Prevalence of Snoring and Sleep-Disordered Breathing in a Student Population*

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Introduction: The prevalence of snoring and sleep-disordered breathing (SDB) in young adults in Southeast Asian countries is unknown. We aim to determine the symptoms and prevalence of SDB in a university student population using a questionnaire survey followed by home sleep monitoring.

Methods: The Sleep and Health Questionnaire (a modified version of the Specialized Centers of Research Sleep Questionnaire, translated into Chinese) was distributed to all first-year students (1,306 male and 1,757 female) enrolled in the Chinese University of Hong Kong. Subsequently, those students who returned the questionnaires were randomly chosen to undergo portable home sleep monitoring using the MESAM IV device (Madaus Medizin-Elektronik; Freiburg, Germany).

Results: A total of 1,910 replies were obtained from 3,063 questionnaires sent by mail (response rate, 62.4%). The female to male ratio was 1.8:1, with mean age of 19.4 years (SD, 1.3 years) and mean body mass index (BMI) of 20.0 (SD, 2.5). Overall, 25.7% of subjects reported snoring; 10.7% and 42.1% reported impaired performance ability and daytime sleepiness, respectively. Of the 88 subjects who underwent overnight sleep monitoring, 66 subjects (75%) were snorers and 8 subjects (9%) snored >10% of the night. Male subjects had a higher BMI (p < 0.001) and tended to snore more often than female subjects (p = 0.06). Subjects with an oxygen desaturation index (ODI) ≥ 3 had a BMI > 22 (p < 0.05). On sleep study, nine subjects (10.2%) and two subjects (2.3%) had a respiratory disturbance index (RDI) ≥ 3 and an RDI ≥ 5, respectively, associated with self-reported sleepiness, giving a minimum estimated prevalence of SDB as 0.1% (RDI ≥ 5) in the study population. There was no correlation between recorded snoring with either RDI or self-reported sleepiness. Questionnaire responses, neck circumference, and alcohol consumption did not predict the occurrence of SDB.

Conclusion: Snoring was prevalent, while SDB was uncommon in this student population. However, snoring and self-reported symptoms by questionnaire were poor predictors for SDB. Male gender showed a trend as an independent predictor for snoring, but not for SDB.

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Key words: prevalence; questionnaire; sleep-disordered breathing; snoring

Abbreviations: BMI = body mass index; CI = confidence interval; HR = heart rate; NS = not significant; ODI = oxygen desaturation index; OR = odds ratio; PSG = polysomnography; RDI = respiratory disturbance index; \( \text{SaO}_2 \) = arterial oxygen saturation; SDB = sleep-disordered breathing

Snoring and sleep-disordered breathing (SDB) are common among middle-aged adults, with an estimated prevalence of SDB of 4% in men and 2% in women in a large population survey.1 However, the prevalence of SDB in adolescents and young adults is not as well characterized. The prevalence of snoring in children between 4 and 6 years old was reported to be 7 to 10%, and that of SDB was estimated at 0.7%.2 The diagnostic criteria for SDB in children are controversial,3 and the high prevalence may be related to tonsillar hypertrophy, which is common in this age group.

Obstructive sleep apnea, the common form of SDB in adults, is characterized by an anatomically narrowed pharyngeal airway that collapses during
sleep. It is unclear whether patients with obstructive sleep apnea are born with narrowed upper airways, or if the airway progressively narrows as the patient ages due to disease progression. Underrecognized SDB in young adults may be responsible for the symptoms associated with SDB such as snoring and daytime somnolence, which are not uncommon in this age group. In this study, we attempted to determine the prevalence of symptoms related to sleep apnea in a population of university students by questionnaire survey, to correlate sleep-related symptoms with obstructive respiratory events by home sleep monitoring, and to estimate the prevalence of sleep apnea in the target population.

**Materials and Methods**

**Study Subjects**

Data were collected from September 1995 to April 1996. A questionnaire on sleep-related symptoms (The Sleep and Health Questionnaire) was sent by mail to every first-year student of the 1995 academic year enrolled in the Chinese University of Hong Kong via the university registry; the questionnaire was returned by prepaid envelope together with a consent form for portable home sleep monitoring. Altogether, there were 3,063 students (1,306 male and 1,757 female) enrolled. The study was approved by the ethics committee of the Chinese University of Hong Kong.

**Symptom Measurement**

The Sleep and Health Questionnaire is a modified version of the Specialized Centers of Research Sleep Questionnaire, which has been shown previously to be a valid means of characterizing symptom distribution in population surveys of sleep apnea. The questionnaire contains 16 questions grouped into five factors (functional impact of sleepiness, self-reported breathing disturbances, roommates-observed breathing disturbances, driving impairment, and insomnia) that have been shown to be useful in predicting the occurrence of sleep apnea. Additional questions were included to document the use of alcohol and the subjects’ sleeping habits, including the patient’s usual sleep schedule and, particularly, the sleep quality the night before the sleep study. Five selected questions from the English-language version of the modified Sleep and Health Questionnaire are shown in the Appendix. The responses to the questionnaire utilized either a 5-point frequency scale (from 1 to 5, corresponding to never, rarely, sometimes, frequently, and always) or by the use of a 6-point Likert scale that graded the severity of the symptoms. These questions were categorized into mild, moderate, and severe as follows for the purpose of data analysis: (1) 6-point Likert scale: 1 to 2 points (not affected); 3 to 4 points (mild); 5 points (moderate); and 6 points (severe), and (2) 5-point frequency scale: never (not affected); rarely, sometimes (mild); frequently (moderate); and always (severe).

**Sleep Monitoring**

The subjects who returned the questionnaires were randomly invited to undergo a portable home sleep study. In the afternoon, the subjects attended the pulmonary function laboratory for the fitting of a MESAM IV device (Madaus Medizin-Elektronik; Freiburg, Germany). Descriptions of the device and the validity of the methods used to collect and display data have been published previously. Four variables were monitored: snoring, heart rate (HR), arterial oxygen saturation (SaO₂), and body position. Details of the data collection have previously been described elsewhere. The subjects slept at home with the device attached, and they recorded the time when they retired to bed and when they awoke. In the morning, the devices were removed and the sleep data were downloaded to a computer.

Snoring sounds were recorded from an electronic microphone (type MCE 2000, Madaus Medizin-Elektronik) at the rate of 8 bits/s; the microphone was attached to the throat over the larynx using a soft neck brace. Two sound levels were monitored. If the relative power of the frequencies between 50 Hz and 100 Hz was > 50% of the total power, “snoring” was identified as a short line on the snoring channel and 1 bit was set in the MESAM device. If the volume was > 1.1 megavolt at 1,000 Hz, a second bit was set and “loud snoring” was identified as a longer line on the snoring channel. HR was measured using three ECG electrodes, with R-R intervals measured in milliseconds. Body position was measured using a circular sensor taped to the center of the body with a soft belt. Five body positions (right, left, back, front, and up) were displayed.

**Mesam IV Data Analysis**

Data was printed using the expanded version of the MESAM IV software program, and analyzed by a single blinded experienced scorer. Sleep time was taken as the subjects’ report of time between bedtime and waking time. Data for oxygen desaturation was omitted if artifactual recording (a broken signal line or a vertical drop in SaO₂) occurred for > 50% of the recorded time. The oxygen desaturation index (ODI) was calculated as the number of episodes of oxygen desaturations ≥ 3% per hour of sleep determined by visual analysis. A respiratory disturbance was scored if an episode of oxygen desaturation ≥ 3% of baseline level, as determined by visual analysis, occurred with either an increase in HR of ≥ 10 beats/min, or a burst of snoring associated with the beginning and the end of a desaturation episode. The respiratory disturbance index (RDI; the number of respiratory disturbances per hour of estimated sleep) was thus calculated for each subject. Snoring was scored as the percentage of estimated sleep time spent snoring. The occurrence of snoring was defined as two short lines on the snoring channel separated by a space < 2 mm. “Loud snoring” and simple snoring were not differentiated in the study. A snoring duration of ≥ 10% of the night was considered as significant snoring, in accordance with previous epidemiologic studies. For the purpose of data analysis, the RDI and the ODI were categorized as ≥ 1, ≥ 3, and ≥ 5, respectively.

The RDI values obtained using the MESAM IV have been shown to be highly correlated with the RDI using standard polysomnography (PSG). The validity of the MESAM IV device was tested by performing a MESAM IV study and nocturnal PSG (Sleep Lab 1000P; Aequiron Medical; Plymouth, MN) simultaneously in eight patients with symptoms of obstructive sleep apnea at the Prince of Wales Hospital. Overnight simultaneous PSG recorded an EEG, electro-oculogram, submental electromyogram, bilateral anterior tibial electromyogram, ECG, chest and abdominal wall movement by inductance plethysmography, oronasal airflow measured with a thermostor, and finger pulse oximetry. Sleep was scored according to standard criteria by Rechtshaffen and Kales. Apnea was defined as the cessation of airflow for ≥ 10 s, and hypopnea was defined as a reduction of airflow ≥ 50% for ≥ 10 s.
Data were given as means and SDs unless otherwise stated. A p value < 0.05 was considered significant. Correlation between sleep parameters and baseline characteristics was done using the Pearson correlation coefficient (r). The frequency distribution of responses on the questionnaire and their relationship to sleep parameters were assessed with the $x^2$ analysis and unpaired t tests. One-way analysis of variance was used to detect the differences between each of the potential correlates: age, gender, BMI, neck circumference, smoking, and time spent supine during sleep in relation to the indexes of SDB (eg, RDI, ODI, and snoring percentage). The potential correlates were analyzed as continuous variables whenever possible. Separate logistic regression models were constructed to evaluate the effects on SDB of variables identified as significant on univariate analysis.

RESULTS

Questionnaire

A total of 1,910 replies were obtained from the 3,063 questionnaires sent out by mail via the university registry (response rate, 62.5%). The female to male ratio in the responders was 1.8:1, with a mean age of 19.4 years (SD, 1.3 years); mean BMI of 20.0 (SD, 2.5); and a mean neck circumference of 32.7 cm (SD, 4.0 cm). Eighteen subjects (1%) had a diagnosis of hypertension. Only 15 subjects (0.8%) were current smokers, and 495 subjects (26%) were current alcohol drinkers, although only 15 subjects (0.8%) admitted to drinking more than once a week.

Less than 3% of the subjects had a family history of snoring or sleep apnea. The responses to the five questions in the questionnaire that had been shown by Kump et al to significantly predict sleep apnea were tabulated with reference to the severity and the frequency of symptoms (Table 1). A total of 802 respondents (42%) reported moderate to severe daytime sleepiness, in contrast to only 497 respondents (26%) who gave a positive response to self-reported snoring, mostly in the mild category. Of the 56 subjects who drove, 12 reported having fallen asleep at least once while driving. As there were very few students driving, we did not include questions related to driving impairment in the final analysis.

Sleep Parameters

Of the 1,910 students who returned the questionnaires, 88 subjects were randomly selected for overnight home sleep monitoring using the MESAM IV device. Their baseline characteristics were similar to the original sample population, with a mean ± SD age of 20.7 ± 2.3 years; a gender ratio of 1:1; a neck circumference of 33.6 ± 3.7 cm; and a BMI of 20 ± 2.3. There was measurement failure involving 10 of the 88 home sleep studies; but, subsequently, the studies were repeated, producing interpretable recordings. Recorded snoring was common; 75% of the subjects tested were objective snorers, and 9% snored > 10% of the night. There was no correlation between self-reported snoring and recorded snoring: 70% of those who denied snoring on questionnaire had recorded snoring, while 18% of those who reported snoring did not have recorded snoring on sleep study. Of the 88 subjects who underwent home sleep monitoring, 9 subjects (10.2%) and 2 subjects (2.3%) had self-reported sleepiness associated with an RDI ≥ 3 and an RDI ≥ 5, respectively; 9% had snoring alone, with a RDI < 3. This would give a minimum estimated prevalence for SDB of 0.5% (RDI ≥ 3) and 0.1% (RDI ≥ 5) in the original study population. There was no significant correlation between recorded snoring with RDI, ODI, or self-reported sleepiness. The distribution of snoring and RDI is shown in Figure 1.

The potential factors that may predict snoring and SDB were analyzed by univariate analysis (Table 2). Male gender was significantly related to snoring (p < 0.03), while younger subjects with age < 20 years (p < 0.03) and a BMI > 22 (p < 0.03) were related to an RDI ≥ 3 and an ODI ≥ 3, respectively. However, other factors such as neck circumference, alcohol consumption, and family history were not significantly related to the occurrence of SDB. The 16 questions in the modified Sleep and Health Questionnaire, including the questions on self-reported snoring and daytime somnolence, did not predict the occurrence of snoring or SDB.

On logistic regression analysis of the potential risk factors that may predict snoring and SDB (Table 3), male gender was the only risk factor that showed a trend toward an association with snoring, (odds ratio [OR], 8; p = 0.06). The subjects who complained of severe daytime sleepiness had a higher OR for snoring. However, this was not statistically significant (OR, 4.86; 95% confidence interval [CI], 0.58 to 40.65).

The RDI values measured by the MESAM IV
device were found to have significant correlation with those measured by PSG simultaneously in the eight subjects selected with Pearson correlation coefficient ($r = 0.907$ and $p = 0.002$).

**Discussion**

To the best of our knowledge, this is the first study to examine the prevalence of snoring and SDB in a young Oriental population. Self-reported symptoms such as daytime somnolence and nocturnal awakenings were common in the study population. Snoring was also very common in our sleep-monitored subjects: 75% were objective snorers, and 9% snored greater than 10% of the night. SDB, defined as an RDI $\geq 5$ associated with self-reported sleepiness, was present in 2.3% of the monitored subjects. This would give an estimated minimum prevalence in the study population of 0.1%. Previous epidemiologic studies in adults have yielded prevalence rates of between 0.3% in middle-aged men$^{11-13}$ and 44% in the elderly$^{14}$ using a similar methodology of screening by questionnaire followed by the home sleep monitoring of a smaller subsample. An Australian study utilizing the same sleep monitoring device and the same definition of SDB as used in our study reported a prevalence rate of 3% in middle-aged men.$^8$ The variations in defining clinically significant SDB among different studies have made comparisons difficult to interpret. There is little data on the prevalence of SDB in the Oriental population. Studies on smaller subgroups have shown a prevalence rate of 3.1% among Japanese industrial workers using a home sleep monitor,$^{15}$ and about 2% in a group of middle-aged Chinese male office workers.$^{16}$

There is controversy in the literature regarding age-related normal PSG in adolescents and young adults. A study had shown that in normal children aged between 6 and 18 years, an apnea index $\geq 1$ and a minimum $\text{Sa}_o_2 \geq 92\%$ could be considered abnormal.$^3$ However, in our study, the mean age of the patients was 20 years; therefore, normal PSG values for adults may be more appropriate as reference. Taking the definition of SDB to be an RDI $\geq 5$ together with the presence of self-reported sleepiness, the prevalence of SDB in our monitored subjects was 2.3%, while the prevalence rate would be 10.2% if the more liberal cutoff point of RDI $\geq 3$ was used. Thus, the minimum estimated prevalence rates of SDB in the original sample population would be 0.1% and 0.5% for RDI threshold values of $\geq 5$ and $\geq 3$, respectively. These cutoff points are controversial and essentially arbitrary, being based on the level of obstructive respiratory events that was thought to lead to daytime sleepiness. This result may be affected by several sources of bias:

**Related to the Survey:** The subjects who consented for sleep monitoring may be those individuals with more significant sleep complaints, so that the prevalence of SDB in the study sample may be higher than that in the source population. Poor sleep hygine, sleep deprivation, and sleep phase delay are common in young adults and may partly account for the high prevalence of self-reported sleepiness and impaired work performance that was not associated with SDB.

**Related to the Home Sleep Monitoring:** The imprecision of the measuring equipment may contribute as an important source of bias. The diagnostic accuracy of MESAM IV at best reached a sensitivity of 69% and a specificity of 97% as a confirmation test by manual scoring against traditional PSG.$^9$ More-

### Table 2—Correlations Between Baseline Characteristics and Indices of Snoring and SDB by Univariate Analysis ($n = 88$)

<table>
<thead>
<tr>
<th>Variables</th>
<th>&gt; 10% Snoring</th>
<th>RDI $\geq 3$</th>
<th>ODI $\geq 3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>NS</td>
<td>$&lt; 0.03$†</td>
<td>NS</td>
</tr>
<tr>
<td>Gender</td>
<td>$&lt; 0.03$*</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>BMI</td>
<td>NS</td>
<td>$&lt; 0.03$‡</td>
<td>NS</td>
</tr>
<tr>
<td>Neck circumference</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Family history</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Male subjects were more likely to be snorers.
†Younger subjects (age $< 20$ years) were more likely to have an RDI $\geq 3$.
‡Subjects with BMI $> 22$ were more likely to have an ODI $\geq 3$. 

**Figure 1.** Distribution of snoring and RDI on sleep monitoring ($n = 88$).
over, the measurement of the severity of SDB by means of indexes such as RDI and ODI was subject to artifactual error. For example, the ODI values can be falsely elevated due to a loose finger probe causing movement artifact. Actual sleep time was estimated as the difference between bed time and wake time as claimed by the subjects, and this would usually result in an overestimation of actual sleep time. In young adults with normal cardiorespiratory reserve, significant upper airway obstruction can occur in the absence of oxygen desaturation, and therefore can be missed by the home sleep monitoring. Furthermore, sleep quality during the study night may be affected by the discomfort of the monitoring device. All of these factors could significantly underestimate the level of real SDB in this population. Taking these limitations into account, the prevalence of SDB in this population is likely to lie between the estimated minimum prevalence (0.1%) and the estimated prevalence (2.3%) in the monitored sample.

Daytime somnolence was reported in a large proportion of subjects without apparent SDB, suggesting that factors other than SDB may be responsible for this symptom. These factors may include sleep deprivation due to demanding study or work schedules, together with irregular sleeping patterns common in this age group. Subjective complaints of sleepiness may not be as reliable as those reported by spouses or bedpartners and do not correlate with objective measurements of sleepiness by multiple sleep latency test. Male subjects were associated with a higher BMI and a higher prevalence of recorded snoring, in keeping with the results of previous studies. However, there was no direct correlation between BMI and recorded snoring, suggesting that male gender may be an independent risk factor for both obesity and snoring.

A total of 9% of the subjects had recorded snoring > 10% of the night. Male gender showed a trend as a risk factor associated with snoring in our study, but it did not predict the occurrence of SDB, suggesting that the mechanisms leading to SDB may be different from those causing simple snoring. There was no correlation between self-reported snoring on questionnaire and recorded snoring, which was not surprising because snoring is often a complaint by spouses that may not be easily noted by the subjects themselves. In our study, snoring for > 10% of the night was recorded in 70% of subjects who reported that they never snored, giving a sensitivity and specificity of 82% and 30%, respectively. This was in contrast to the results of a Swedish study in which the sensitivity and specificity of questions on snoring vs recorded snoring were 42% and 83%, respectively. Thus, it is important to obtain an objective record of snoring, such as a bedpartner questionnaire, in studies using snoring as a surrogate marker for SDB.

Among the 88 monitored subjects, individuals with

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<th>Table 3—Factors Predictive of Snoring and SDB by Logistic Regression Analysis (n = 88)</th>
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<tr>
<td>Variables</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Female</td>
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<td>Male</td>
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<tr>
<td>BMI</td>
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<td>&lt; 18</td>
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<tr>
<td>18–22</td>
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<td>&gt; 22</td>
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<tr>
<td>Alcohol use</td>
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<tr>
<td>No</td>
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<tr>
<td>Yes</td>
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<tr>
<td>Family history</td>
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<tr>
<td>No</td>
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<tr>
<td>Yes</td>
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<tr>
<td>Performance ability*</td>
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<td>Mild</td>
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<td>Moderate</td>
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<tr>
<td>Severe</td>
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<tr>
<td>Daytime sleepiness†</td>
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<td>Mild</td>
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<td>Moderate</td>
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<td>Severe</td>
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*Graded responses to question 1 are in the Appendix.
†Graded responses to question 2 are in the Appendix.
a BMI > 22 were more likely to have an ODI ≥ 3, but the relationship with RDI was not significant (NS). Previous studies have shown that BMI was the most important risk factor for SDB,8,11 and the association was more significant in obese subjects with a BMI > 30. This relationship, not surprisingly, was less apparent in our population with a mean BMI of only 20 (SD, 2.5). Interestingly, younger subjects aged < 20 years were more likely to have a higher RDI (≥ 3; p < 0.03) on univariate analysis (Table 2); however, this was NS when gender and obesity were taken into account (Table 3). Other factors such as neck circumference, family history, and alcohol consumption had no direct relationship with either snoring or SDB, in keeping with the results of previous studies.22,23 Self-reported symptoms of moderate to severe daytime sleepiness had a trend toward an increased risk for snoring. However, other questionnaire data in the Sleep and Health Questionnaire did not predict either snoring or SDB in this population (Table 3).

Snoring in the absence of SDB has been shown to be associated with daytime sleepiness and impaired performance ability.21 This was thought to be related to arousals and sleep fragmentation as a result of partial upper airways obstruction during sleep without the presence of frank apneas or hypopneas.24 Sleep fragmentation has been shown to lead to sleepiness, impaired cognition, and altered mood.25 Thus, snoring in the absence of SDB on routine sleep study may not be “benign,” but may represent a subclinical phase of upper airways obstruction. Various vascular diseases such as hypertension, ischemic heart disease, and cerebrovascular accident have been associated with snoring, after accounting for the potential confounding risk factors such as obesity and age.26–28 It is unclear whether young patients with snoring or SDB are at higher risk of developing vascular diseases with age. The degree of snoring and SDB that is “pathologic” (ie, associated with excess morbidity and warrants treatment) is also unknown. It is possible that snoring and sleep apnea in adolescents may represent an early asymptomatic phase of the disease before overt clinical sleep apnea develops in adulthood. Longitudinal data is needed to support this hypothesis.

In conclusion, we have shown that SDB was uncommon in this group of relatively young Oriental adults, with an estimated prevalence rate between 0.1% and 2.3%. Male gender had a trend predictive of snoring, but not SDB. Individuals with a BMI > 22 were more likely to have an ODI ≥ 3. However, there was no correlation between neck circumference, alcohol consumption, and family history with either snoring or SDB. Sleep-related symptoms such as daytime sleepiness and impaired performance ability were commonly reported, but these self-reported symptoms were unreliable in predicting either snoring or SDB in this population.

APPENDIX

The Modified Sleep and Health Questionnaire

The five selected questions from the questionnaire6 included in the final analysis are shown:

1. Performance ability: “During the past month, how do you rate your ability to perform tasks at home and at work?” (Likert scale: [1] best; alert, concentrate well; [6] worst: feel foggy, tired)
2. Daytime sleepiness: “Over the last month, have you experienced excessive sleepiness during the day or during your normal working hours?” (5-point frequency scale: [0] never; [1] rarely: less than once a week; [2] sometimes: once or twice a week; [3] frequently: three to four times a week; [4] almost always: five to seven times a week; and [5] not sure)
3. Snoring intensity over the last month: “During the last month, how has your snoring been?” (0) I have never snored; (1) only slightly louder than heavy breathing; (2) about as loud as mumbling or talking; (3) louder than talking; (4) extremely loud: can be heard through a closed door; and [5] do not know)
4. Frequent awakenings: “Over the last month, have you experienced frequent awakenings after falling asleep?” (5-point frequency scale)
5. Observed apneas: “At night, do you notice that your roommate/bed partner stops breathing?” (5-point frequency scale; asked of roommate/bed partner)

REFERENCES


