Does Snoring Contribute to Presbycusis?

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It is well known that hearing acuity decreases with age. The precise mechanism responsible for this phenomenon, called presbycusis, is unknown. One hypothesis advanced to explain this loss of acuity implicates chronic exposure to snoring noise. Consequently, the purpose of this study was to investigate whether snoring is associated with hearing loss. We examined 219 patients (63 women and 156 men) referred to our sleep disorders center. All of the patients underwent nocturnal polysomnography with measurements of snoring, as well as standard audiometry (i.e., measurement of hearing thresholds at 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, and 8 kHz). Snoring was quantified by measuring three parameters: snoring index (SI = number of snores/h of sleep), average nocturnal sound intensity (dBav), and maximum nocturnal sound intensity (dBmax). We used simple correlation analysis to investigate the relationship between snoring and hearing thresholds; multiple linear regression analysis to determine individual contributions of age, sex, and snoring to the variability in hearing thresholds; and comparison tests to determine whether mild snorers had less hearing impairment than severe snorers. None of these statistical tests demonstrated that snoring was a significant determinant of hearing. We conclude that snoring is not associated with hearing loss and is therefore unlikely to account for presbycusis. Hoffstein V, Haight J, Cole P, Zamel N. Does snoring contribute to presbycusis? AM J RESPIR CRIT CARE MED 1999;159:1351–1354.

Snoring is an important symptom of sleep apnea, and is often the reason for referral of such patients to a sleep disorders center. However, whether snoring by itself, without sleep apnea, causes adverse health effects is not yet clear. Possible consequences of snoring, currently under investigation, include vascular disease (e.g., hypertension, coronary artery disease, and cerebrovascular disease), daytime dysfunction (sleepiness, fatigue, poor concentration), and hearing loss. The last may be a consequence of chronic exposure to episodic nocturnal noise. It has been suggested that the commonly observed reduction in hearing acuity with age (presbycusis or presbyacusis) might be a consequence of snoring (1). Consequently, we undertook a study to determine the relationship between snoring and hearing loss.

METHODS

Subjects and Measurements

We studied 219 patients referred to our sleep clinic at St. Michael's Hospital because of suspected sleep apnea. Most of them were definite snorers, with snoring the chief complaint in 108 and another 74 patients admitting to being habitual snorers, and only 37 patients not complaining of snoring.

All subjects had standard nocturnal polysomnography, which included monitoring of respiration (using oronasal thermistors, inductive plethysmography, and oximetry), sleep architecture (electroencephalography [EEG], chin electromyography [EMG]), leg movements, and heart rate (HR). Snoring was measured as previously described (2), using a calibrated microphone–sound meter system. The microphone was placed on the nasion, and its output was fed into a sound meter calibrated at a frequency of 1,000 Hz. Signal amplitude was continuously sampled by an analogue-to-digital converter, and the results were stored for further analysis. With this system, any spike in sound intensity registering more than 50 dB is usually perceived as a snore. Snoring was quantified with three parameters: number of snores/h of sleep (snoring index [SI]), maximum nocturnal sound intensity (dBmax), and average nocturnal sound intensity (dBav).

Audiograms were recorded for all subjects prior to the sleep study. This was done in accordance with the standard protocol, which included determination of the hearing thresholds at 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, and 8 kHz.

Statistical Analysis

The goal of statistical analysis was to determine whether snoring severity affects hearing threshold. This was done in three ways.

First, we performed simple linear regression analysis of hearing thresholds at each frequency (independent variable) versus each snoring variable (SI, dBav, and dBmax) taken separately.

Second, we divided all patients into quartiles for each of the three snoring variables. To maximize the chances of finding a significant difference in hearing thresholds with snoring severity, we compared only the patients belonging to the lowest and the highest quartiles (i.e., pa-

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TABLE 1

ANTHROPOMETRIC AND SLEEP DATA

	Women		Men	
Variable	Mean ± SD	Range	Mean ± SD	Range
N	63		156	
Age, yr	46 ± 13	13–74	47 ± 12	18–77
BMI, kg/m^2	29.3 ± 8.6	18–55	30.3 ± 5.7	19–52
Weight, kg	76.5 ± 22.7	46–142	92.6 ± 18.7	56–160
AHI, events/h	12.4 ± 17.8	0–101	23.6 ± 24.2	0–107
SI, events/h	331 ± 387	1–1,687	483 ± 281	2–1,824
dBmax, dB	82.9 ± 9.8	58–100	87.2 ± 9.5	63–100
dBav, dB	57.4 ± 5.3	50–78	58.8 ± 4.0	50–71

tients at the two extremes of the "snoring spectrum," the mildest snorers and the most severe snorers).

Last, we performed multiple linear regression analysis with hearing thresholds as the dependent variable and age, sex, SI, dBmax, and dBav as independent variables.

All statistical analyses were done with SAS version 6.12 software (SAS Institute, Cary, NC).

RESULTS

The study included 63 women ranging in age from 13 to 74 yr and 156 men aged 18 to 77 yr. Their anthropometric and sleep data are shown in Table 1. We noted that the women had less severe sleep apnea and snoring than did the men.

Figure 1 shows the relationship between hearing thresholds and age. The purpose of this analysis was simply to check, albeit indirectly, that our sample population was representative of the general population. It is well known that hearing thresholds depend strongly on age, and we were gratified to find that our sample population reproduced this well-known result. Furthermore, the slope of the plot for the relationship was significantly ($p < 0.05$) greater for men (slope = 0.86) than for women (slope = 0.54).

An audiogram for the entire population is shown in Figure 2. We noted that although the mean values of hearing thresholds at frequencies of 2 kHz, 3 kHz, 4 kHz, and 6 kHz were below 25 dB, which is considered to be a limit for mild hearing loss, there was a wide scatter of the data, as may be seen with large standard deviations.

To determine whether there was any relationship between snoring and hearing thresholds, we performed linear regression analyses at all frequencies from 250 Hz to 8 kHz, with hearing thresholds (right and left ear separately) as dependent variables and SI, dBav, and dBmax as independent variables. The results were similar for all frequencies and for both ears. A typical example of these results is given in Figure 3 for the right ear at 4 kHz, which is the frequency commonly associated with industrial hearing loss due to noise; in fact, hearing loss at 4 kHz, the so-called 4000-Hz dip, has become a characteristic link between noise exposure and hearing loss. Simple visual inspection of the scatter plots did not suggest a relationship between snoring and hearing loss. Regression analysis confirmed this visual impression, showing no significant correlation between hearing threshold and SI, dBmax, or dBav; the product SI · dBmax, which may be thought of as the maximum "acoustic dose," also did not correlate with hearing thresholds.

Figure 4 shows the typical bar-and-whiskers graph commonly used to illustrate division of variables into quartiles. The highest and the lowest values are represented by the short bars, and the median is the long bar inside the rectangle, which represents the interquartile range. Patients within the lowest quartile (mildest snorers) had SI < 191, dBmax < 78, and dBav < 55. Patients within the highest quartile (most severe snorers) had SI > 622, dBmax > 94, and dBav > 61. The hearing threshold at 4 kHz was not significantly different for the patients in the highest and the lowest snoring quartiles (Figure 5).

Multiple forward linear regression analysis with hearing threshold at 4 kHz as the dependent variable yielded $R^2 = 0.34$; only age and sex, and none of the snoring variables, made a statistically significant contribution to the regression coefficient. This was true for both ears and for hearing thresholds at all other frequencies.

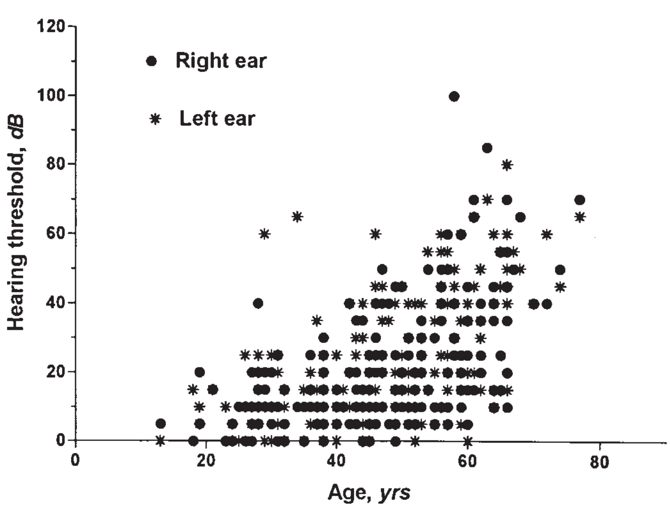

Figure 1. Age dependence of hearing threshold.

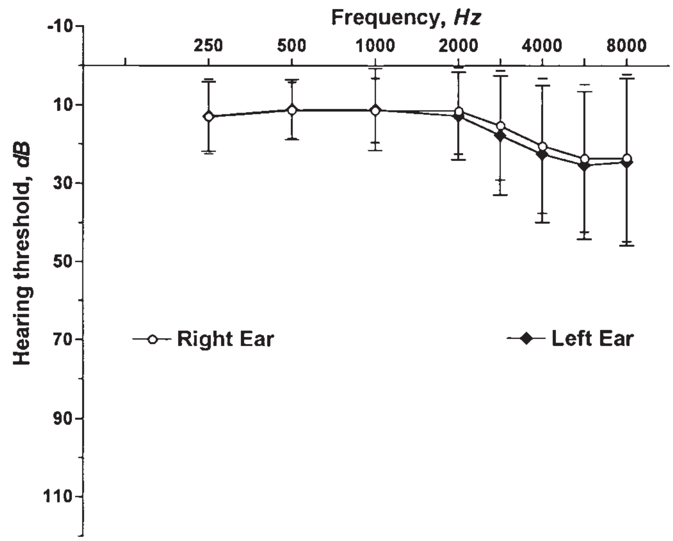

Figure 2. Composite audiogram for all patients (mean ± SD).

DISCUSSION

This study demonstrated that snoring has no influence on hearing loss. Most of the hearing loss in the patient population examined in the study was associated with age and gender.

Before discussing the implications of our findings, let us address some methodologic issues having to do with measurement of snoring, separation of patients into different catego-

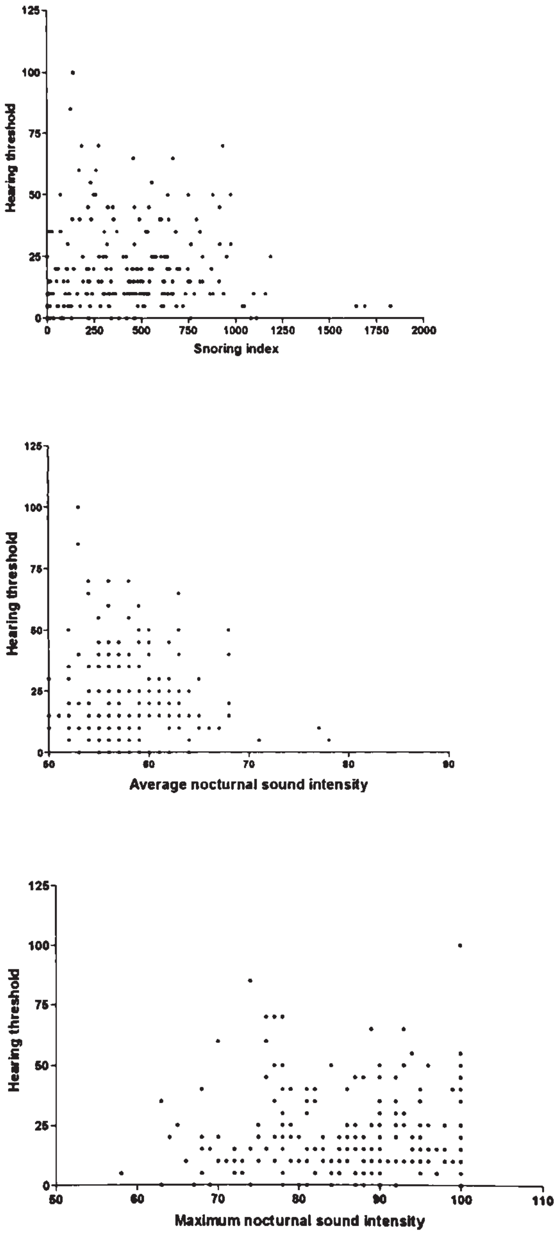

Figure 3. Scatter plots of hearing thresholds (right ear, 4 kHz) versus snoring index (*top panel*), average nocturnal sound intensity (*middle panel*), and maximum nocturnal sound intensity (*bottom panel*).

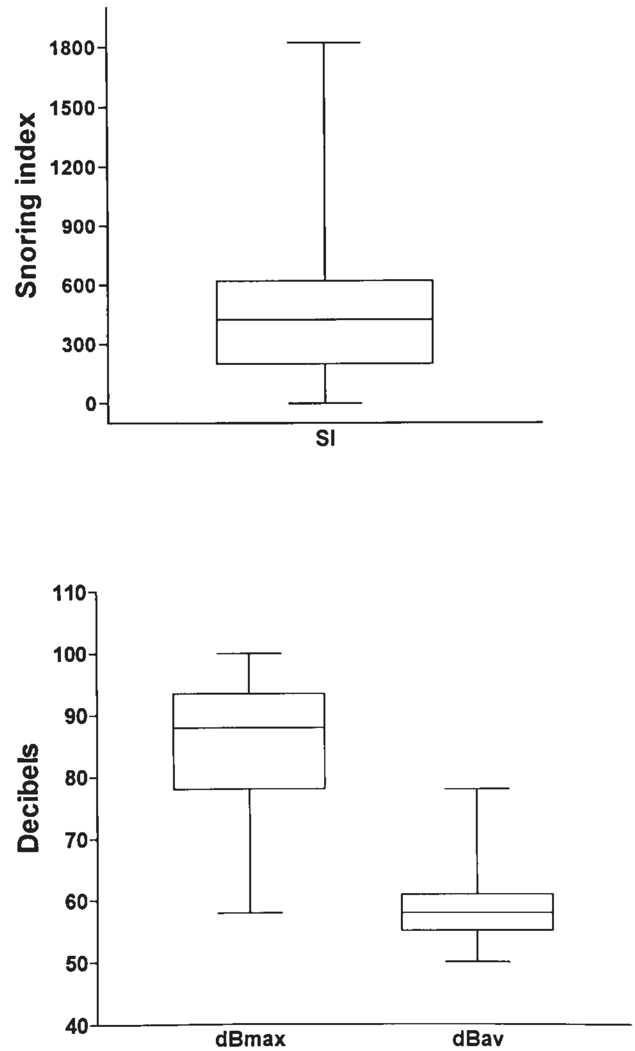

Figure 4. Quartiles of snoring index (*top panel*) and maximum and average nocturnal sound intensity (*bottom panel*).

ries based on snoring severity, and sample size—all of which may potentially influence our results.

Snoring is foremost a perception on the part of the listener. Any objective measurement must be validated against the listener's perception. We did this in our earlier investigations (2, 3), but in any event, because we measured snoring consistently and similarly in all patients, any error would be systematic rather than random, and would not affect the results of our statistical analysis.

Comparison of hearing thresholds among patients grouped into different categories of snoring severity is affected by possible hearing loss from factors not related to snoring, and by the validity of such separation on the basis of a single-night sleep study. We knew that none of the patients was taking ototoxic drugs at the time of the study, but we did not have a good occupational history with particular attention to noise exposure. However, occupational factors cannot have been important in our patient population, since: (*1*) the audiograms of the patient group were essentially normal (in only six patients did the hearing threshold exceed 40 dB); and (*2*) we did not find any difference in hearing thresholds between mild and severe snorers. With respect to judging snoring severity on the basis of a single-night sleep study, this issue is difficult to resolve because of the paucity of data dealing with the variability of snoring measurements. Sériès and coworkers (4) compared snoring measured in the hospital sleep laboratory and at home, and found it to be louder in the laboratory than at home.

Was our sample sufficient to detect the difference in hearing thresholds between mild and heavy snorers? We can easily estimate the power of the test through the use of standard statistical principles and our results (5). Assuming the significance level (α) to be 0.05, and that a clinically significant effect of snoring on hearing threshold is a difference of 10 dB between mild and heavy snorers, the statistical power (i.e., $1 - \beta$) is 0.87. This means that our study had an 87% chance of detecting a statistically significant difference of 10 dB in hearing

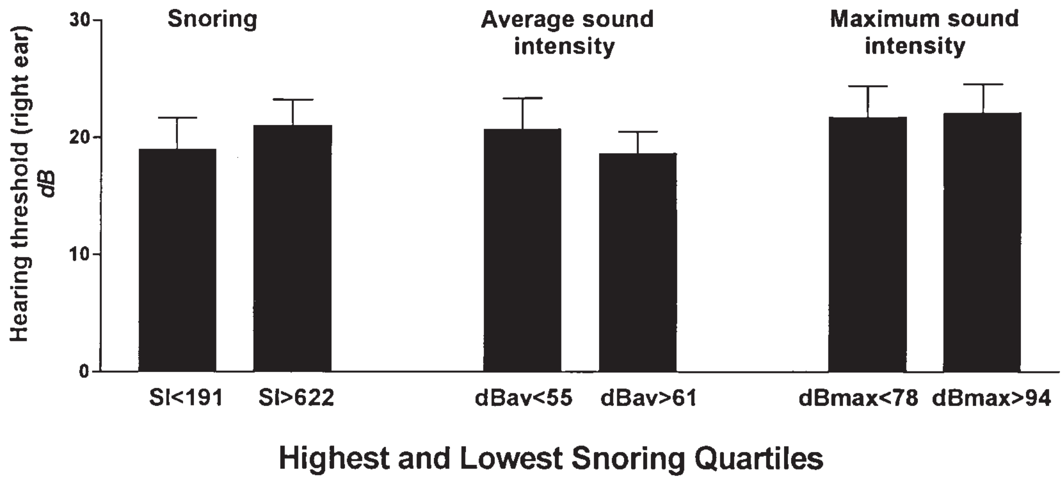

Figure 5. Hearing threshold (right ear, 4 kHz) in mild and severe snorers.

threshold between mild and heavy snorers. Alternatively, there was a 13% chance that our result was falsely negative because of an insufficient sample size.

Having examined the various confounding factors, let us now turn to the possible explanation and implication of our results.

It is well known that hearing loss accompanies the aging process. The etiology of this age-related loss in hearing is unknown (6). Because exposure to noise is one of the most important factors contributing to hearing loss, chronic snoring appears to be an attractive hypothesis to explain at least some of the presbycusis. This possibility was first raised by Prazic (1), who evaluated audiograms of 17 snorers aged 60 yr and older and found a presbyacoustic reduction in hearing in all of them. Prazic concluded that snoring might account for these individuals' hearing loss. However, no concrete results were presented for the degree of hearing loss or documentation of snoring, nor were the patients' data given. No other studies of the relationship between snoring and hearing loss were done during the subsequent 25 years.

Exposure to external environmental noise during sleep has been found to influence some autonomic phenomena, such as cardiac contractility and sympathetic activity (7). However, with regard to the effect of snoring on hearing, it may not be entirely correct to equate exposure to snoring noise with exposure to occupational or environmental noise. In the latter case the exposure is extrinsic (i.e., the source of the noise is located at some distance from the exposed individual). Snoring, which can sometimes be very loud, with sound intensities exceeding industrial levels, is a different kind of noise. It is intrinsic to the exposed individual, and the exposure occurs only during sleep, when the state of consciousness, perception, arousal mechanisms, and thresholds of response to various stimuli are depressed from their levels during wakefulness. It is therefore possible that the effect of snoring noise on hearing loss is not the same as the effect of occupational noise for several reasons.

First, the cumulative exposure to noise generated during snoring may not be sufficient to produce hearing loss; despite occasional loud snores, the average nocturnal sound intensity for our sample was 59 $\pm$ 4 dB, a level too low to produce a significant hearing loss even after many years of exposure. Second, noise produced during wakefulness may have a different effect on the hearing apparatus than noise produced during sleep, when sensorineural reflexes are absent or attenuated. Third, the highly intermittent nature of snoring noise, with wide fluctuations in sound level every few seconds, may not be sufficient to produce either temporary or permanent reductions in hearing thresholds. Because the present study was not designed to investigate the mechanisms by which snoring affects hearing, we can only speculate on these possibilities, all of which offer plausible explanations for our findings.

In summary, we conclude that snoring is not associated with hearing loss, and is therefore an unlikely cause for presbycusis.

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