95.0	99/1.2	Not done

[1]M, male; F, female; AHI, apnea/hypopnea index. Sleep-related symptoms: 1, mouth-breathing; 2, neck hyperextension; 3, restless sleep; 4, apnea; 5, difficulty breathing; 6, excessive daytime sleepiness.

TABLE 5—Overall Results of Survey of Natural History of Snoring and Mild OSAS[1]

	Present study		
Previous study	Improve/resolve	Snore	OSAS
Nonsnorer (n = 409)		12 (2.9)	0
Habitual snorer (n = 55)	40 (72.7)	10 (18.2)	5 (9.1)
Mild OSAS (n = 6)	1 (16.7)		5 (83.3)

[1]Values are presented as number (%).

important variables for snoring and OSAS, we excluded 3 children who suffered from mental problems from this second survey. The parents of the remaining 1,005 children were contacted again 3 years after the initial survey, with a response rate of 75%. Analysis of results of the first survey showed that the respondents to the second survey were a representative sample of those who had responded to the first survey. Most children (74.6%) slept in the same room as their parents, and thus this study accurately reflects the natural history of snoring.

Very few studies have reported on the natural history of snoring and mild OSAS.[3–5] In our study, we found that 65% of children who snored habitually in an earlier study no longer did so. This agrees with Ali et al.,[3] who also found that more than half of those who snored habitually no longer did so after a 2-year follow-up. These findings suggest that habitual snoring usually resolves spontaneously with increasing age, probably due to increasing pharyngeal size as well as regression of lymphoid tissue.[9] However, snoring remained a common symptom in 10-year-old children, for even though the majority of habitual snorers had resolved their symptoms spontaneously, the prevalence of habitual snoring decreased only slightly, from 8.5% in children aged 7 to 6.9% at age 10, due to the emergence of new cases. Corbo et al.[10] reported that the prevalence of habitual snoring in children aged 10–15 years was 5.6%, and was strongly associated with decreased nasal patency and body mass index of greater than the 90th percentile. We suspect that these predisposing factors may contribute to the emergence of new cases of habitual snoring. However, these associations cannot be confirmed, as we did not explore these factors in the present study. Previous studies found the prevalence of snoring to be the same in boys and girls in the prepubertal age group,[2,11–13] and higher in boys than in girls after puberty.[10] In our study, we found that habitual snoring occurred more frequently in boys than in girls, which is similar to Corbo et al.[10] This suggests that the increased levels of testosterone in boys in the pubertal age group could increase the prevalence of snoring.

As snoring is so common in children and may resolve over time, the clinical practice guidelines of the American Academy of Pediatrics[14] suggests that primary snoring may be considered benign, and surgical removal of adenotonsillar tissue is not currently recommended unless OSAS is present. However, two recently published studies,by Kennedy et al.[15] and O'Brien et al.,[16] showed that primary snoring in children seems to be associated with significant neurobehavioral deficits, possibly related to increased susceptibility to sleep fragmentation. The authors suggested that larger studies are urgently required, because current guidelines for treatment of snoring in children may require reevaluation. Regarding cardiovascular complications, Kwok et al.[17] reported that children with primary snoring had significantly increased daytime systemic blood pressure and reduced arterial distensibility. The authors suggested that these findings may jeopardize long-term cardiovascular health.

When the overall results of the study were analyzed, it was found that 5 of 55 (9.1%) habitual snorers in the previous survey had developed mild to moderate OSAS over 3 years. This finding is similar to that of Marcus et al.,[4] who performed repeated polysomnography in a cohort of 20 children with a mean age of 6 years diagnosed 1–3 years previously with primary snoring. They found that only 2 of 20 (10%) children had developed mild OSAS. This was also shown by Topol and Brooks,[5] who evaluated 13 children with primary snoring 3 years after their original polysomnographies, and found that these children were not likely to develop OSAS.

There are limitations to this study in that we were unable to perform polysomnographic studies on all snoring children. Also, it is difficult to distinguish OSAS from primary snoring by clinical assessment, because snoring in children without sleep-related symptoms does not rule out the presence of OSAS. Additionally, obstructive hypoventilation can be associated with no snoring; the gold standard remains polysomnography. However, since polysomnography is costly and an overnight hospital stay is required, we tried to identify some symptoms suggestive of OSAS and then select for a polysomnograpic study. This selection procedure may have underestimated the presence of OSAS. Regarding the polysomnograph used in this study, there was also a limitation in that apnea and hypopnea were identified based on a thermistor, a nonquantitative airflow signal that may not reliably detect episodes of partial airway obstruction with reduced tidal volume. To meet the standard evaluative testing protocol for OSAS in children, measurement of ventilation with end-tidal CO_2 is recommended.[7]

The natural history of mild OSAS is also not well-understood because no study has examined the apnea index and its rate of increase in severity in terms of the complications that can occur over an extended period of time. In our previous survey, we found 7 children with mild OSAS. Five of these children had increased their AHI by the second survey, but were still in a range that is not considered severe OSAS. These 5 children also had

increased their body mass index (BMI), which may have contributed to the increase in AHI, but we could not confirm this because we had no control cases. As our study population was small and we did not have a control group for comparison, we could not determine whether or not our mild OSAS children had significant complications in terms of growth, blood pressure, or neurobehavior. However, we did not find any obvious complications in this group of children. For early detection of complications of untreated mild OSAS, more intensive investigations such as blood hemoglobin concentration,[10] cognitive and behavior assessment,[18–20] and echocardiography[21–25] should be performed.

In conclusion, we found that 65% of children who snored habitually resolved their symptoms, while 9% of children had developed OSAS after a 3-year follow up. Therefore, regular follow-ups may be needed to watch for more severe disease. We believe that additional research is required to determine the indications for polysomnographic study and neurobehavioral and cardiovascular assessments in children with habitual snoring. Additionally, we showed that children with mild OSAS may develop more severe disease if left untreated, suggesting that deferment of treatment may not be safe. To recommend at what apnea index treatment should begin, a larger group of children needs to be followed up longitudinally.

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