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SCIENTIFIC INVESTIGATIONS

The Presence of Snoring as Well as its Intensity Is Underreported by Women

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Study Objectives: Women are underrepresented and thus sleep conditions are underdiagnosed at sleep clinics that evaluate sleep-disordered breathing. The most common sign of obstructive sleep apnea (OSA) is snoring; therefore, it is one of the main red flags for suspected OSA. The aim of this study is to determine whether self-reported snoring and snoring intensity by women and men correlates with snoring volume measured objectively during sleep laboratory study.

Methods: Consecutive patients who were referred to a polysomnography (PSG) study in a university hospital over a 2-year period had their snoring volume quantified by means of a calibrated digital sound survey meter. Participants were given a questionnaire in which they were asked to rate the severity of their snoring. The correlation between objective snoring intensity as measured during PSG and the self-reported snoring intensity was evaluated.

Results: A total of 1,913 patients were enrolled in the study. A positive correlation was found between objectively measured snoring intensity and the intensity listed by each participant in the questionnaire. Measurement of the volume of snoring revealed that women snored as loudly as men; however, 28% of the females (189/675) considered themselves to be nonsnorers compared to only 6.9% of men ($P < .05$). Furthermore, 36.5% of women (69/189) who reported themselves as nonsnorers turned out to have severe or very severe snoring intensity, whereas, in contrast, only 11.7% of men (10/85) of men had this discrepancy. These findings are in concordance with the finding that fewer women quantified their snoring as very severe or severe (38.4%), significantly less than men of whom 61.5% reported their snoring to be severe or very severe.

Conclusions: In a population of individuals referred to a PSG study, although no difference in snoring intensity was found between sexes, women tend to underreport the fact that they snore and to underestimate the loudness of their snoring. Improved awareness of this discrepancy may increase women's access to sleep laboratories, and improve diagnostic rates of sleep apnea in females.

Keywords: obstructive sleep apnea, sex, snoring

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BRIEF SUMMARY

Current Knowledge/Study Rationale: In women with symptoms of sleep-disordered breathing, sleep apnea is less likely to be diagnosed and treated than in men. The presence of snoring is one of the main symptoms searched for by clinicians who are screening for obstructive sleep apnea.

Study Impact: This study showed that although no objective difference in snoring intensity was found between women and men, there was a significant discrepancy in self-reported volume of snoring. Compared to men, women reported snoring less often and described it as milder. This difference may be one of the barriers preventing women from reaching sleep clinics and sleep laboratories for polysomnography.

INTRODUCTION

Obstructive sleep apnea (OSA) is a common condition with substantially increased occurrence over the past 2 decades.[1,2] Clinically, OSA is associated with decreased quality of life, daytime sleepiness, and increased incidence of motor vehicle accidents and work-related accidents. OSA was also found to be an independent risk factor for stroke and hypertension.[3] The most common sign of OSA is snoring, which is found in 85% to 98% of patients in whom OSA is diagnosed.[4–7] The correlation between OSA and snoring is so strong that many physicians use it as a screening question to predict the presence of OSA.[8] Most studies conducted on snoring in OSA relied on patients or family members to report the presence and intensity of snoring.[9] According to several studies, it appears that men snore twice as often as women; however, these studies do not reflect objective measurements of snoring and relied solely on questionnaires or telephone surveys.[10–12]

The early epidemiological studies of OSA included only men. Still, years after the large population-based study of Young et al., it has been suggested that discrepancies between females and males in the prevalence of OSA could be simply the result of misdiagnosis or underdiagnosis; it was estimated that in more than 90% of women with sleep apnea, the condition may be undiagnosed.[13] Is it possible that women are less likely to mention snoring because of the perception it is "unfeminine"? Could it be that this phenomenon is one of the causes of underdiagnosed OSA in women?

The general aim of this study is to assess the correlation between self-reported snoring and objective measurement of snoring volume during polysomnography (PSG). Specifically, we sought to compare how often women and men self-report snoring and the volume thereof, and then to compare it to an objective snoring evaluation during in-laboratory PSG. Our hypothesis was that compared to men, women will underreport snoring—and when they do report snoring—they will underestimate its intensity.

METHODS

The study population included all outpatients referred for PSG at our sleep laboratory over a 2-year period. The study included all patients older than 18 years who slept for at least 30 minutes during the test. All patients using continuous positive airway pressure or other oral equipment during the night as well as patients with a history of neck or upper airway surgery were excluded. In cases where patients underwent multiple PSG tests, only their first analysis was used for our study. OSA is defined as individuals having an apnea-hypopnea index (AHI) equal to or greater than 5 events/h. Snoring was considered as any volume above 40 decibels (dB) recorded during sleep.

Polysomnography

PSG was performed on every participant for an entire night using the Sandman 5.0 software (NPB-Melville, Ottawa, Canada). Monitoring equipment included electroencephalography, electrooculography, submental and bilateral anterior tibialis electromyography, electrocardiography, measurements of chest and abdominal respiratory efforts using respiratory inductance plethysmography, finger pulse oximetry, and subcutaneous capnography. Body posture was continuously assessed by a body position sensor. In addition to the aforementioned tests, height and weight were measured on the night of the test. Sleep scoring was done according to The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications version 2.4.[14] Sleep efficiency and total sleep time were expressed as a proportion of the total PSG recording. OSA severity was estimated based on the AHI as follows: no OSA: AHI < 5, mild OSA: AHI 5 to 15, moderate OSA: AHI 15 to 30, severe OSA: AHI > 30 events/h. Data are presented as mean ± standard deviation (SD).

Measuring Snoring Intensity and Self-Assessment of Snoring

Participants completed a questionnaire in which they were asked if they snore or not. In cases where they answered positively, participants were asked to rate the severity of their snoring on a scale ranging from 1 (mild snoring) to 4 (very severe). If no snoring was reported they were graded as 0. In addition, participants were asked about the disturbance caused to them by their snoring, and whether they slept in a different room from their spouses.

Snoring intensity was measured using a digital sound survey meter CEL-231 (produced by Cel Instruments, Ltd., Bedford, England), which has undergone adaptation and validation for use in sleep laboratories. The CEL-231 is an overhead digital sound level meter designed to measure noise levels from 30 dB (A) to 135 dB (A) with ± 1 dB accuracy. It complies with the regulatory orders of the American National Standards Institute and International Electrotechnical Commission standards (sound level meters). The overhead microphone was located on the wall 40 cm above the bed, in all the tests. The device measured noise levels in decibels. The following parameters were analyzed by the device: absolute maximal snoring intensity, overall mean snoring intensity, mean minimum snoring intensity, and mean maximal snoring intensity. Each of the aforementioned parameters was measured for each of the different sleep stages (wakefulness, rapid eye movement [REM] and non-rapid eye movement [NREM]), body positions (prone, supine, lying on the right or on the left) and also for total sleep time. Care was taken in using the device according to the manufacturing company's specifications.[15]

The results of this study were based on the mean maximal snoring intensity, which is the maximal snoring intensity recorded every 30 seconds during the test. It is important to emphasize that the decibel scale is a logarithmic one and thus the difference between 40 and 50 dB represents an increase in noise intensity by a factor of 10 and not a mere 25%.

Data Collection

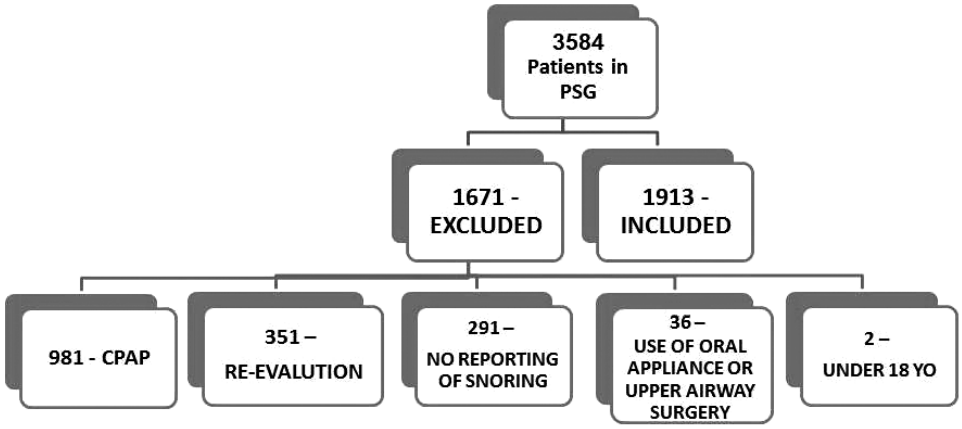
Patient data were collected as part of a cohort study investigating the relationship between snoring intensity and OSA severity. The data collected from each patient included sleep study results, demographic questionnaires, and surveys regarding quality of life and sleeping habits. Previous medical history was also collected before each study.

Data Analysis

Statistical analysis was carried out in three stages:

1. Statistical description of qualitative variables and description of the distribution percentages. For normally distributed quantitative variables (such as age) degree, mean, and SD were calculated. For arranged quantitative variables, or other subnormally distributed ones, only the median and range were calculated (verification of the quantitative variables' normality was done using the Kolmogorov-Smirnov statistical test).
2. Comparison of dichotomous variables (such as snoring yes/no) with independent qualitative variables was done using the chi-square test. To compare those same variables with normally distributed quantitative ones, the *t* test for independent samples was used. To compare the aforementioned changes with arranged quantitative variables or abnormally distributed variables, the Mann-Whitney *U* test was used. In order to evaluate the correlation between qualitative variables describing dichotomous self-reports with objective variables measured in the laboratory, the kappa value was calculated and the McNemar test was used. To analyze self-reported snoring intensity versus snoring intensity measured in the laboratory both the Spearman and Wilcoxon tests were used.

Figure 1—Flow chart.



CPAP = continuous positive airway pressure, PSG = polysomnography, YO = years old.

Table 1—Characteristics of patients referred for polysomnography.

Patient Characteristic	All Patients	Females	Males
Number	1,913	675 (35.3%)	1,238 (64.7%)
Age (years)	49.0 ± 13.7	49.8 ± 14.1	48.7 ± 13.5
Body mass index (kg/m^2)	30.1 ± 6.7	30.8 ± 8.1	29.7 ± 5.7
Neck circumference (cm)	39.4 ± 4.3	36.1 ± 3.7	41.1 ± 3.5
Mean decibels (for total sleep time)		50.0 ± 6.0	51.7 ± 6.5

3. For multivariable processing (for dichotomous variables such as snoring yes/no) a logistic regression was carried out. For processing of snoring intensity (grade 0–4) a Poisson regression was used.

Data analysis was performed using the SPSS software version 14 (SPSS Inc., Chicago, Illinois, United States).

Ethics

This study obtained approval from the institution's ethical committee and the need for informed consent was waived by the board.

RESULTS

PSG studies were performed on 3,584 patients; 1,671 (46%) were excluded for various reasons (**Figure 1**).

Patient Characteristics

Our study analyzed 1,913 patients (demographic data are presented in **Table 1**), of whom 675 (35.3%) were women and 1,238 (64.7%) were men. The mean age among our study population was 49 years (SD ± 13.7). There was no significant difference between the mean ages of male versus female participants (females 49.8 ± 14.1, males 48.7 ± 13.5, $P = .095$). We observed significant differences between women and men in neck circumference (females 36.1 ± 3.7, males 41.1 ± 3.5, $P < .01$), body mass index (BMI) (females 30.8 ± 8.1, males 29.7 ± 5.7, $P < .01$), and mean maximal snoring intensity (females 50 ± 6, males 51.7 ± 6.5, $P < .01$).

Results from sleep studies revealed the presence of mild to moderate OSA in most participants. Of all the participants analyzed, only 409 had an AHI < 5 events/h. A total of 620 patients had an AHI between 5 and 15 events/h, 526 patients had an AHI between 15 and 30 events/h, and 668 patients had an AHI > 30 events/h.

PSG results for females and males are displayed in **Table 2**. It shows that there are no statistical differences between women and men in the amount of time they spend in REM sleep during their PSG (females 15.9 ± 7.6, males 16 ± 7.1, $P = .86$). Sleep efficiency was not statistically different between the two groups (females 78.8 ± 15.5, males 78.5 ± 15.3, $P = .71$). However, there was a significant difference between women and men in the AHI for total sleep time (females 18.8 ± 23.1, males 28.7 ± 26, $P < .01$), when lying supine (females 25 ± 30.3, males 42.9 ± 35.8, $P < .01$), and when lying prone (females 14.4 ± 22.7, males 20.6 ± 25.4, $P < .01$).

Finally, sleep time was similar for both sexes (females 5.7 ± 1.2, males 5.6 ± 1.2, $P = .33$).

Snoring Questionnaires and Measurements Results

Table 3 shows patients' responses to the preliminary questionnaire. To the question "Do you snore?" 274/1,913 patients responded no and 1,639/1,913 patients responded yes. A significant difference was found between the sexes, 6.9% of men compared to 28% of women considered themselves as nonsnorers ($P < .05$).

The second part of the aforementioned questionnaire involved rating the severity of the participants' snoring. Each participant who reportedly snored was asked to rate snoring severity as follows:

Table 2—Snoring intensity (mean maximum decibels) for all participants.

	All Patients	Females	Males
Total sleep time	51.1 ± 6.4	50.0 ± 6.0	51.7 ± 6.5
NREM sleep	51.4 ± 6.6	50.2 ± 6.1	52.0 ± 6.7
REM sleep	49.8 ± 6.0	49.2 ± 5.8	50.2 ± 6.0
Supine	52.4 ± 6.7	50.9 ± 6.4	53.1 ± 6.7
Prone	50.1 ± 6.5	49.3 ± 6.1	50.6 ± 6.6
BMI < 30 kg/m^2	48.7 ± 5.2	48.6 ± 4.4	50.6 ± 5.5
BMI > 30 kg/m^2	54.1 ± 6.5	51.3 ± 5.7	57.4 ± 5.5
Neck circumference < 40 cm	49.5 ± 5.2	46.6 ± 3.5	51.7 ± 5.3
Neck circumference > 40 cm	54.9 ± 6.8	50.4 ± 5.1	54.9 ± 6.2

BMI = body mass index, NREM = non-rapid eye movement, REM = rapid eye movement.

Table 3—Self-reported snoring intensity.

	Sex	
Snoring Intensity (Self-Report)	**Female (n = 675)**	**Male (n = 1238)**
0 = None	189 (28%)	85 (6.9%)
1 + 2 = Mild + moderate	227 (33.6%)	391 (31.5%)
3 + 4 = Severe + very severe	259 (38.4%)	782 (61.5%)

Table 4—Self-report versus objective evaluation of snoring intensity in males.

	Snoring Intensity (Measured During Sleep Study)					
Snoring Intensity (Self-Report)	**0 ≤ 40 dB**	**1 = 40–45 dB**	**2 = 45–55 dB**	**3 = 55–60 dB**	**4 ≥ 60 dB**	**Total**
0 = None	44	19	12	1	9	85
1 + 2 = Mild + moderate	45	107	91	35	113	391
3 + 4 = Severe + very severe	3	77	166	266	250	762
Total	92	203	269	302	372	1,238

- Mild snoring = 1
- Moderate snoring = 2
- Severe snoring = 3
- Very severe snoring = 4

In general, these findings show that women across the entire range of snoring loudness rated their snoring to be less severe compared to men. For example, 32% of men reported their snoring to be very severe compared to only 21% of women ($P < .05$).

In the next stage of the study we evaluated snoring intensity during the sleep laboratory. We used the mean maximal intensity as a reference point. According to this value, a rating of snoring intensity was established and was compared against the snoring intensity evaluated by each patient.

The rating of objectively measured snoring intensity was established on a scale of 0–4 as follows:

- No snoring = 0 (≤ 40 dB)
- Mild snoring = 1 (40–45 dB)
- Moderate snoring = 2 (45–55 dB)
- Severe snoring = 3 (55–60 dB)
- Very severe snoring = 4 (≥ 60 dB)

Table 3 presents results obtained for mean maximal snoring intensity during sleep. A nonsignificant difference in mean snoring intensity between women and men was seen during total sleep time (females 50 ± 6, males 51.7 ± 6.5 dB), during REM sleep (females 49.2 ± 5.8, males 50.2 ± 6 dB), during NREM sleep (females 50.2 ± 6.1, males 52 ± 6.7 dB), when lying supine (females 50.9 ± 6.4, males 53.1 ± 6.7 dB) and when lying prone (females 49.3 ± 6.1, males 50.6 ± 6.6 dB).

A statistical difference was noted in average snoring intensity when our study population was divided into two groups: BMI > 30 kg/m^2 and BMI < 30 kg/m^2. In the first group, BMI > 30 kg/m^2, the average intensity was 54.1 dB (± 6.5 SD) whereas it was only 48.7 dB (± 5.2 SD) in the BMI < 30 kg/m^2 group.

The last stage of this study included the comparison of the questionnaires with the objective snoring measurements (**Table 3**, **Table 4**, and **Table 5**).

Again, results show that although women snore as loudly as men they are more likely than men to rate their snoring as mild or moderate and less likely to report their snoring as severe or very severe—38.4% in women compared to 61.5% in men ($P < .05$) (**Table 3**).

Furthermore, approximately 40% of women who reported themselves as nonsnorers were measured as having a severe or very severe snoring intensity. This is in contrast to only 12% of men (10/85) who had this discrepancy (**Table 4** and **Table 5**).

According to the results displayed, of 1,913 participants analyzed, only 492 (25.7%) evaluated their snoring

Table 5—Self-report versus objective evaluation of snoring intensity in females.

	Snoring Intensity (Measured During Sleep Study)					
Snoring Intensity (Self-Report)	**0 ≤ 40 dB**	**1 = 40–45 dB**	**2 = 45–55 dB**	**3 = 55–60 dB**	**4 ≥ 60 dB**	**Total**
0 = None	65	30	25	21	48	189
1 + 2 = Mild + moderate	19	64	57	57	30	227
3 + 4 = Severe + very severe	0	34	52	80	103	269
Total	84	128	134	148	181	675

intensity correctly when we compared it to objective PSG measurements ($P < .01$).

DISCUSSION

The main finding of our study is that women underreport their snoring habits. Therefore, our results identify the importance of relying on risk factors other than snoring when screening women for enrollment to sleep laboratory. The following discussion will consider these results in light of the extant literature. We will discuss differences between women and men in sleep-disordered breathing expression and diagnosis, snoring sex characteristics and variances, and the techniques and limitations of snoring assessment.

Studies estimate that one in four women has OSA. OSA is underdiagnosed in approximately 90% of women who do have the condition, and it is thus crucial for the medical community to be aware of this in order to increase diagnosis in women.[16,17] We showed that more women considered themselves to be nonsnorers in comparison with men (6.9% versus 28%, $P < .01$). This was contrary to what was later seen after objective measurement by PSG—that women snored as frequently and as loudly as men. Although women appear less susceptible to OSA, recent studies have raised concerns about female-specific complications of OSA. It was found that 50% of the female participants did not experience nocturnal symptoms to the same extent as men who had the same level of sleep-disordered breathing, and further study showed that female patients report more symptoms such as fatigue and tiredness than males.[18,19] These differences between women and men are some of the reasons why sleep conditions in women tend to be underdiagnosed/undertreated even when these women experience serious diurnal complications. To the best of our knowledge, differences in self-reported snoring and the objective measurement of snoring volume during PSG between women and men have never before been investigated. This study therefore newly identifies clinically relevant data of interest to all physicians who screen patients for sleep studies.

Studies have looked at the differences between the two sexes' clinical presentation in order to account for the discrepancy in prevalence and diagnosis rates of the syndrome. Flemons et al., for example, reported in their study that snoring in the context of sleep apnea was found two to three times more often in males than in females.[8] This study used self-report questionnaires and not objective measurement by digital sensors of snoring intensity. When comparing findings from Flemons et al. to the present study, results were similar; however, the addition of snoring volume assessment uncovered a previously unknown phenomena of women underreporting snoring despite, objectively, snoring just as often and as loudly as men.

Interestingly, clinical population studies found that women with sleep apnea tend to underreport their husbands' snoring as a way to ease the burden of their own condition.[20,21] This may indicate differences between women and men in their approach to sleep problems generally. We can postulate that women underreport their snoring habits because of social perception of this condition in women and men. This parameter should be taken into account by clinicians in order to efficiently screen for OSA in women. In summary, the reason why women are underrepresented at sleep clinics is unclear. It has been speculated that the symptom profile of women differs from that of men, but studies designed to identify specific sleep-disordered breathing symptoms in women have failed. Our study shows that at least in one parameter, of critical importance in the early diagnosis of sleep-disordered breathing, the self-reporting of snoring, there is significant difference between women and men.

In most studies to date, researchers have relied on patients or family members in order to find out about snoring and snoring frequency in their patients. However, several studies have analyzed snoring sounds in order to find out if any differences existed between a "simple" and an "OSA" snore. Pastercamp et al.[20] recorded tracheal sounds during awakening in patients in whom OSA was diagnosed. An increase in low-, medium-, and high-frequency sounds was also noted when these same patients were compared to other individuals without OSA. These findings are the basis of a new way to screen for OSA according to the investigators. In another study conducted by Fiz et al.,[21] snoring sounds were compared between participants who were "simple snorers" and patients with OSA. They found a significant statistical difference between the two groups. Another interesting study conducted by Perez-Padilla et al.[22] identified postapneic snoring in patients with OSA that was different from what was observed in "simple snorers." However, none of the aforementioned studies compared the objective measurement of snoring intensity with self-report. Unfortunately, there is currently no gold standard for the assessment of snoring sound. In a study by Arnadottir et al., microphone cannulas were compared with piezoelectric sensors. They showed that the overhead digital system (as used in this study) is better than other methods at detecting snoring events.[23]

A meta-analysis of 63 studies by Chan et al.[24] showed consistent male predominance in snoring among the general population, with an odds ratio for snoring of 1.89 for male versus female. Again, all studies were questionnaires based.[24] In

another study by De Silva et al.,[25] sex-specific differences in the acoustic properties of snoring sound were investigated. They showed the importance of adopting sex-specific models for the snoring-based OSA screening technique.[25]

Limitations

Our data for each patient were based on a single PSG measurement. PSG is objective and highly specific, but it is possible that for some participants, the data obtained did not reflect their true snoring habits. However, our study comprises more than 1,000 patients and therefore we believe that the average results are clinically relevant.

CONCLUSIONS

Surveys are extremely important in identifying patients at risk for OSA, but health care providers should understand that patients may not reliably answer questions regarding snoring and snoring intensity, probably because of sex-based social stigma. In this study we found that there are differences in the way women and men report their snoring habits. Even though women were objectively observed to have similar snoring volumes as men, they tend to underreport the fact that they snore and underestimate the volume of their snoring. This information is of great importance to physicians who wish to know how to best screen for OSA. Because it is important to obtain as many clinical tools as possible to screen for and diagnose OSA, our study should aid in the screening process of women with suspected OSA. Consequently, we suggest that the level of suspicion of the presence of OSA in women should be higher and based on other symptoms such as daytime fatigue, depression, chronic pain, and headaches.

ABBREVIATIONS

AHI, apnea-hypopnea index
BMI, body mass index
OSA, obstructive sleep apnea
PSG, polysomnography

ABBREVIATIONS

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DISCLOSURE STATEMENT

The authors report no conflicts of interest related to the subject of this paper.