Original Article

Snoring time versus snoring intensity: Which parameter correlates better with severity of obstructive sleep apnea syndrome?

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ABSTRACT

Objective: The relationship between the severity of obstructive sleep apnea syndrome (OSAS) and both snoring intensity and rate measured objectively has not been sufficiently investigated. The aim of this study was to evaluate the relationship between severity of OSAS and snoring parameters including snoring intensity and rate. **Patients and Methods:** A total of 150 records of individuals who complained of snoring were analyzed. Patients were classified into four groups according to apnea–hypopnea index (AHI). Polygraphy recordings including the snoring intensity and the snoring rate (defined as the percentage of snoring time during the total sleep time) and the clinical data were compared and analyzed. **Results:** AHI was significantly correlated, respectively, with snoring rate ($r = 0.341$; $P < 0.0001$) and maximal intensity of snoring ($r = 0.362$; $P < 0.0001$). However, no correlation was found between the average intensity of snoring and AHI ($P = 0.33$). When assessing each respiratory event individually, snoring rate was more correlated with hypopnea index ($r = 0.424$; $P < 0.0001$) than with AI ($r = 0.233$; $P = 0.004$). The snoring rate (%) in the severe OSAS group (31.79 ± 19.3) was significantly higher than that in the mild OSAS group (18.02 ± 17; $P = 0.001$) and the control group (17 ± 16.57; $P = 0.011$). Similarly, the maximal intensity of snoring (db) in the severe OSAS group (90.45 ± 13.79) was higher than that in the mild OSAS group (86.46 ± 15.07; $P = 0.006$) and the control group (84.75 ± 6.65; $P < 0.001$). **Conclusion:** The snoring rate and maximal intensity of snoring correlate better with the severity of OSAS than average snoring intensity.

KEY WORDS: Obstructive sleep apnea syndrome, polygraphy, snoring, snoring intensity, snoring rate

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INTRODUCTION

Snoring is a highly prevalent disorder,[1,2] and it is one of the most common symptoms in obstructive sleep apnea syndrome (OSAS) frequently associated with altered quality of sleep. It is, therefore, an important clinical guidance element for screening for OSAS.[3,4] Snoring, not perceived by the patient himself, often alerts the family and is a reason for consultation. It is typical inspiratory breathing noise occurring during sleep, even though a small expiratory component can be heard.[3,5,6] The sound source is the segment pharyngeal upper airways. It is

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the audible sign of increased upper airway resistance.[7] Being a noise, it can be defined, like all noises, by its time of occurrence, its duration, and its intensity. In practice, recording techniques most often define the number of snores per hour (or "snoring index"), cumulative duration of snoring, and the average intensity or energy of snoring.[6] Before the last years, the majority of the published data interesting associations between snoring and severity of OSAS was based on subjective reports of snoring either from the snorer himself or from members of his family.[8-10] The overly subjective perception of snoring makes an objective measure of snoring necessary if one wants to assess patient's condition and evaluate treatment effects accurately.[11] The relationship between the severity of OSAS and both snoring intensity and rate measured objectively has not been sufficiently investigated; most of the studies have been restricted to examine one or the other of the two parameters. Therefore, this study was aimed to evaluate the relationship between severity of OSAS and snoring parameters including snoring intensity and rate.

PATIENTS AND METHODS

Subjects

We retrospectively analyzed 150 records of patients aged older than 18 years, who were referred to the department of otorhinolaryngology-head and neck surgery with complaints of sleep apnea, excessive daytime sleepiness, and snoring and underwent polygraphy between March 2017 and January 2019. We excluded individuals with a history of smoking or consumption of alcohol, individuals with craniofacial abnormalities, severe cardiovascular disorders, severe neuromuscular disorders, or previous surgery for snoring and sleep apnea.

Polygraphy

Respiratory polygraphy over a night period of at least 6 h was performed to all participants and included the following: measurement of blood oxygen saturation by oximetry and airflow nasobuccal, position analysis, and quantification of snoring with recording of tracheal sound from an air-coupled microphone (sensor) attached on the neck. When the larynx vibrates sufficiently, the sensor detects the vibration and records snoring time in the respiratory cycle. Snoring rate was defined as the percentage of snoring time during the total sleep time.[12,13]

Polygraphy recordings were scored according to the criteria of the American Academy of Sleep Medicine.[14-16] Apnea was defined as complete cessation of airflow at least during 10 s. Hypopnea was defined as the reduction of more than 30% of the airflow signal with an associated fall of at least 3% in oxygen saturation. Apnea–hypopnea index (AHI) was defined as the number of apneas and hypopneas per hour of sleep. Apnea index (AP) and hypopnea index (HI) were, respectively, defined as the number of apneas per hour of sleep and the number of hypopneas per hour of sleep. Patients with AHI at least five events per hour were diagnosed as having OSAS. As a result of polygraphy, patients were classified into four groups according to AHI: control group: individuals with simple snoring (AHI <5), mild OSAS group ($5 \leq$ AHI <15), moderate OSAS group ($15 \leq$ AHI <30), and severe OSAS group (AHI ≥ 30).

Statistical analysis

Statistical analyses were performed with SPSS version 20.0 software (SPSS Inc., Chicago, Illinois, USA). All data are presented as mean ± standard error for continuous variables and frequencies (percent) for categorical variables. Differences in proportions of categorical variables between the study groups were assessed by the Chi-square test. Differences in means of continuous variables were assessed using a Kruskal–Wallis nonparametric test. Spearman's correlation coefficient was used to analyze the relationship between the total AHI and snoring rate, average snoring intensity, and maximal snoring intensity. $P < 0.05$ was considered statistically significant.

RESULTS

Of our study population, 36.7% ($n = 55$) were male and 63.3% ($n = 95$) were female. The mean age was 51.92 ± 10.63 years, and the mean body mass index was 31.27 ± 5.68 kg/m^2. The mean snoring rate (%), maximal intensity of snoring (db), and mean intensity of snoring (db) were 23.93 ± 17.98, 87.72 ± 14, and 66.12 ± 9.76, respectively. The baseline characteristics of the 150 patients in our study are presented in Table 1.

Among the groups, 13.3% ($n = 20$) had no OSAS (simple snoring group), 30% ($n = 45$) had mild OSAS, 21.3% ($n = 32$) had moderate OSAS, and 35.3% ($n = 53$) had severe OSAS. AHI was significantly correlated, respectively, with snoring rate ($r = 0.341$; $P < 0.0001$) and maximal intensity of snoring ($r = 0.362$; $P < 0.0001$) [Figure 1]. However, no correlation was found between the average intensity of snoring and AHI ($P = 0.33$).

Table 1: Baseline characteristics of the control and obstructive sleep apnea syndrome groups

	Control (*n*=20)	Mild (*n*=45)	Moderate (*n*=32)	Severe (*n*=53)
Age (years)	52.4±10.48	50.11±12.08	53.09±12.71	52.58±7.71
Body mass index (kg/m^2)	29.06±4.38	30.51±5.68	31.85±5.89	32.65±5.86
Snoring rate (%)	17.02±16.57	18.02±17.03	23.53±12.69	31.79±19.3
Average intensity of snoring (dB)	66.37±1.97	65.89±10.28	66.34±12.36	66.1±9.55
Maximal intensity of snoring (dB)	84.75±6.65	86.46±15.07	86.82±16.24	90.45±13.79
Apnea index	0.82±0.76	3.54±2.78	5.66±4.9	17.72±10.78
Hypopnea index	1.59±1.04	5.78±2.98	14.46±5.83	30.19±14.21

When assessing each respiratory event individually, snoring rate was more correlated with HI ($r = 0.424$; $P < 0.0001$) than with AI ($r = 0.233$; $P = 0.004$).

The snoring rate (%) in the severe OSAS group (31.79 ± 19.3) was significantly higher than that in the mild OSAS group (18.02 ± 17; $P = 0.001$) and the control group (17 ± 16.57; $P = 0.011$) [Figure 2]. Similarly, the maximal intensity of snoring (db) in the severe OSAS group (90.45 ± 13.79) was higher than that in the mild OSAS group (86.46 ± 15.07; $P = 0.006$) and the control group (84.75 ± 6.65; $P < 0.001$). However, no significant difference was found between the severe and moderate OSAS groups either in terms of snoring rate ($P = 0.139$) or in terms of maximal intensity of snoring ($P = 0.055$).

Moreover, the difference between the average intensity of snoring among all the groups was no significant ($P = 0.066$).

DISCUSSION

Snoring, like any other sound, can be estimated by its intensity, frequency and duration. Even better, it could be evaluated by the snoring rate which represents the proportion of snoring period during total sleep time. It has been identified to be of clinical importance in OSAS. Few studies reported the relationship between severity of OSAS and snoring measured objectively. In our study, increment in snoring rate and maximal intensity of snoring has been observed in patients with severe OSAS. A positive correlation between the severity of OSAS and snoring rate and maximal intensity of snoring was observed, but no significant correlation was found between AHI and mean intensity of snoring. Similarly, Kim *et al*. demonstrated that the snoring time of females showed an association with respiratory index.[17] A recent study including 211 participants, aged 18 years and older, showed that there is a strong positive correlation ($r = 0.727$, $P < 0.001$) between periodic snoring sounds measured during home sleep apnea testing and AHI.[18] Conversely, Hong *et al*., while studying the relationship between OSAS severity and snoring time, did not find a linear correlation between the snoring rate and total AHI. However, while comparing the snoring rates between the groups (divided according to the severity of OSAS by AHI), they found that the snoring rates increased as the AHI increased from the control to the moderate OSAS group and decreased as the AHI increased from the moderate to the very severe OSAS group.[12] Most of the studies proved that there is an association between snoring intensity and the severity of OSAS and reported a positive correlation between the intensity of snoring sound and AHI; therefore, they showed that snoring became louder as OSAS became more severe.[4,19-21] Acar *et al.* have also reported an association between the severity of OSAS and the maximum snoring frequency.[20]

The origin of snoring has been little studied, and only two models are now identified: either an opening of upper airways partially or totally closed with sudden equalization of pressures, generating an explosive noise, or a vibration of pharyngeal walls.[6] As mentioned above, apnea is defined as a complete cessation of airflow of at least 10 s. During apneas, there is no breathing sound. Resumption of breathing is associated with a sequence of snores,[22] so that as the number of apneas increases, the snoring episodes following the cessation of airflow may increase. This may be an explanation to the positive correlation between AI and snoring rate in our results. In addition, during hypopnea, airflow is decreased but not abolished. Snoring persists during this event[3] and causes more snoring than in apnea. This is in accordance with our results that showed a higher correlation of snoring rate with HI than with AI. In this direction, a recent study demonstrated that snoring was more dependent on hypopnea.[23] The mechanism how the maximal intensity of snoring increased with increasing severity of OSAS is not well known. Snoring is characterized by high-frequency oscillations of the soft palate, epiglottis, and pharyngeal walls. When AP increases as OSAS becomes more severe, the pressure generated in the upper airways during apnea might be higher, leading to a higher snoring intensity. Nonetheless, this requires more explanations and clarifications with further studies. Although the maximal intensity of snoring was correlated with AHI in our study, the average intensity of snoring was not correlated with AHI. Such findings seem controversial and may be

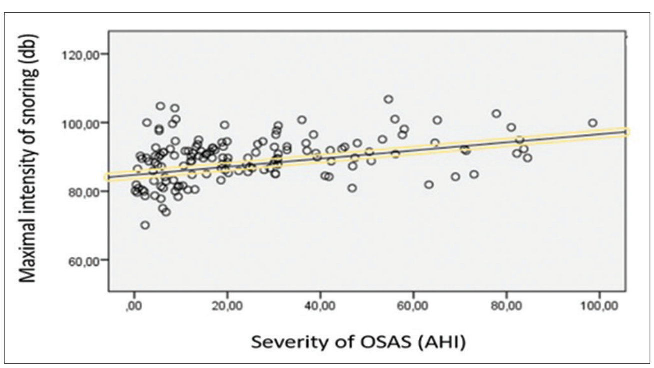

Figure 1: Correlation between severity of obstructive sleep apnea syndrome and maximal snoring intensity

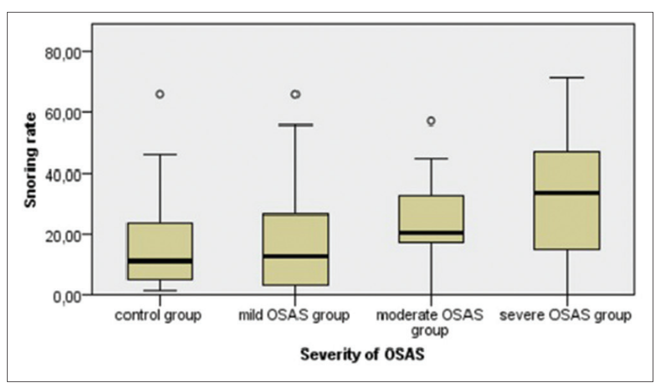

Figure 2: Comparison of the snoring rates among the control group and obstructive sleep apnea syndrome subgroups

explained by the reduced number of our sample size. Otherwise, the average intensity of snoring is the average between the maximal and minimal intensities which can be very variable depending on the stage or the position of sleep. Further, randomized controlled studies are needed to confirm our results.

The heterogeneity of the results is due to the heterogeneity of factors influencing snoring including the route of breathing, vibrating sites, sleep position, and presence of sleep apnea or hypopnea.

The current study evaluated the role of snoring for expecting severe OSAS.

Characteristics of snoring, which is one of the most common symptoms of OSAS,[24] should be taken into consideration, and therefore, we should consider the intensity and duration of snoring in the stratification of OSAS. The objective measure of snoring may be a reliable marker cheaper than polygraphy to track OSAS. Moreover, high-risk patients could be more effectively counseled about the likelihood of a severe OSAS, and accordingly, sleep doctors might consider performing sleep studies on these patients, allowing titration to nasal continuous positive airway pressure immediately. We report also the utility of screening severe OSAS precociously in reducing the risks for complications from OSAS principally cardiovascular diseases.[25,26]

Our findings are all the more important when looking at recent studies showing an association between OSAS and quality of life of bed partners.[27,28] These people are, in fact, exposed to a loud and frequent sound that can cause a noise-induced hearing loss.[29,30]

This study had some limitations. First, the study population was relatively small. Second, each patient had only one polygraphic record; a single sleep study could be not representative of patient's sleep.

CONCLUSION

The snoring rate and maximal intensity of snoring correlate better with the severity of OSAS than average snoring intensity. This association between snoring and OSAS severity should be considered in both diagnostic and therapeutic approaches.

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Conflicts of interest
There are no conflicts of interest.

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