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# Objective and Subjective Evaluation of Voice Parameters in Early and Late Periods After Smoking Cessation

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## ABSTRACT

**Objective:** Cigarette smoking impairs voice quality by inducing inflammatory and structural changes in the vocal folds, resulting in measurable alterations in acoustic parameters such as jitter, shimmer, and harmonics-to-noise ratio (HNR). However, the temporal pattern of voice recovery after smoking cessation remains insufficiently defined. This study aimed to determine whether smoking cessation leads to early and progressive improvement in objective acoustic voice parameters and subjective voice-related quality of life. The authors hypothesized that cessation would reduce jitter, shimmer, and Voice Handicap Index-30 scores and increase HNR within 3 months.

**Methods:** This prospective controlled study included 38 smokers and 40 non-smokers. Acoustic parameters were analyzed from sustained vowel phonations using Praat software, and subjective voice quality was assessed with the Voice Handicap Index-30 (VHI-30). Smokers were evaluated at baseline, 1 month, and 3 months after smoking cessation; controls were assessed once.

**Results:** After smoking cessation, smokers showed significant progressive improvement in all voice parameters. Voice Handicap Index-30 scores, jitter, and shimmer decreased, whereas HNR increased at both follow-up points ($P < .001$). At baseline, smokers had worse acoustic parameters than controls. By 3 months, several parameters improved to levels comparable to or better than controls. Voice Handicap Index-30 scores correlated positively with jitter and shimmer and negatively with HNR.

**Conclusion:** Smoking cessation leads to rapid, progressive improvement in objective and subjective voice parameters. These findings suggest that smoking-related vocal impairment is at least partially reversible in the short term and support acoustic analysis for monitoring recovery.

**Keywords:** Harmonics-to-noise ratio, jitter, smoking cessation, voice quality, Voice Handicap Index

## Introduction

Voice is an essential tool for human communication, underpinning social interaction, professional performance, and quality of life. Its production depends on the coordinated function of the respiratory, phonatory, resonance, and articulatory systems. The vocal folds, as the primary sound source, are particularly susceptible to exogenous irritants. Cigarette smoke induces histopathological changes in the laryngeal mucosa, including chronic inflammation, submucosal edema, squamous metaplasia, and fluid accumulation in Reinke's space, impairing vibratory function and degrading voice quality.[1-3]

The main acute effect of smoke exposure is edema in the superficial lamina propria, lowering fundamental frequency and increasing vibratory aperiodicity.[1] Acoustically, smoking-related laryngeal changes have been associated with increased jitter and shimmer, decreased harmonics-to-noise ratio (HNR), and poorer subjective voice outcomes. Jitter reflects frequency variation, shimmer amplitude instability, and HNR the ratio of periodic to aperiodic energy, serving as indicators of phonatory instability.[4-6]

Subjective impact can be assessed using the Voice Handicap Index-30 (VHI-30), a validated tool measuring physical, functional, and emotional domains (0-120 total score).[7]

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Previous studies report worse VHI-30 scores and acoustic parameters in smokers compared to non-smokers.[8,9] However, longitudinal recovery after cessation—especially early versus later changes with a control group—remains insufficiently defined, with prior studies limited by design or scope.[10]

Therefore, the primary research question of this study was whether smoking cessation leads to measurable improvement in objective acoustic voice parameters and subjective voice-related quality of life during the early post-cessation period. The aim of the study was to prospectively evaluate changes in jitter, shimmer, HNR, and Voice Handicap Index-30 scores at 1 and 3 months after smoking cessation and to compare these findings with those of a non-smoking control group. The authors hypothesized that smoking cessation would result in progressive improvement in both objective and subjective voice parameters, reflected by reductions in jitter, shimmer, and VHI-30 scores and an increase in HNR over time.

## Methods

### Study Design

This prospective, controlled study was conducted between December 2021 and June 2022 at the Smoking Cessation Clinic. The study protocol was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Written informed consent was obtained from all participants prior to enrollment. The study protocol was approved by the Keçiören Trainig and Research Hospital institutional ethics committee, approval number: 2012-KAEK-15/2382, date: September 28, 2021.

### Participants

Group 1 (smoking cessation group) included 38 participants (21 men, 17 women) who were current smokers with ≥10 pack-years and a voluntary intention to quit. Smoking abstinence was monitored at follow-up visits, and participants who resumed smoking were excluded. Exclusion criteria for both groups were acute upper respiratory tract infection at the time of assessment, any organic or neurological laryngeal pathology, systemic disease affecting voice, previous laryngeal or pharyngeal surgery, and professional voice use. Organic laryngeal pathologies included vocal fold nodules, polyps, cysts, Reinke's edema, leukoplakia, malignancy or suspected malignant lesions, vocal fold scarring, and inflammatory or infectious laryngeal lesions. Neurological laryngeal pathologies included vocal fold paresis or paralysis, spasmodic dysphonia, tremor, and other neuromotor disorders affecting phonation.

Group 2 (control group) comprised 40 non-smoking healthcare volunteers (16 men, 24 women) with no history of tobacco use or systemic illness.

### Clinical Evaluation

All participants in Group 1 underwent detailed otorhinolaryngological examination, including flexible nasopharyngolaryngoscopy, at T0 to confirm the absence of organic or neurological laryngeal pathology prior to study inclusion. The same procedure was performed for Group 2 participants at their single assessment visit. Participants with abnormal vocal fold mobility, visible benign or malignant laryngeal lesions, inflammatory lesions, Reinke's edema, leukoplakia, vocal fold scarring, or clinical findings suggestive of neuromotor voice disorders were excluded.

### Voice Handicap Index-30

Subjective voice-related quality of life was assessed using the Turkish-validated version of the VHI-30.[7] The VHI-30 comprises 30 items equally distributed across 3 subscales—Functional (F), Emotional (E), and Physical (P)—each scored on a 5-point Likert scale (0-4). Total scores range from 0 to 120, with higher scores reflecting greater perceived voice-related handicap.

### Acoustic Voice Analysis

Voice recordings were obtained in a quiet room with ambient noise levels below 45 dB(A). Participants were instructed to sustain the vowel /a/ at a comfortable pitch and loudness for at least 5 seconds, with 3 repetitions recorded. A calibrated Audio-Technica AT2005 dynamic microphone was positioned 10 cm from the lips, and recordings were captured at 16-bit resolution and a 44100 Hz sampling rate. From each recording, a stable 3-second mid-portion was selected for analysis. Acoustic parameters—jitter (local, %), shimmer (local, %), and HNR (dB)—were analyzed using Praat software (version 6.017; Paul Boersma and David Weenink, University of Amsterdam). The mean of 3 recordings was used for statistical analysis.

### Study Protocol and Time Points

Participants in Group 1 were assessed at 3 time points: T0 (baseline, while actively smoking), T1 (1 month after confirmed smoking cessation), and T2 (3 months after confirmed smoking cessation). Smoking cessation at T1 and T2 was confirmed by participant self-report corroborated by clinical assessment during follow-up visits. Biochemical verification, such as exhaled carbon monoxide or cotinine measurement, was not performed. All 38 participants in the smoking cessation group completed the T1 and T2 follow-up assessments and were included in the longitudinal analysis. No follow-up data were missing, and no participant resumed smoking or was excluded from the final analysis because of smoking relapse during the follow-up period. Group 2 participants underwent a single assessment using identical protocols.

### Main Points

- Cigarette smoking impairs voice quality by inducing inflammatory and structural changes in the vocal folds, which are reflected in measurable alterations in acoustic parameters such as jitter, shimmer, and harmonics-to-noise ratio.
- Following smoking cessation, both objective (acoustic analysis) and subjective (Voice Handicap Index-30) voice parameters show significant early improvement.
- The recovery process is progressive; improvements begin as early as the first month and continue up to the third month, with some parameters reaching levels comparable to healthy individuals.
- Improvement in voice quality indicates that smoking-related vocal impairment is at least partially reversible in the short term.

### Statistical Analysis

All statistical analyses were performed using SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). Normality was evaluated using the Shapiro–Wilk test and visual inspection. Descriptive statistics were expressed as mean ± standard deviation (SD) for normally distributed variables and as median (min-max) for non-normally distributed variables. Normally distributed variables were compared between 2 independent groups using the independent-samples *t*-test; non-normally distributed variables were compared using the Mann–Whitney *U*-test. Categorical variables were compared using the chi-square or Fisher's exact test. Within-group comparisons across time points used the Wilcoxon signed-rank test or paired *t*-test as appropriate. Correlations between acoustic parameters and VHI-30 scores were examined using Spearman's rank correlation coefficient. A 2-tailed *P* value of < .05 was considered statistically significant.

## Results

### Demographic Characteristics

Demographic characteristics are summarized in Table 1. Group 1 was significantly older than Group 2, whereas sex distribution was comparable between groups. The mean smoking exposure in Group 1 was 22.1 ± 9.7 pack-years.

### Within-Group Changes Over Time (Group 1)

All 38 participants in the smoking cessation group completed the T1 and T2 assessments. No follow-up data were missing, and no participant resumed smoking during the follow-up period. Within Group 1, all voice parameters showed significant improvement over time. Voice Handicap Index-30, jitter, and shimmer decreased progressively, whereas HNR increased from T0 to T2 (Table 2).

### Between-Group Comparisons

At baseline, smokers exhibited worse voice quality than non-smokers in both subjective and objective measures, except for shimmer. Following cessation, subjective voice scores normalized, whereas acoustic parameters showed continued differences, with persistent differences in selected acoustic parameters at T2 (Table 3).

### Correlation Analysis

No significant correlation was observed between age and acoustic parameters within Group 1. At baseline, VHI-30 scores correlated positively with jitter (rs = 0.41) and shimmer (rs = 0.38). During follow-up, VHI-30 remained positively correlated with jitter and shimmer and showed a negative correlation with HNR (all *P* < .05).

**Table 1. Demographic Characteristics**

| Parameter | Group 1 (Smokers) | Group 2 (Non-smokers) |
|---|---|---|
| Number of participants (n) | 38 | 40 |
| Age (years, mean ± SD) | 43.3 ± 12.2 | 34.4 ± 8.0 |
| Sex (male/female, n) | 21/17 | 16/24 |
| Male (%) | 55.3 | 40.0 |
| Smoking history (pack-years) | 22.1 ± 9.7 | — |

## Discussion

The present prospective study demonstrates that smoking cessation leads to progressive improvement in both acoustic voice parameters and voice-related handicap within the first 3 months. These findings extend previous cross-sectional studies by defining the temporal trajectory of recovery in comparison with a non-smoking control group.

The adverse effects of cigarette smoking on voice quality are well established, with structural, mucosal, and acoustic alterations in smokers consistently reported in the literature.[2-6] Consistent with these findings, the baseline results showed increased jitter and reduced HNR in smokers compared with non-smokers, reflecting impaired vibratory stability associated with edema and inflammation of the vocal folds.[1-3]

Consistent with earlier reports, VHI-30 scores are higher in smokers compared with non-smokers.[8] In line with this, the findings showed a progressive decrease in VHI-30 scores following smoking cessation, approaching non-smoker levels by 3 months. This improvement likely reflects recovery of vocal fold function with resolution of smoking-related mucosal inflammation.

At baseline, shimmer was elevated in smokers but did not differ significantly from controls, suggesting lower sensitivity of amplitude perturbation to moderate smoking exposure, as previously reported.[8,9] By T2, however, shimmer and jitter values were lower in the cessation group than in controls. This finding may be attributable to the composition of the control group, which consisted predominantly of healthcare workers and may therefore have been exposed to higher occupational voice load. Recent evidence indicates that voice-related

**Table 2. Changes in Acoustic Parameters and Voice Handicap Index-30 Scores at T0, T1, and T2 in Group 1 (n = 38)**

| Parameter | T0 (Baseline) | T1 (1 month) | T2 (3 months) | *P* (T0-T1) | *P* (T1-T2) | *P* (T0-T2) |
|---|---|---|---|---|---|---|
| VHI-30* | 23.5 (8-65) | 15.5 (6-48) | 11.0 (5-35) | <.001+ | <.001+ | <.001+ |
| Jitter (%)** | 0.463 ± 0.128 | 0.378 ± 0.105 | 0.328 ± 0.091 | <.001++ | <.001++ | <.001++ |
| Shimmer (%)** | 3.420 ± 1.785 | 2.501 ± 1.106 | 2.050 ± 0.807 | <.001++ | <.001++ | <.001++ |
| HNR (dB)** | 19.270 ± 2.496 | 21.426 ± 1.942 | 22.570 ± 1.503 | <.001++ | <.001++ | <.001++ |

HNR, harmonics-to-noise ratio; VHI-30, Voice Handicap Index-30.
*Median (min-max), **Mean ± SD.
+Wilcoxon signed-rank test, ++Paired *t*-test.

**Table 3. Comparison of Acoustic Parameters and Voice Handicap Index-30 Scores Between Group 1 (T0) and Group 2**

| Parameter | Group 2 (n = 40) | Group 1 – T0 (n = 38) | *P* value |
|---|---|---|---|
| VHI-30* | 14 (7-25) | 23.5 (8-65) | < .001+ |
| Jitter (%)** | 0.372 ± 0.095 | 0.463 ± 0.128 | .001++ |
| Shimmer (%)** | 3.315 ± 0.854 | 3.420 ± 1.785 | .744++ |
| HNR (dB)** | 20.574 ± 1.551 | 19.270 ± 2.496 | .008++ |

HNR, harmonics-to-noise ratio; .VHI-30, Voice Handicap Index-30.
*Median (min-max), **Mean ± SD.
+Mann–Whitney *U*-test, ++Independent-samples *t*-test.

symptoms are highly prevalent among healthcare providers and are associated with occupational factors such as loud speaking and vocal fatigue.[11]

Recent evidence suggests that smoking can measurably alter voice features and that smoking cessation may lead to detectable changes in acoustic voice parameters.[10] The findings support this concept, demonstrating significant improvement as early as 1 month and continuing through 3 months. In addition, acoustic parameters such as jitter, shimmer, and HNR are recognized as sensitive markers of smoking-related vocal changes.[10] The elevated baseline jitter values observed in the cohort further support its sensitivity to early smoking effects, consistent with previous reports.[9,12]

Reported correlations between subjective and objective voice measures are variable, reflecting the multidimensional nature of voice perception.[13,14] In this study, the strength of correlation between VHI-30 and acoustic parameters increased over time, with a negative correlation between VHI-30 and HNR during follow-up. This suggests that, as vocal fold function recovers, subjective voice perception increasingly reflects objective phonatory measures.

The present findings also have practical clinical implications. Acoustic voice analysis and VHI-30 assessment may provide clinicians with objective and patient-reported measures to monitor voice recovery after smoking cessation. In smoking cessation counseling, demonstrating measurable improvement in voice quality may help reinforce abstinence, particularly in patients who are concerned about voice changes or use their voice frequently in daily life. Similarly, in voice clinics, these tools may support follow-up by documenting functional improvement and guiding patient education regarding the reversibility of smoking-related vocal impairment.

Several limitations should be acknowledged. First, the sample size was moderate and the absence of randomization limits causal inference. Second, smoking abstinence was based on participant self-report supported by clinical assessment and was not biochemically verified using exhaled carbon monoxide or cotinine measurement. Therefore, possible misclassification of smoking status during follow-up cannot be completely excluded, and this should be considered when interpreting the findings. Third, a significant age difference existed between the smoking cessation and control groups, with participants in the smoking cessation group being older. Because aging may influence laryngeal structure, vocal fold vibration, and acoustic voice parameters, this imbalance may have affected between-group comparisons. However, the primary strength of the present study is its longitudinal design, in which the same participants were evaluated before and after smoking cessation. Therefore, the within-group changes observed over time are less likely to be explained by age-related differences and provide stronger evidence for post-cessation voice improvement. Fourth, the control group consisted of healthcare professionals, which may limit generalizability due to potential occupational voice use. Fifth, videostroboscopic evaluation was not routinely performed, precluding direct assessment of mucosal wave recovery. Finally, the relatively short follow-up period does not allow evaluation of long-term voice outcomes after smoking cessation.

In conclusion, smoking cessation leads to significant and progressive improvement in both acoustic voice parameters and voice-related quality of life within 3 months. These findings demonstrate that smoking-related vocal impairment is at least partially reversible in the short term. Acoustic voice analysis may serve as a useful objective tool for monitoring recovery following smoking cessation.

**Data Availability Statement:** The data that support the findings of this study are available on request from the corresponding author.

**Artificial Intelligence Usage Statement:** This study used ChatGPT (OpenAI) to improve language and grammar during the preparation of the manuscript. The authors reviewed and approved all changes and take full responsibility for the final content.

**Ethics Committee Approval:** Ethical committee approval was received from the Ethics Committee of Keçiören Trainig and Research Hospital (Approval No.: 2012-KAEK-15/2382; Date: September 28, 2021).

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## References

1. Murphy CH, Doyle PC. The effects of cigarette smoking on voice-fundamental frequency. *Otolaryngol Head Neck Surg*. 1987;97(4):376-380. [CrossRef]
2. Guimarães I, Abberton E. Health and voice quality in smokers: an exploratory investigation. *Logoped Phoniatr Vocol*. 2005;30(3-4):185-191. [CrossRef]
3. Kelleher JE, Siegmund T, Chan RW. Collagen microstructure in the vocal ligament: initial results on the potential effects of smoking. *Laryngoscope*. 2014;124(9):E361-E367. [CrossRef]

4. Raghuwanshi N, Mundra A, Dubey NK, Godha S, Mundra R. Multimodal analysis of dysphonia in smokers: a two year comprehensive study. *Indian J Otolaryngol Head Neck Surg*. 2022;74(suppl 3):4948-4953. [CrossRef]
5. Banjara H, Mungutwar V, Singh D, Gupta A. Objective and subjective evaluation of larynx in smokers and nonsmokers: a comparative study. *Indian J Otolaryngol Head Neck Surg*. 2014;66(suppl 1):99-109. [CrossRef]
6. Byeon H, Cha S. Evaluating the effects of smoking on the voice and subjective voice problems using a meta-analysis approach. *Sci Rep*. 2020;10(1):4720. [CrossRef]
7. Jacobson BH, Johnson A, Grywalski C, et al. The Voice Handicap Index (VHI): development and validation. *Am J Speech Lang Pathol*. 1997;6(3):66-70. [CrossRef]
8. Pinar D, Cincik H, Erkul E, Gungor A. Investigating the effects of smoking on young adult male voice by using multidimensional methods. *J Voice*. 2016;30(6):721-725. [CrossRef]
9. Chai L, Sprecher AJ, Zhang Y, Liang Y, Chen H, Jiang JJ. Perturbation and nonlinear dynamic analysis of adult male smokers. *J Voice*. 2011;25(3):342-347. [CrossRef]
10. Ma Z, Bullen C, Chu JTW, Wang R, Wang Y, Singh S. Towards the objective speech assessment of smoking status based on voice features: a review of the literature. *J Voice*. 2023;37(2):300.e11-300.e20. [CrossRef]
11. Erol S, Duran A. Voice use, voice disorders, and awareness levels in healthcare providers. *J Health Sci*. 2025;10(4):399-404. [CrossRef]
12. Gonzalez J, Carpi A. Early effects of smoking on the voice: a multidimensional study. *Med Sci Monit*. 2004;10(12):CR649-CR656.
13. Hsiung MW, Pai L, Wang HW. Correlation between voice handicap index and voice laboratory measurements in dysphonic patients. *Eur Arch Otorhinolaryngol*. 2002;259(2):97-99. [CrossRef]
14. Karlsen T, Sandvik L, Heimdal JH, Aarstad HJ. Acoustic voice analysis and maximum phonation time in relation to Voice Handicap Index score and larynx disease. *J Voice*. 2020;34(1):161.e27-161.e35. [CrossRef]