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Original articles

# Self-perception of voice in individuals who report snoring

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## ABSTRACT

**Purpose:** to evaluate the self-perception of vocal signs and symptoms in people who report snoring, analyzing how the intensity and frequency of snoring can impact voice-related quality of life.

**Methods:** participants were assessed remotely regarding their voices (Voice-Related Quality-of-Life Protocol and Voice Symptom Scale), self-perception of snoring (the Berlin Questionnaire and the Stanford Snoring Scale), and obstructive sleep apnea (STOP-Bang Questionnaire). Data analysis involved data description, multiple linear regression, and correlation assessment (Pearson's test) between variables. Significance was set at p-value $< 0.05$.

**Results:** the study included 178 individuals divided into the snoring (SG) and non-snoring groups (NSG), according to the presence or absence of self-reported snoring, respectively. Multiple regression analysis indicated that group and sex were significant predictors of the Voice Symptom Scale score. The SG had a significantly higher Voice Symptom Scale score, suggesting a more negative self-perception of vocal symptoms.

**Conclusions:** people who report snoring also report more vocal signs and symptoms. Snoring intensity correlates positively with vocal issues, suggesting that snoring may be related to vocal health.

**Keywords:** Snoring; Voice; Self-Testing

A study conducted at the Medical School of Ribeirão Preto at the Universidade de São Paulo, Ribeirão Preto, SP, Brazil.

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## INTRODUCTION

Snoring is a common problem, whose prevalence varies worldwide[1]. It is estimated to affect 5% to 50% of the population, with rates increasing as age advances[2]. The International Classification of Sleep Disorders (ICSD-3)[3] classifies it as audible upper airway (UA) vibrations when inhaling during sleep. It refers to a wide spectrum that includes primary snoring, UA resistance syndrome, and obstructive sleep apnea (OSA), for which snoring is a common sign[4].

The pharyngeal muscle tone is believed to decrease during sleep, resulting in excessive relaxation that exceeds the functional limit. Thus, this region's size and volume decrease, causing a pressure imbalance during inhalation. When this decrease is significant enough to obstruct the pharynx partially, airflow becomes difficult, vibrating the UA soft tissues and causing snoring[5]. Other factors may predispose to UA obstruction, such as anatomical changes, craniofacial malformations, dental malocclusion, obesity, advancing age, and so forth. These can be classified as anatomical or non-anatomical factors, contributing in various ways to the development of snoring and related disorders[6].

Some studies have found relationships between snoring and oropharyngeal changes (orofacial myofunctional impairment) and vocal changes (hoarse and breathy voices and vocal fatigue)[7,8]. However, studies relating voice to snoring are still incipient and have non-representative samples[9,10], with a gap concerning the relationship between the intensity of snoring and the intensity of vocal symptoms[10].

These vocal changes can be explained by the vibration caused by snoring, leading to trauma, edema, and inflammation in the UA, including the larynx and vocal folds[11-14]. Moreover, snoring can dry the UA mucous membranes[15,16] and affect airway motor control[17,18]. However, the literature lacks studies evaluating the presence and intensity of snoring or relating them to vocal symptoms. Therefore, this research initially hypothesized that individuals who snore have more vocal symptoms than those who do not snore. It also assumed that the more intense the snoring, the worse the reported vocal signs and symptoms, with a negative impact on voice-related quality of life. This approach seeks to fill a gap in the understanding of how snoring influences people's vocal health and general well-being.

Thus, this study aimed to evaluate the self-perceived presence and quantity of vocal signs and symptoms and whether voice-related problems affect the quality of life of people who self-report snoring, according to the intensity and frequency of snoring.

## METHODS

This study was approved by the Human Research Ethics Committee of the Clinics Hospital of the Medical School of Ribeirão Preto at the Universidade de São Paulo, SP, Brazil (CEP-HC-FMRP-USP) (approval protocol number 6,793,824, CAAE number 52547321.2.0000.5440). All participants were informed about the research and its objectives and were invited to voluntarily participate in it by signing a remote informed consent form, according to the Brazilian Resolution No. 466/2012 CNS/MS, respecting Circular Letter No. 2/2021/CONEP/SECNS/MS.

### Participants

The sample was recruited by convenience through invitations in digital media and television to people aged 18 to 50 years who reported snoring or not and with a body mass index (BMI) ≤ 30. Participants could not be occupational voice users or have undergone any type of voice treatment previously.

The required sample size was calculated as 172 participants, considering the need to reliably detect (with a probability of 0.9 or higher) an effect size of $|\delta| \geq 0.5$. This calculation assumes a two-tailed detection criterion that allows for a maximum type I error rate of $\alpha = 0.05$.

The inclusion criteria for the Non-Snoring Group (NSG) were the participant's self-reported not snoring, adequate sleep hygiene habits, and absence of symptoms suggestive of OSA (snoring, suffocation, witnessed apneas, dry mouth upon waking, nasal congestion, diuresis, dyspnea, cough, palpitation, chest pain, sweating, and daytime sleepiness), according to criteria of the STOP-Bang Questionnaire, Brazilian version[19]; no daytime sleepiness according to the Epworth Sleepiness Scale, Brazilian version[20]; and no reported snoring according to the Stanford Snoring Scale (SSS)[21,22].

The inclusion criteria for the Snoring Group (SG) were a report of snoring, SSS[21,22] scores equal to or greater than 1, and not undergoing or having undergone any treatment to reduce OSA and snoring signs and symptoms.

## Procedures

Participants were asked to complete an electronic questionnaire sent by email, including an informed consent form for participation and the evaluation protocols listed below.

All questionnaires used in this research are self-administered and were conducted during the SARS-CoV-2 pandemic between December 2021 and February 2022, which justifies remote collection.

The self-assessment and self-perception of voice and its impact on quality used the Voice Symptom Scale (VoiSS)[23] and Voice-Related Quality-of-Life (V-RQOL)[24,25], respectively. For questions related to sleep and snoring, the study applied the Berlin Questionnaire (BQ)[26], the SSS[21,22], and the STOP-Bang Questionnaire[19].

The BQ[26], one of the most widely used tools in the field, helped assess the risk of OSA. Its 10 questions are divided into three categories. The first category investigates the presence of snoring and apnea. The second category addresses sleepiness and fatigue. The last category verifies the presence of obesity. Meeting two of the three categories is considered a high risk for OSA.

The SSS[21,22] assesses the frequency and intensity of snoring through five questions, with scores ranging from 0 to 10. It grades the intensity of snoring reported by family members, considering the need to sleep in separate rooms or the discomfort of noise during sleep.

The STOP-Bang Questionnaire[19] has eight yes/no questions. Individuals who answer three or more questions affirmatively are considered at high risk for OSA.

The VoiSS, in its version validated for Brazilian Portuguese[23], is a rigorous and psychometrically robust 30-question vocal self-assessment protocol, providing information on functioning, emotional impact, and physical symptoms that a voice problem or complaint can cause in a person's life[27].

The V-RQOL[24,25] specifically assesses the impact of vocal dysfunction on quality of life. It has 10 questions with proven validity, reliability, and sensitivity in Portuguese. Its standard score is calculated after completing the questionnaire.

## Statistical data analysis

Descriptive statistics were performed for all variables investigated, presented as frequencies, means, and standard deviations. Multiple linear regression verified how each dependent variable, including group, sex, BMI, and age, influenced the outcome (VoiSS[23] result). The reported intensity of snoring was correlated with the intensity and frequency of vocal symptoms and the voice-related quality of life (V-RQOL)[24,25]. The correlation analysis calculated the correlation coefficient and p-value using Pearson's correlation test (parametric). Significance was set at $p$-value $< 0.05$, and the JASP software (Intel, Netherlands, version 0.19.1) was used for analyses.

# RESULTS

Initially, 278 subjects agreed to participate in the study and completed the questionnaire. However, after applying the inclusion and exclusion criteria, it excluded those with a BMI greater than 30 and over 50 years old (n = 89), who did not complete the questionnaires correctly (n = 2), and who did not know whether they snored (n = 9). Hence, the study sample had 178 volunteers, divided into the SG (n = 116) and NSG (n = 62).

The participants' mean age was 34.79±10.92 years, and their mean BMI was 24.73±3.20. Table 1 presents the sample's demographic profile in detail.

**Table 1.** Descriptive statistics presenting the sample profile per group

| N= 178 | | Age | BMI | Berlin | SSS | STOP- Bang | VoiSS | V-RQOL |
|---|---|---|---|---|---|---|---|---|
| NSG (n=62, 10 males) | Mean | 30.45 | 23.22 | 2.93 | 0.29 | 0.56 | 19.01 | 13.56 |
| | SD | 10.16 | 2.79 | 2.75 | 0.73 | 0.64 | 13.87 | 7.55 |
| SG (n=116, 71 males) | Mean | 37.10 | 25.54 | 13.56 | 5.70 | 2.10 | 24.11 | 14.78 |
| | SD | 9.64 | 3.12 | 5.02 | 2.90 | 1.54 | 15.25 | 7.68 |

Captions: NSG = non-snoring group; SG = snoring group; SD = standard deviation; BMI = body mass index; Berlin = Berlin Questionnaire; SSS = total score on the Stanford Snoring Scale; STOP-Bang = total score on the STOP-Bang Questionnaire; VoiSS = score on the Voice Symptom Scale; V-RQOL = total score on the Voice-Related Quality-of-Life Protocol.

Multiple linear regression was initially performed on a full model, as it modeled a linear relationship between several explanatory variables (predictors) and a continuous dependent variable (response). The VoiSS[23] score was the dependent variable, and group, sex, age, and BMI were predictors. Tables 2, 3, and 4 show that only group and sex met the full model – i.e., they significantly predicted the VoiSS[23].

**Table 2.** Multiple Linear Regression – full model summary

| Model | R | $R^2$ | Adjusted $R^2$ | RMSE | $R^2$ Change | df1 | df2 | p |
|---|---|---|---|---|---|---|---|---|
| $M_0$ | 0.00 | 0.00 | 0.00 | 14.94 | 0.00 | 0 | 177 | 0.004 |
| $M_1$ | 0.29 | 0.08 | 0.06 | 14.45 | 0.08 | 4 | 173 | |

Captions: $M_0$ = intercept model; $M_1$ = full model, including group, age, sex, and BMI (body mass index). R = multiple correlation; $R^2$ = coefficient of determination; Adjusted $R^2$ = $\beta$ or adjusted $R^2$ or standardized coefficient; RMSE = Root Mean Square Error; R2 Change = change in $R^2$ after adding more variables; df1 = degrees of freedom for the numerator; df2 = degrees of freedom for the denominator. Significant values when $p < 0.05$.

**Table 3.** Analysis of variance (ANOVA) for the full multiple regression model

| Model | | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|---|
| $M_1$ | Regression | 3399.57 | 4 | 849.89 | 4.067 | 0.004 |
| | Residual | 36132.20 | 173 | 208.85 | | |
| | Total | 39531.77 | 177 | | | |

Captions: $M_1$ = full model, including group, age, sex, and BMI (body mass index). The intercept model was omitted as no meaningful information could be verified. df = degrees of freedom); F = ANOVA F statistics. Significant values when $p < 0.05$.

**Table 4.** Coefficients of multiple linear regression analysis in the full model

| Model | | Unstandardized | Standard Error | Standardized | t | p |
|---|---|---|---|---|---|---|
| $M_0$ | (Intercept) | 22.34 | 1.12 | - | 19.94 | <0.001* |
| $M_1$ | (Intercept) | 13.37 | 8.68 | - | 1.54 | 0.125 |
| | Group | 6.56 | 2.49 | 0.21 | 2.63 | 0.009 |
| | Age | -0.09 | 0.12 | -0.07 | -0.81 | 0.418 |
| | Sex | -7.94 | 2.45 | -0.25 | -3.24 | 0.001* |
| | BMI | 0.43 | 0.40 | 0.09 | 1.06 | 0.289 |

Captions: $M_0$ = intercept model; $M_1$ = model including group, age, sex, and BMI (body mass index). Intercept = value of the dependent variable estimated by the model when all predictors are zero or reference value of linear regression; unstandardized = unstandardized coefficient; standardized = standardized coefficient; t = significance of each variable's coefficient. Significant values when $p < 0.05$.

In the full model presented above, only group and sex appeared to explain the VoiSS ($p < 0.05$). Next, the stepwise model was performed to maintain only the significant variables. When adjusting the model to include only significant variables, group, and sex maintained their significance in predicting vocal symptoms. The final analysis confirmed that the SG reported greater vocal problems, and women reported more intense symptoms than men.

**Table 5.** Multiple Linear Regression, reduced model with only the variables with significance in the full model

| Model | R | $R^2$ | Adjusted $R^2$ | RMSE | $R^2$ Change | df1 | df2 | p |
|---|---|---|---|---|---|---|---|---|
| $M_0$ | 0.00 | 0.00 | 0.00 | 14.94 | 0.00 | 0 | 177 | - |
| $M_1$ | 0.18 | 0.03 | 0.03 | 14.73 | 0.03 | 1 | 176 | 0.014 |
| $M_2$ | 0.28 | 0.08 | 0.07 | 14.42 | 0.04 | 1 | 175 | 0.004 |

Captions: $M_0$ = intercept model; $M_1$ = model including group, age, sex, and BMI (body mass index). R = multiple correlation; $R^2$ = coefficient of determination; Adjusted $R^2$ = β or adjusted $R^2$ or standardized coefficient; RMSE = Root Mean Square Error; $R^2$ Change = change in $R^2$ after adding more variables; df1 = degrees of freedom for the numerator; df2 = degrees of freedom for the denominator. Significant values when $p < 0.05$.

**Table 6.** Multiple regression analysis of variance for the reduced model

| Model | | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|---|
| $M_1$ | Regression | 1350.33 | 1 | 1350.33 | 6.22 | 0.014 |
| | Residual | 38181.45 | 176 | 216.94 | | |
| | Total | 39531.77 | 177 | | | |
| $M_2$ | Regression | 3126.63 | 2 | 1563.31 | 7.51 | < 0.001 |
| | Residual | 36405.15 | 175 | 208.03 | | |
| | Total | 39531.77 | 177 | | | |

Captions: The intercept model is omitted since no significant information was found. df = degrees of freedom; F = ANOVA F statistics. Significant values when $p < 0.05$.

**Table 7.** Coefficients of multiple linear regression analysis in the reduced model

| Model | | Unstandardized | Standard Error | Standardized | t | p |
|---|---|---|---|---|---|---|
| $M_0$ | (Intercept) | 22.337 | 1.120 | | 19.941 | <0.001 |
| $M_1$ | (Intercept) | 24.179 | 1.328 | | 18.206 | <0.001 |
| | Sex | -5.961 | 2.389 | -0.185 | -2.495 | 0.014 |
| $M_2$ | (Intercept) | 20.243 | 1.872 | | 10.811 | <0.001 |
| | Sex | -7.604 | 2.406 | -0.236 | -3.160 | 0.002 |
| | Group | 6.819 | 2.334 | 0.218 | 2.922 | 0.004 |

Captions: The following BMI and sex covariates were considered but not included in the reduced model: Age, BMI. Intercept = value of the dependent variable estimated by the model when all predictors are zero or reference value of linear regression; unstandardized = unstandardized coefficient; standardized = standardized coefficient; t = significance of each variable's coefficient. Significant values when $p < 0.05$.

The VoiSS[23] was correlated with sex, the BQ, the STOP-Bang[19], and the SSS[21,22] in the study sample. Furthermore, the presence of vocal symptoms was related to sleep characteristics and snoring intensity.

The V-RQOL[24,25] was also positively correlated with the BQ[26] and the SSS[21,22] but not with the STOP-Bang[19]. Complete information is provided in Table 8.

**Table 8.** Correlations between all variables investigated in the study

| Variable | | Age | BMI | Sex | Berlin | Stanford | STOP -Bang | VoiSS | V-RQOL |
|---|---|---|---|---|---|---|---|---|---|
| Age | r | — | | | | | | | |
| | p | — | | | | | | | |
| BMI | r | 0.47 | — | | | | | | |
| | p | <0.01 | — | | | | | | |
| Sex | r | 0.15 | 0.25 | — | | | | | |
| | p | 0.05 | <0.01 | — | | | | | |
| Berlin | r | 0.36 | 0.41 | 0.25 | — | | | | |
| | p | <0.01 | <0.01 | <0.01 | — | | | | |
| Stanford | r | 0.41 | 0.50 | 0.25 | 0.81 | — | | | |
| | p | <0.01 | <0.01 | <0.01 | <0.01 | — | | | |
| STOP-Bang | r | 0.40 | 0.41 | 0.16 | 0.66 | 0.61 | — | | |
| | p | <0.01 | <0.01 | 0.03 | <0.01 | <0.01 | — | | |
| VoiSS | r | 0.00 | 0.07 | -0.18 | 0.33 | 0.21 | 0.26 | — | |
| | p | 0.96 | 0.34 | 0.01 | <0.01 | 0.01 | <0.01 | — | |
| V-RQOL | r | -0.05 | -0.01 | -0.11 | 0.20 | 0.15 | 0.14 | 0.72 | — |
| | p | 0.478 | 0.89 | 0.15 | 0.01 | 0.04 | 0.06 | <0.01 | — |

Captions: $p < 0.05$ considered significant, r = Pearson's correlation test. BMI = body mass index; Berlin = Berlin Questionnaire; Stanford = Stanford Snoring Scale total score; STOP-Bang = STOP-Bang questionnaire total score; VoiSS = Voice Symptom Scale score; V-RQOL = Voice-Related Quality-of-Life Protocol.

## DISCUSSION

The results of this study demonstrated that the SG had significantly higher VoiSS[23] scores, indicating a more negative self-perception of the frequency and quantity of vocal symptoms than the NSG. This finding is consistent with previous studies that associate snoring with vocal dysfunctions[11,14]. The explanation may be broad, especially when considering the abnormal respiratory pressures and the impact on laryngeal structures caused by snoring.

An important point to highlight is the possible irritation and trauma to the UA and vocal folds caused by the intense and repetitive snoring vibration, which can lead to microtrauma. These repetitive traumas cause inflammation, edema, and, in some cases, lesions in the vocal folds, predisposing individuals to vocal changes such as hoarseness, vocal fatigue, and pain when speaking[11,14].

OSA is associated with a chronic systemic inflammatory response, increasing inflammatory mediators that can affect the laryngeal mucosa. This chronic inflammatory state[12,13] can promote edema and other changes that impair vocal quality. Although this study did not aim to evaluate the relationship between vocal issues and OSA, patients who reported snoring often had high scores on OSA risk assessment instruments (STOP-Bang[19]) and the BQ[26].

UA dehydration, caused by frequent mouth breathing in sleep by patients who report snoring, reduces vocal fold moisture. This dehydration interferes with the natural vibration of the vocal folds, increasing the likelihood of hoarseness and vocal fatigue throughout the day[15,16].

It is essential to highlight the possible changes in UA motor control during snoring episodes, characterized by reduced UA muscle tone, including the larynx. This repetitive muscle relaxation can compromise fine motor control of the vocal folds, resulting in phonatory instability and a feeling of vocal fatigue[17,18]. These factors justify the vocal problems in patients with OSA and snoring, reinforcing the importance of a detailed vocal assessment and possible referrals for multidisciplinary treatment.

The study showed a significant difference between the sexes regarding their perception of vocal symptoms, as women reported more intense symptoms than men. This finding corroborates research that shows greater female sensitivity to the perception of vocal symptoms, possibly influenced by hormonal and social factors, which shape their vocal self-perception and response[28].

On the other hand, the study had fewer men than women. This disproportion can be justified by the higher prevalence of snoring in men[29], as observed in the SG group. It can also be assumed that women are more willing and supportive to participate in research than men due to biopsychosocial issues such as differences in perception, evaluation, and behaviors that could influence the greater participation of women than men[30].

Although variables such as age and BMI were not significant predictors in the analytical model adopted, excluding participants over 50 years old and with a BMI above 30 may have limited the generalization of the findings to other age groups and weight profiles. Future studies with larger and more heterogeneous samples could investigate whether these variables affect the intensity of vocal symptoms in populations with different physiological characteristics. The study limited the age range and BMI because sarcopenia in older people may be associated with vocal issues related to presbyphonia[31] and a higher prevalence of OSA[6], making it difficult to form the NSG. Likewise, increased BMI is directly related to the increased prevalence of OSA and snoring[32], making it difficult to form the SG. Accumulated adipose tissue in the UA is reported as a risk factor for dysphonia[33,34].

Individuals with morbid obesity may have a shorter maximum phonation time than those with an adequate BMI, in addition to a hoarse, breathy, unstable, and strangled voice[34]. This change is caused by the abundant laryngeal fat, leading to problems in vocal production, as it deprives the movement of myoelastic and aerodynamic forces[34].

As previously discussed, individuals who snore and suffer from OSA have unstable UA due to anatomical and functional factors, including excess weight[35]. In obesity, fat accumulates in the cervical region, causing respiratory difficulty. In addition, the UA is smaller in individuals with OSA than in those with adequate BMI[36]. The former also have the anteroposterior axis as the longest in the oropharynx, unlike healthy individuals, in whom the transverse axis is the longest.

The correlations between the VoiSS[23] and sleep questionnaires (BQ[26] and STOP-Bang[19]) corroborate the hypothesis that snoring and sleep-disordered breathing directly influence vocal health and voice-related quality of life (V-RQOL)[24,25] in people who report snoring[10]. Other studies have also evaluated data related to snoring with the BQ[26,37] and found improvements related to snoring after speech-language-hearing intervention.

It is known that the lack of adequate alveolar ventilation and oxyhemoglobin desaturation (increasing carbon dioxide in the arterial blood) can lead to systemic changes in individuals with OSA. Likewise, the imbalance between inspiratory and intrapharyngeal suction pressure and the dilating forces of the UA pharyngeal muscles in snoring can lead to changes in the UA[7]. The influence of these factors highlights the importance of an integrated clinical approach. Thus, the history and intensity of sleep-related symptoms should be considered when assessing vocal symptoms in snorers.

The SSS[21,22] was correlated with the VoiSS[23] and the V-RQOL[24,25], showing that the greater the intensity of snoring, the greater the incidence of vocal symptoms and their impact on the person's quality of life and daily life.

The association between snoring and vocal symptoms suggests relevant clinical implications for speech-language-hearing pathology, especially in preventive and therapeutic interventions aimed at individuals who snore. Programs with vocal and respiratory exercises may help improve symptoms and, potentially, these people's voice-related quality of life.

Future studies should conduct longitudinal investigations into the progression of vocal symptoms and their relationship with snoring intensity over time. Furthermore, expanding the sample to include different age groups and BMIs could provide a more comprehensive understanding of the effects of snoring on vocal health, especially using objective measures (such as type I polysomnography to identify sleep disorders) and instrumental vocal assessments.

## CONCLUSIONS

The study indicates that the group of participants who reported snoring perceived more vocal symptoms, which may affect their voice-related quality of life. These findings highlight the importance of including factors such as snoring and sex in vocal symptoms assessments and interventions to improve voice-related quality of life.


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**Authors' contributions:**

MFLM: Data curation; Writing - Original draft; Writing - Review and editing.

GAF: Conceptualization; Data analysis; Methodology; Writing - Original draft; Writing - Review and editing.

**Data Sharing Statement:**

Additional data may be provided upon due request to the corresponding author, subject to ethics committee approval and compliance with confidentiality guidelines to ensure the security of participants' personal information.