Prevalence and Correlates of Habitual Snoring in High School Students*

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Study objectives: **To examine the prevalence and correlates of habitual snoring in senior high school students in Korea.**
Design: **A cross-sectional survey.**
Setting: **Ten high schools in the southern part of Seoul, Korea.**
Participants: **A total of 3,871 high school students (2,703 male students and 1,168 female students; age range, 15 to 18 years; mean age: male students, 16.8 years; female students, 16.9 years) who were attending the 11th grade.**
Measurements and results: **Data were collected on sociodemographic characteristics, school performance, and patterns of sleep and sleep-related disturbances. The overall prevalence of habitual snoring was 11.2% (boys, 12.4%; girls, 8.5%). The mean total sleep time was similar in habitual snorers vs nonsnorers (6.4 and 6.3 h per day, respectively). Frequency of snoring increased significantly with body mass index (BMI) [$p < 0.001$], cigarette smoking ($p < 0.01$), prevalence of witnessed apnea ($p < 0.001$), and Epworth sleepiness scale score ($p < 0.001$). The frequency of snoring increased with a decline in school performance ($p < 0.001$). For those whose school performance was low, there was a 35% excess in the odds of habitual snoring vs those whose school performance was high (odds ratio, 1.35; 95% confidence interval, 1.01 to 1.78).**
Conclusions: **These findings suggest that chronic habitual snoring is associated with multiple factors in adolescents. Whether interventions to modify BMI and smoking can alter snoring habits and related clinical problems warrants further study, particularly as it also may improve academic performance in high school students.** ***(CHEST 2003; 124:1709–1715)***

Key words: correlates; habitual snoring; high school adolescents; Korea; prevalence

Abbreviations: BMI = body mass index; CI = confidence interval; ESS = Epworth sleepiness scale; OR = odds ratio; OSA = obstructive sleep apnea; OSAS = obstructive sleep apnea syndrome

Habitual snoring is the most prominent manifestation related to obstructive sleep apnea syndrome (OSAS) and may cause hypoxemia and hypercapnia due to the partial obstruction of the upper airway during sleep.[1] Many studies have also indicated that habitual snoring is associated with hypertension,[2–5] heart disease,[6–10] cerebrovascular disease,[7,11,12] and daytime sleepiness[13] in adults. Thus, the public health importance of habitual snoring as a potential source of morbidity is increasingly being recognized.

Previous studies have demonstrated that the prevalence of habitual snoring could vary between 3.2% and 12.1% in children,[14–20] and between 5% and 40% in adults.[21–28] One study[29] reported that the prevalence of habitual snoring was 14.8% in adolescents. This wide variation in the prevalence of snoring may result from differences in population characteristics, definitions, and methodology of the studies performed.

Among the multiplicity of social and biological changes taking place during adolescence, sleep patterns and sleep-related alterations are considered to be important. Nevertheless, most studies of the prevalence of habitual snoring and its risk factors have been carried out in populations of adults and

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children in Western countries. Only a few, however, have occurred in adolescents in Asian countries,[30,31] and none have occurred in Korea. The purpose of this study was to determine the prevalence of habitual snoring and its associations with sociodemographic characteristics, including school performance and sleep-related factors in senior high school students in Korea.

Materials and Methods

Study Sample

A cross-sectional study was carried out in a sample of high school students of both genders between September and December 2001. A total of 11 schools was randomly selected using the official directory of public and private senior high schools in the southern part of Seoul, Korea. Institutional approval for the survey was granted in 10 schools. One school, however, refused to participate in the study. The overall selected sample comprised 4,781 students in the 11th grade from each of 10 schools.

Procedures

A questionnaire was developed to assess sleep patterns and sleep problems for the student participants. The questionnaire draft was given to 350 senior high school students and their parents for a pretest. To determine the test-retest reliability of the questionnaire, 240 senior high school students and their parents were retested 4 weeks after the first test. The κ values for questions on snoring and witnessed sleep apnea were 0.73 and 0.89, respectively.

The final version for the questionnaire included queries on sleep duration and latency, and sleep-related problems, such as snoring, witnessed sleep apnea, and daytime sleepiness. Collected sociodemographic data included age, gender, height, weight, family income, alcohol intake, smoking status, and school performance.

After a full explanation of the purpose of the study by investigators, questionnaires were distributed to the students in a class and were taken to their home to fill out. Questions on sociodemographic data, sleep habits, and daytime sleepiness were answered by the subject, and those about the occurrence and frequency of snoring and sleep apnea were answered by parents or guardians and sleeping partners, including sisters or brothers. Participation was on a voluntary basis without teacher input.

Definition

The frequency of snoring occurrence was classified as never, 1 to 2 days per week, 3 to 4 days per week, 5 to 6 days per week, and always (every night). In this study, students who snored 1 to 2 days per week were defined as *simple snorers*, and those who snored $\geq$ 3 days per week were defined as *habitual snorers*. To assess sleep apnea, the occurrence of breathing cessation during sleep was determined as never, 1 to 3 days per week, 4 to 5 days per week, and 6 to 7 days per week. *Snoring* and *sleep apnea* in this study are defined as snoring or sleep apnea that is witnessed by parents or a sleeping partner. Daytime sleepiness was measured using the Epworth sleepiness scale (ESS), a frequently used subjective sleepiness scale that consists of an eight-item self-administered questionnaire. In our application, the ESS was properly adapted to measure adolescent activities such as falling asleep at school rather than at a meeting. Possible ESS scores range from 0 to 24. In the present study, excessive daytime sleepiness (EDS) was defined as an ESS score of $\geq$ 11.

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Subjects were classified as smokers if they were currently smoking cigarettes, and as nonsmokers if they had never smoked or if they had smoked but had quit. Subjects were classified as alcohol consumers if they consumed at least three drinks per month.

Here, one drink is equivalent to the intake of 12.5 g ethyl alcohol. School performance was defined as being high-grade if students were ranked among the top quartile of their class, and as being low-grade if students were ranked among the bottom quartiles of their class, based on the results of final examinations of the first semester in the 2001 academic year. Student rankings in the middle two quartiles were defined as being moderate performance.

Statistical Analysis

Basic data are presented as the mean $\pm$ SD for continuous variables and as percentages for categoric variables. Analysis of variance procedures were used to examine differences in sociodemographic and sleep-related factors among habitual snorers, simple snorers, and nonsnorers. *Post hoc* comparisons were made to identify the significance between two groups in each variable. To explore the association of sociodemographic and sleep-related factors with habitual snoring, the prevalence rates of habitual snoring within subgroups for each variable were estimated. Both univariate and multiple logistic regression models were examined to identify factors with an overall and independent relationship with habitual snoring. The relative odds of habitual snoring associated with the presence and absence of various characteristics (and 95% confidence intervals [CIs]) also are provided. All hypothesis testing was based on a two-sided level of significance.

Results

Characteristics of Study Sample

Of 4,781 students in our study sample, 587 (12.3%) refused to answer the questionnaire and 14 (0.3%) were absent on the day of the survey. Insufficient information regarding sociodemographic and sleep-related characteristics was collected in 309 other students (6.5%). After excluding those individuals, data from 3,871 students (2,703 boys and 1,168 girls) were included in these analyses, representing a response rate of 80.9%. There were twice as many boys as girls who participated in the study. This was due to a higher rate of refusal to participate by girls and institutional refusal by an entire high school with 100% female enrollment.

The mean age of students was 16.8 years in boys and 16.9 years in girls. In male adolescents, the mean BMI was 21.3 $\pm$ 3.1 kg/m^2, and in female students it was 19.6 $\pm$ 6.5 kg/m^2. The percentage of current smokers was 13.2% for male students and 9.2% for female students. The rate of alcohol drinkers among male adolescents was 28.7%, and among female adolescents it was 32%. Other detailed sociodemographic characteristics of students are shown in Table 1.

Table 1—*General Characteristics of Study Sample

Characteristics	Male Patients (n = 2,703)	Female Patients (n = 1,168)	Total (n = 3,871)
Age, yr	16.8 ± 0.8	16.9 ± 0.8	16.8 ± 0.8
Height, cm	173.6 ± 5.7	161.8 ± 5.1	170.0 ± 7.7
Weight, kg	64.3 ± 10.8	51.3 ± 7.0	60.4 ± 11.5
BMI, kg/m^2	21.3 ± 3.1	19.6 ± 6.5	20.7 ± 3.1
ESS score	6.7 ± 3.7	7.4 ± 3.5	6.9 ± 3.6
Night sleep duration, h/d	6.3 ± 1.5	6.5 ± 1.6	6.4 ± 1.5
Sleep latency, min/d	17.4 ± 15.4	19.0 ± 15.7	17.9 ± 15.5
Current smoker, %	13.2	9.2	12.0
Alcohol drinker, %	28.7	32	29.7

*Values given as mean ± SD.

Prevalence and Related Factors of Snoring by Severity

Comparison of prevalence of snoring and its association with sleep-related factors by frequency of snoring is given in Table 2. The overall prevalence of habitual snoring, which was defined as snored ≥ 3 days per week, was 11.2%. The prevalence of simple snoring, which was defined as snored 1 to 2 days per week, was 18.6%.

The frequency of snoring was significantly associated with BMI and ESS score. The mean BMI for habitual snorers (21.9 ± 3.6 kg/m^2) was the highest compared with those of simple snorers (21.1 ± 3.3 kg/m^2) and nonsnorers (20.5 ± 2.8 kg/m^2). As expected, a dose-response relationship was observed between the frequency of snoring and BMI ($p < 0.001$) and ESS score ($p < 0.001$). In each instance, BMI and ESS score increased with an increase in the frequency of snoring. In contrast, there appeared to be no consistent pattern of association between nocturnal total sleep time and the frequency of snoring. Although sleep latency seemed to decline with snoring frequency, an association with snoring failed to reach statistical significance.

Correlates of Habitual Snoring

As indicated in Table 3, male gender, BMI of > 23, current smoking, low-grade school performance, witnessed apneic events on ≥ 1 day per week, and ESS score of ≥ 11 were significantly associated with an increased risk of habitual snoring. Alcohol intake, however, was not significantly related to habitual snoring.

After adjustment for those factors that were significantly associated with habitual snoring, the effects of gender were no longer statistically significant. In contrast, a BMI of > 23 was associated with a 2.6-fold excess in the risk of habitual snoring compared to a BMI of < 20. There was a > 10-fold risk of habitual snoring in subjects with witnessed apneic events on ≥ 4 days per week vs subjects with no apneic events. An ESS score of > 15 was associated with more than a threefold excess risk of habitual snoring vs ESS scores of < 11. Other factors that continued to have relationships with habitual snoring included smoking and school performance. Students with low grades had a 35% excess in the odds of habitual snoring compared to those with high grades ($p < 0.05$). The risk of habitual snoring also increased with a decline in school performance ($p < 0.001$).

Discussion

In the current study, a sample of 3,871 adolescent students was examined using a questionnaire that contained items about individual sociodemographic

Table 2—*Prevalence and Related Factors of Snoring by Frequency

Variables	Habitual Snoring (n = 433)	Simple Snoring (n = 721)	Nonsnoring (n = 2,717)	p Value
Prevalence, %	11.2	18.6	70.2	
Height,† cm	171.1 ± 7.5	170.1 ± 7.4	169.8 ± 7.8	< 0.01
Weight,† kg	64.5 ± 13.2	61.6 ± 12.0	59.4 ± 10.8	< 0.001
BMI,† kg/m^2	21.9 ± 3.6	21.1 ± 3.3	20.5 ± 2.8	< 0.001
Night sleep duration, h/d	6.4 ± 1.7	6.3 ± 1.4	6.3 ± 1.4	0.642
Sleep latency, min/d	17.0 ± 14.9	17.5 ± 14.0	18.1 ± 15.7	0.278
ESS score†	8.2 ± 4.6	7.1 ± 3.4	6.8 ± 3.4	< 0.001

*Values given as mean ± SD.
†Values are significantly different between two groups in each variable, except for values in height between simple snoring and nonsnoring groups.

Table 3—*Prevalence and Correlates of Habitual Snoring by Logistic Regression Analyses*

Variables	Habitual Snoring,* %	Crude Values		Adjusted Values†	
		OR	95% CI	OR	95% CI
Gender					
Female	8.5 (99/1,168)	1.00		1.00	
Male	12.4 (334/2,703)	1.52‡	1.20–1.92	1.24	0.96–1.56
BMI,§ kg/m^2					
< 20	8.4 (151/1,794)	1.00		1.00	
20–23	9.9 (132/1,328)	1.20	0.94–1.53	1.24	0.94–1.56
> 23	20.0 (150/749)	2.72‡	2.13–3.48	2.61‖	2.01–3.40
Smoking					
No	10.4 (353/3,405)	1.00		1.00	
Yes	17.2 (80/466)	1.79‡	1.38–2.34	1.58‖	1.19–2.09
Alcohol intake					
No	10.5 (285/2,721)	1.00			
Yes	12.9 (148/1,150)	1.32	0.98–1.78		
School performance§					
High grades	10.0 (97/967)	1.00		1.00	
Moderate grades	10.4 (201/1,936)	1.04	0.80–1.35	1.07	0.82–1.40
Low grades	13.9 (135/968)	1.46‖	1.11–1.92	1.35¶	1.01–1.78
Apneic events§					
None	9.6 (333/3,483)	1.00		1.00	
1–3 d/wk	22.7 (80/353)	2.77‡	2.10–3.64	2.56‡	1.94–3.40
≥ 4 d/wk	57.1 (20/35)	12.61‡	6.39–24.86	10.32‡	5.07–21.02
ESS score§					
< 11	10.1 (327/3,253)	1.00		1.00	
11–15	14.2 (74/522)	1.47‖	1.13–1.94	1.41¶	1.07–1.87
> 15	33.3 (32/96)	4.48‡	2.88–6.94	3.37‡	2.10–5.43

*Values in parentheses are No. of patients with habitual snoring/total No. of patients.
†Adjusted for age and including significant variables in univariate analysis.
‡Excess of habitual snoring ($p < 0.001$).
§$p < 0.001$ for tests for trend.
‖Excess of habitual snoring ($p < 0.01$).
¶Excess of habitual snoring ($p < 0.05$).

characteristics, school performance, and patterns of sleep and sleep-related problems. Previous studies from a variety of countries have found that the prevalence of habitual snoring ranged from 3.2 to 12.1% in children[14–20] and from 5 to 40% in adults,[21–28] depending on the definition of habitual snoring, population characteristics such as age and gender, and study setting. On the other hand, data for the prevalence of habitual snoring in adolescents have been reported much less often than those for children and adults. In a sample of 2,209 early adolescents (age range, 10 to 15 years),[32] the prevalence of habitual snoring (*ie*, those who snored "often") was reported to be 5.6%. It also has been demonstrated[33] that the prevalence of habitual snoring (*ie*, those who snored "often and every night") ranged from 2.2 to 4.6% in girls and from 5.8 to 8.8% in boys among those aged 15 to 20 years, depending on BMI. Another survey,[29] on the other hand, has revealed that the prevalence of habitual snoring could be as high as 14.8% in adolescents between the ages of 12 and 16 years, using the same criteria as for our definition of habitual snoring. In the current report, the prevalence of habitual snoring (defined as snoring ≥ 3 days per week) was estimated to be 11.2% (boys, 12.4%; girls, 8.5%) among the 11th grade high school students. These differences in prevalence rate, therefore, may be largely attributed to the definitions of habitual snoring that were being used. Although there is still some uncertainty about the definition of snoring, the most frequently used method for estimating the prevalence of snoring is based on the results of questionnaires in epidemiologic surveys. Since there is no standard and uniformly accepted technique for the objective measurement of snoring,[34] the validation of these questionnaires remains a problem. In this respect, some consideration is needed in the interpretation of questionnaire results including our study. Despite this limitation, the importance of this study is that it is the first to report on the prevalence of snoring and associated factors in a sample of adolescents in Korea. Furthermore, our results are in the range of prevalence rates reported by other studies.[29–33] In addition, Korean parents commonly check on their sleeping adolescents during the night and/or the

family sleeps in close proximity to one another. Thus, the reports on the snoring or breathing cessation of study subjects could be more reliable than those in other population-based surveys. The use of polysomnography to validate reported snoring by questionnaire is also in need of further investigation.

With regard to gender, a higher prevalence of snoring in male adults has been consistently observed in many studies.[13,23,26,35] In adolescents, a greater prevalence of snoring was found in boys than in girls in univariate logistic regression analysis. Among the high school students in the study by Delasnerie-Laupretre et al,[33] boys were reported to snore (sometimes, 33.4%; habitually, 6.5%) significantly more often than girls (sometimes, 25.1%; habitually, 3.3%). Corbo et al[32] found that the prevalence of habitual snoring was higher in boys (7.0%) than in girls (4.1%) who were aged 10 to 15 years. However, other pertinent confounding factors to habitual snoring were not evaluated in these previous studies. Our results also showed that male adolescents were more likely than female adolescents to be habitual snorers (odds ratio [OR], 1.5; 95% CI, 1.2 to 1.9). This significance, however, failed to persist after controlling for other confounding information. Since biological development in adolescents is not fully complete, habitual snoring in the current study may not have had a chance of being significantly affected by gender after adjustment for other factors.

The strong association between BMI and snoring in the current report in adolescents also has been noted in previous studies.[22,25,36,37] Bloom et al[37] suggested that this may be related to a reduction in pharyngeal airway diameter produced by deposits of adipose tissue in obese individuals. Pharyngeal resistance correlates with increasing weight/height ratio or obesity. It has been proposed that a BMI of > 23 defines the term *overweight* among Asians.[38] Here, overweight adolescents had a 2.6-fold excess risk of habitual snoring vs those with a BMI < 20. This association was left unexplained by other confounding factors that were examined in this report.

It has been demonstrated that active smoking is also a widely known risk factor for habitual snoring[28,33,39] and sleep-disordered breathing.[40] Smoking may provoke mucosal edema and inflammation of the pharynx, resulting in the narrowing and collapsibility of pharyngeal airway, and leading to an increased risk of snoring.[37] It is also reported that passive parental smoking is a risk factor for snoring in children.[16,32] Although the amount and exposure period of smoking were low and short in our adolescents, current smokers had a significantly increased risk of habitual snoring, compared with nonsmokers (OR, 1.6; 95% CI, 1.2 to 2.1). Thus, our data confirm that smoking is an independent risk factor for habitual snoring in adolescents.

In the present study, the percentage of current drinkers was 28.7% for male students and 32.0% for female students (Table 1). Alcohol has been shown to decrease pharyngeal muscle tone.[41] Therefore, after the ingestion of alcohol, the normal inspiratory increase in the pharyngeal dilator muscle tone during sleep may be reduced, predisposing a person to upper airway narrowing or collapse and to snoring or obstructive sleep apnea (OSA).[42,43] Previous studies,[5,7,37,44] however, have reported that there was no significant association between alcohol consumption and snoring. In this report, alcohol intake also was not significantly associated with an increased prevalence of habitual snoring. This may in part be due to limits on the amount and duration of alcohol consumed by adolescents.

It is generally understood that bedtime becomes later with increasing age throughout adolescence, while rise time remains constant through high school due to school activities.[45] In the present study, $> 80\%$ of students went to bed at midnight or later and $> 50\%$ rose before 7:00 AM. Thus, the mean total sleep time was 6.4 h per day for habitual snorers and 6.3 h per day for nonsnorers, which may be an insufficient amount of sleep for adolescents during puberty. Many students complained that they do not get enough sleep, which presumably is attributable to school schedules requiring earlier wake-up times, increased academic demands, expanding social opportunities, involvement in part-time jobs requiring staying up late, and increased access to drugs and alcohol. In addition, laboratory tests by Carskadon[46] have shown that adolescents probably need more sleep than before entering puberty. Therefore, puberty itself may produce daytime sleepiness with no change in nocturnal sleep time.

As expected, our data showed that habitual snoring was correlated with increasing degrees of daytime sleepiness, as measured by the ESS score. However, there were no significant differences in the total number of sleep hours among habitual snorers in the three different ESS score groups in this study. This indicates that daytime sleepiness may be affected by sleep quality rather than by sleep quantity.

Although it is recognized that poor school performance by adolescent students has been attributed in part to insufficient sleep, the recent study by Eliasson et al[47] found no correlation between total sleep time and academic performance in middle school and high school students. We also found no significant differences in total sleep time between snorers and nonsnorers in the current study.

It is estimated that 20 to 30% of children with either OSAS or with loud and frequent snoring may

have clinically significant problems of inattention and hyperactivity.[15,48,49] Furthermore, the inattentive and behavioral problems observed in children with OSAS could have a negative impact on cognitive and academic performances.[15,48,50] Although the mechanisms of cognitive dysfunction in sleep-disordered breathing in both adults and children are not known, underlying reasons for these problems could include sleep fragmentation and deprivation that lead to repeated arousals and brain damage induced by hypoxic events. A recent study showed that children with abnormalities in sleep-associated gas exchanges have lower academic performance, and that after therapeutic intervention (adenotonsillectomy), subsequent school performance is significantly improved.[50] In addition, it has been reported that children with OSA tend to have significantly poorer performance on standardized neurocognitive tests than do their non-OSA counterparts. When snoring and OSA are accompanied by adenotonsillar hypertrophy, treatment usually includes adenotonsillectomy in children.[51] On the other hand, our results also showed that students with low grades reported a greater frequency of habitual snoring than did those with high grades (OR, 1.35; 95% CI, 1.01 to 1.78), which is consistent with results reported by others.[50,52] They found that snoring in early adolescence was more frequently reported among adolescents 13 to 14 years old who were ranked in the lower quartile of their class when compared with adolescents whose performance was in the upper quartile ranks. Whether interventions to modify the amounts of snoring can improve academic performance in adolescents who are habitual snorers warrants further consideration.

In conclusion, our findings show that habitual snoring is common in adolescents in Korea, and the risk of habitual snoring is significantly increased with a BMI of > 23, in current smokers, in students with higher frequencies of witnessed apneic events, and in those with higher ESS scores. In terms of interventions, the role of changes in BMI may be important, as are continued efforts to discourage the use of cigarettes.

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