

Fundamental Frequency, Voice Intensity, Jitter, and Shimmer of the Vowel /a/ in Different Head and Neck Postures in Healthy Individuals: A Comparative Cross-Sectional Study

Fariba Mojiri¹  , Parvin Shakeri²  ,
Ebrahim Sadeghi-Demneh³  

Original Article

Abstract

Introduction: This study aimed to investigate the effect of head and neck posture on the acoustic characteristics of the vowel /a/, namely fundamental frequency, voice intensity, shimmer, and jitter.

Materials and Methods: In this descriptive-analytical, cross-sectional study, 33 individuals were recruited via convenience sampling and asked to sustain the vowel /a/ in a seated position under three head positions: neutral (aligned with the trunk), flexed (head forward), and extended (head tilted backward). Mean fundamental frequency, jitter, voice intensity, and shimmer were extracted using Praat software and subsequently analyzed using analysis of variance (ANOVA) and the LSD post hoc test.

Results: In women, the mean fundamental frequency differed significantly between the flexed and extended head positions ($P = 0.024$) and between the flexed and neutral positions ($P = 0.04$). Voice intensity in men differed significantly between the flexed and extended positions ($P = 0.005$) and between the neutral and flexed positions ($P = 0.006$). Mean jitter did not differ significantly across the three head positions in either women ($P = 0.907$) or men ($P = 0.795$). In men, mean shimmer differed significantly between the neutral and extended positions ($P = 0.022$) and between the neutral and flexed positions ($P = 0.013$).

Conclusion: It can be concluded that the optimal posture for voice production is alignment of the head and neck with the trunk and pelvis, and that any deviation from this alignment may affect acoustic parameters. Although some acoustic parameters in this study did not show statistically significant differences, these findings may be clinically important, particularly for professional voice users.

Keywords: Fundamental frequency; Jitter; Voice intensity; Shimmer; Head posture

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Introduction

Voice is one of the most important components of verbal communication among humans, enabling them to convey their emotions and ideas (1). Any alteration in voice parameters or impairment of vocal function may affect an individual's quality of life, limit

communication, and impact the social aspects of daily living (2-4). At present, voice disorders are increasingly prevalent due to poor vocal habits and improper voice use (5). Numerous factors, both direct and indirect, contribute to normal voice production, including the structural integrity of the vocal folds and

1- Instructor, Department of Speech Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran

2- Department of Speech Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran

3- Professor, Department of Orthotics and Prosthetics, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran

Corresponding Author: Fariba Mojiri; Instructor, Department of Speech Therapy, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran; Email: mojiri@rehab.mui.ac.ir

other intrinsic laryngeal muscles, the health of the neuromuscular system, and the absence of functional problems (6). Factors such as personality-related issues (7, 8), laryngopharyngeal reflux (9, 10), neuromuscular disorders (11), and structural lesions, including nodules, polyps, cysts, and tumors (12), can lead to voice disorders and alterations in voice quality, pitch, and loudness.

Among the important factors influencing voice production is appropriate body posture (2). Appropriate posture refers to a state in which the body can function properly with minimal energy expenditure by the neuromuscular system and without placing undue stress on the muscles and tissues of the body (13, 14). Many voice teachers emphasize the importance of correct head and neck positioning for singing (15, 16); however, the precise physical characteristics of optimal posture remain unclear, and there is no consensus on the effects of different head positions on voice quality (17). Miller (18) describes proper posture as a state in which the head, neck, and upper torso are aligned with the pelvis and surrounding regions. McKinney (19) argues that the head should not droop forward of the shoulders and that singers should feel as though their chin is slightly tucked in. Several studies have reported an association between head posture and vocal problems, particularly disruptions in airflow, resonance, and pitch control (2, 13, 20, 21). Gilman and Johns (22) reported that singers' vocal effort to maintain voice quality increases in exaggerated forward and backward head positions.

Based on the above, it can be concluded that craniocervical positional changes affect voice production, given that the musculoskeletal system functions as a kinetic chain, in which a change at one joint can produce consequences at any point along the chain. Such changes may affect neural function, endurance, muscle strength, balance and coordination, respiratory function, and ultimately voice (23). Furthermore, an imbalance in head and neck posture alters the shape of the pharyngeal soft tissues. It weakens the muscles responsible for elevating the larynx, thereby affecting pitch control, resonance, and voice quality (24, 25).

Voice production is not solely the result of intrinsic laryngeal muscle activity; the muscles surrounding the larynx—referred to as extrinsic laryngeal muscles—also exert an indirect effect on voice production, and excessive tension or contraction of these muscles is considered one of the causes of functional voice disorders (26, 27). On the other hand, the extrinsic laryngeal muscles (suprahyoid and infrahyoid muscles) help maintain the larynx's normal position

and stability, which is essential for proper vocal fold vibration and normal voice production (28). Among the most important of these muscles are the sternocleidomastoid and scalene muscles. Excessive contraction of these muscles results in improper head and neck posture and indirectly affects phonation (29). Singers employ various breathing strategies during performance, which result from the activity of the sternocleidomastoid and scalene muscles. Excessive tension in these muscles is considered one of the most common technical errors in singing, leading to excessive strain on other muscles, neck and upper-region pain, and vocal impairment. Recent studies on non-singers have also shown that the sternocleidomastoid muscle and the sternum influence laryngeal position, and their activity increases during forceful breathing and phonation (30).

In summary, phonation requires rapid and coordinated movement of the vocal folds, whereby the intrinsic laryngeal muscles carry out adduction, abduction, and elongation of the vocal folds. In contrast, the extrinsic laryngeal muscles play a critical role in elevating and lowering the larynx, complementing the action of the intrinsic muscles in proper voice production (31). It is worth noting that this relationship is bidirectional, as improper voice use—one of the causes of functional voice disorders—disrupts the coordination of voice production mechanisms and leads to irregular activity of both intrinsic and extrinsic laryngeal muscles, which in turn compromises voice quality, particularly among professional voice users (32).

As previously noted, voice and singing specialists agree that body posture influences the voice; however, they have not defined the optimal posture quantitatively or precisely. Moreover, the methodology of some of these studies is not consistent with the natural head and neck posture adopted during speech. In one such study, magnetic resonance imaging (MRI) was used to examine the effect of head position on voice characteristics, requiring participants to lie in a supine position, whereas during speech, individuals are typically seated or standing; the supine position is not a natural posture for voice and speech production, and thus the findings cannot be generalized to the natural postures adopted during phonation and speech (33). Another study proposed using quantitative instruments to examine voice across different body postures (34). In the present study, head position was determined using objective, clinically applicable landmarks that can be readily assessed in a clinical setting and that do not carry the side effects associated with previous methods (35). In addition,

voice was evaluated using standard voice measurement techniques, namely acoustic analysis (36).

This study aimed to obtain more accurate, evidence-based results regarding whether changes in head posture can produce significant alterations in the acoustic characteristics of voice. Specifically, this study sought to determine whether positioning the head in extension (tilted backward) and flexion (tilted forward) results in significant changes in the acoustic characteristics of voice.

Materials and Methods

Sample Size and Participants: In this descriptive-analytical, cross-sectional study, the sample size for repeated-measures analysis of variance was calculated using the formula below, assuming a type I error (α) of 5% ($Z = 1.96$), a statistical power of 80% ($Z = 0.84$), several repeated observations ($W = 3$), and an intra-cluster correlation coefficient (between repeated observations) of $\rho = 0.6$, which yielded $R \cong 0.8$ for detecting a standardized effect size of $\Delta = 1$. Accordingly, a sample size of 17 participants was obtained, which was increased to 33 participants to compensate for potential non-response.

$$R = \left[\frac{1 + (w - 1)\rho}{w} \right]$$

$$n_{\text{repeated}} = R \left[\frac{2(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2} + \frac{(z_{1-\alpha/2})^2}{4} \right]$$

Sample size calculation formula: Convenience sampling was used to recruit students of Isfahan University of Medical Sciences who met the inclusion criteria during the summer of 2020. The study objectives were explained to each individual in plain language, and written informed consent was obtained from those who fully agreed to participate. The inclusion criteria consisted of the absence of any voice disorder; general good health, including no gastroesophageal-laryngeal reflux and no neuromuscular problems (assessed via self-report); absence of laryngeal tension (assessed through observation and clinical examination); and absence of any spinal abnormality or forward head posture (FHP). The craniovertebral angle (CVA) was used to determine the presence of FHP in participants. This angle is formed between two hypothetical lines drawn on the head and neck: one line connects the tragus of the ear to the spinous process of the seventh cervical vertebra (C7), and the other is a horizontal line passing through the C7 spinous process. The use of this angle is common in postural assessments of the head (37, 38). Although previous studies have not established a definitive normal value for this angle

(39), a decrease in the CVA indicates greater cervical flexion and increased FHP (40). This angle was assessed from a lateral view (observed on the side opposite the participant's dominant hand) by an orthotics and prosthetics specialist. Exclusion criteria included diagnosis of a common cold or observation of a voice disorder on the day of testing, unwillingness to continue participation, and lack of cooperation during the study.

Procedure: The present study was conducted at the Speech Therapy Clinic of the School of Rehabilitation Sciences, Isfahan University of Medical Sciences. To ensure the accuracy of the voice recordings, all assessments were performed in an acoustically treated room with a noise level below 50 dB. Recordings were performed individually, in a single session lasting 30 to 45 minutes per participant. To obtain voice samples, participants were asked to sustain the vowel /a/ for at least 5 seconds at a pitch and loudness level they found comfortable. This phonation task was performed in three head positions—forward, backward, and neutral—while seated. The order of head positions was randomized. A height-adjustable chair with armrests and a backrest was used, with the participant's hands resting on the armrests during assessment. The backrest was important to ensure that the positions of the remaining spinal vertebrae were consistent across all participants, since changes in the positions of the lower vertebrae affect the positioning of the cervical vertebrae (41), which could otherwise compromise the consistency of the assessment. Given that most studies addressing posture have been conducted with eyes open, the present study was likewise conducted with eyes open. Since the range of motion is not constant throughout the day, measurements were taken two hours after waking.

Given the asymmetry of the left-right rotational axis, which varies with hand dominance in healthy individuals, the rotational axis for all participants was positioned on the side opposite the dominant hand (41). To precisely position the head in the neutral posture, the Spirit Level application (developed by Keuwlsoft, released in 2014), installed on a mobile phone (Samsung Galaxy J7 model) running Android 8.0, was used as the measurement tool for the target angle. The mobile phone's sensors were sensitive to changes in head angle and accurately detected these changes. The Frankfort horizontal plane was used in conjunction with the application. The Frankfort horizontal plane is a hypothetical line, when the face is in an upright position, connecting two points: the superior margin of the tragus and the inferior margin of the bony orbit (42, 43). When the head is in a neutral

position, the Frankfort horizontal plane should be aligned with the horizontal plane. To precisely determine this position, markers were placed on the two reference points—the tragus and the inferior orbital margin—on each participant. These two points were then connected with a ruler, and the mobile phone was placed along this line. The head was considered to be in a neutral position when the angle displayed by the application was zero degrees. For the backward head position, participants were positioned such that their gaze was directed toward the ceiling above their heads. For the forward head position, the head was flexed until the chin touched the chest (42). Voice recording was performed using a ZOOM H1 recorder (manufactured by ZOOM, Japan), positioned 5 cm from the mouth. To eliminate the effects of vowel onset and offset, the first and last one second of each recording were removed using Praat software, and the middle 3 seconds of the acoustic signal were analyzed. The parameters analyzed included fundamental frequency, jitter, voice intensity, and shimmer, which were calculated using Praat (version 5.3.32; downloaded from www.praat.org) on an ASUS X452-E laptop (44). The collected data were statistically analyzed using analysis of variance (ANOVA) and the LSD post hoc test in SPSS (IBM Corp., 2018; IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY, USA).

Results

In this study, 18 women and 15 men were evaluated. Table 1 presents the mean and standard deviation values of fundamental frequency, jitter, voice intensity, and shimmer in the neutral, flexed, and extended head positions, stratified by sex.

Given the significant differences in mean voice intensity and shimmer in men, as well as mean fundamental frequency in women, across the three head positions (neutral, flexed, and extended), the LSD post hoc test was used to determine precisely between

which positions these differences existed; the results are presented in Table 2.

According to the results presented in Tables 1 and 2, a significant difference was observed in mean fundamental frequency among women across the three head positions ($P = 0.045$); based on the LSD post hoc test results, this difference was significant between the extended and flexed positions ($P = 0.024$) and between the flexed and neutral positions ($P = 0.040$), but not between the extended and neutral positions ($P = 0.837$). However, no significant difference in mean fundamental frequency was observed among men across the three head positions ($P = 0.411$). No significant difference in jitter was observed among women ($P = 0.907$) or men ($P = 0.795$) across the three head positions. No significant difference in voice intensity was observed among women across the three head positions ($P = 0.090$). A significant difference in voice intensity was observed among men across the three head positions ($P = 0.006$); based on the LSD post hoc test results, this difference in voice intensity among men was significant between the extended and flexed positions ($P = 0.005$) and between the flexed and neutral positions ($P = 0.006$), but not between the extended and neutral positions ($P = 0.917$). No significant difference in shimmer was observed among women across the three head positions ($P = 0.096$). Based on the analysis of variance results, a significant difference in shimmer was observed among men across the three head positions ($P = 0.023$). According to the LSD post hoc test results, shimmer differed significantly between the extended and neutral positions ($P = 0.022$) and between the flexed and neutral positions ($P = 0.013$), but not between the extended and flexed positions ($P = 0.831$).

Discussion

Based on the results obtained, it appears that changes in head position affect frequency-related characteristics more strongly in women than in men.

Table 1. Comparison of Voice Acoustic Characteristics across Different Head and Neck Postures, Stratified by Sex

Gender	Acoustic Characteristic	Neutral Head Position	Flexed Head Position	Extended Head Position	Significance of Difference
Male	Fundamental Frequency	129.1±15.16	136.5±16.2	131.1±14.6	0.411
	Jitter	0.32±0.10	0.34±0.07	0.35±0.16	0.795
	Voice Intensity	62.80±3.40	67.0±4.48	62.70±3.99	0.006
	Shimmer	3.23±0.59	4.14±1.32	4.06±0.79	0.023
Female	Fundamental Frequency	224.6±24.4	242.2±25.7	222.9±24.9	0.045
	Jitter	0.31±0.1	0.31±0.12	0.33±0.13	0.907
	Voice Intensity	63.00±5.17	66.90±5.09	64.00±5.74	0.090
	Shimmer	3.03±0.73	2.70±1.30	3.55±1.37	0.096

Table 2. Significance Results of the LSD Post Hoc Test Between Different Head Positions

Head Positions Compared	Significance: Female Fundamental Frequency	Significance: Male Voice Intensity	Significance: Male Shimmer
Extended vs. Flexed	0.024	0.005	0.831
Extended vs. Neutral	0.837	0.917	0.022
Flexed vs. Neutral	0.040	0.006	0.013

As shown in Table 1, a significant difference in mean fundamental frequency was observed among women between the extended and flexed head positions, as well as between the flexed and neutral positions. Numerous neck muscles play a critical role in altering laryngeal position. When the head is flexed forward, the digastric and geniohyoid muscles (elevator muscles of the larynx) contract and pull the hyoid bone upward; consequently, the thyroid cartilage is also elevated. This elevation of the thyroid cartilage increases the tension of the cricothyroid muscle, thereby increasing the fundamental frequency (45).

Furthermore, elevation of the larynx stretches the cricothyroid muscle, thereby affecting its frequency-regulating function (46). In general, changes in head position toward flexion or extension influence the effective contraction of the cricothyroid muscle and lead to changes in fundamental frequency (47). Jitter values did not differ significantly across the three head positions in either women or men. Jitter and shimmer typically increase in voice disorders, and lower values indicate a more normal voice. In the present study, jitter and shimmer in women were lower in the flexed and neutral head positions than in the extended position, suggesting that backward extension of the head in women may adversely affect voice. However, these differences were not statistically significant. In men, changes in head position substantially affected shimmer, with values higher in the extended and flexed positions than in the neutral position. Head position had little effect on voice intensity in women but produced a significant difference in men. Voice intensity is influenced by subglottal pressure and vocal fold contact; therefore, forward and backward head-position changes affect vocal fold contact and mean subglottal airflow and pressure, resulting in changes in voice intensity and amplitude (48).

The simultaneous increase in voice intensity and shimmer observed in the flexed-head position among men can be explained by biomechanical changes in the extrinsic laryngeal muscle chain. Cervical flexion, by bringing the hyoid bone closer to the sternum and altering the thyrohyoid angle, may exert non-physiological pressure on the vocal tract and vocal folds, thereby impairing the efficiency of complete and symmetric glottal closure (49, 50). Disruption of

glottal closure symmetry and completeness directly increases irregularity in vocal fold vibration amplitude, thereby increasing shimmer; this instability may, in turn, be compensated for by increased subglottal pressure to maintain phonation, which subsequently raises voice intensity as well (51). This finding is consistent with previous reports on the role of neck posture in the development of muscle tension dysphonia, in which abnormal neck muscle tension has been associated with inefficient compensatory phonation patterns (21).

In contrast, in women, the predominant effect of the flexed position was observed on fundamental frequency rather than on intensity or shimmer. This sex-related difference may be partly attributable to anatomical differences between the male and female larynx: the shorter and thinner vocal folds of women, along with the less prominent thyroid cartilage, may exhibit greater sensitivity to length and tension changes resulting from hyoid displacement during flexion, which directly affects cricothyroid muscle tension and, consequently, fundamental frequency (52). This finding is consistent with the results of Knight and Austin (2020), who demonstrated a direct and systematic relationship between head angle and changes in fundamental frequency (53), and is also consistent with the observations of Lin et al. (2000), who identified changes in head position as a factor influencing voice perturbation parameters (49). However, unlike the study by Lin et al., which focused on head extension, the present study identified flexion as the more influential position. This discrepancy may be attributable to differences in study design (a three-position versus a two-position comparison), differences in the study population, or differences in the operational definitions of flexion and extension angles.

Another noteworthy finding was the absence of a significant difference between the neutral and extended positions across all three variables. This finding suggests that mild extension of the head, unlike flexion, may remain within the physiological tolerance range of the hyoid-laryngeal muscle chain, allowing the body's natural compensatory mechanisms (such as automatic regulation of cricothyroid muscle tension) to counteract its effects; flexion, by contrast, appears to exceed this compensatory capacity due to greater

compression of cervical structures. This pattern is consistent with clinical evidence on forward head posture, which has typically been associated with voice disorders in the context of a reduced craniovertebral angle (indicating flexion) rather than extension (2, 54).

Unlike voice intensity, shimmer, and fundamental frequency, jitter was not significantly affected by head position in either sex. This finding is consistent with the report by Lin et al. (2000), who showed that shimmer is more sensitive to changes in head position than jitter (49). A plausible explanation is that jitter primarily reflects subtle neuromuscular instabilities in controlling the vocal fold vibration cycle. In contrast, shimmer and voice intensity are more sensitive to pronounced mechanical changes in vibration amplitude and airflow pressure. Accordingly, short-term postural changes in the neck are likely insufficient to produce a measurable disruption in the periodic regularity of frequency (jitter). However, they may affect vibration amplitude and subglottal pressure (55, 56).

These findings hold considerable practical significance for two groups. First, in the field of instrumental voice assessment, the results indicate that head position—particularly flexion—can act as a confounding variable in acoustic measurements; therefore, standardizing head position (e.g., by controlling the craniovertebral angle) during voice sample recording in laboratories and speech therapy clinics is essential (49, 53). Second, in the context of professional voice use, given the high prevalence of forward head posture (chronic flexion) among occupations such as teachers, office workers, and habitual screen users, the findings of this study provide new empirical support for the association between this postural habit and vocal instability—namely, increased shimmer and intensity in men and increased fundamental frequency in women—and underscore the necessity of corrective postural interventions in programs aimed at preventing occupational voice disorders and muscle tension dysphonia (21, 28).

Limitations

Nevertheless, the results of this study should be interpreted with caution. The sample size (18 women and 15 men) was relatively limited, reducing the statistical power to detect smaller effects, such as changes in jitter. Furthermore, the study was based on a cross-sectional assessment conducted under controlled laboratory conditions, and generalizing the findings to dynamic, real-world, long-term postures (such as prolonged working hours) requires caution. The absence of concurrent measurement of complementary indices, such as precise assessment of

craniovertebral angles or electromyography of the laryngeal muscles, is another methodological limitation of this study that could be addressed in future research.

Recommendations

Given the relatively limited sample size of the present study (18 women and 15 men), future studies are recommended to be conducted with larger sample sizes to provide sufficient statistical power for detecting smaller effects (such as the minor jitter changes that were not significant in this study) and to allow greater generalizability of the results to the general population. In addition, since the precise mechanism underlying the effect of flexion on intensity and shimmer in men, and on fundamental frequency in women, was explained in this study solely based on theoretical inference, future studies are recommended to employ complementary instruments such as surface electromyography (sEMG) of the extrinsic laryngeal muscles (sternothyroid, thyrohyoid), videostroboscopy for direct observation of glottal closure patterns, or measurement of subglottal pressure, in order to directly and quantitatively confirm the physiological mechanism underlying the effect of head position. The present study employed a cross-sectional design under short-term laboratory conditions; future studies using longitudinal designs are recommended to examine the effect of prolonged exposure to improper neck postures (such as the actual working hours of teachers or computer users) on acoustic parameters and the onset of vocal fatigue or muscle tension dysphonia, in order to more clearly establish the causal relationship between chronic neck posture and occupational voice disorders. Given that the findings of this study were obtained in a healthy population, it is recommended that the effect of head and neck posture be examined in populations with existing voice disorders (such as patients with muscle tension dysphonia) as well as in high-risk occupational voice users (teachers, singers, broadcasters, call center employees), in comparison with a healthy control group, to more clearly determine the clinical applicability of these findings in voice screening and rehabilitation.

Conclusion

Overall, the findings of this study demonstrated that, among the three head positions examined, flexion—rather than extension—had the greatest adverse effect on the acoustic characteristics of voice, exhibiting a distinct sex-specific pattern (voice intensity and shimmer in men versus fundamental frequency in women). These results, while confirming the

sensitivity of the phonatory mechanism to postural changes in the neck, underscore the necessity of attending to standardized head positioning in acoustic voice assessments and of designing sex-specific ergonomic interventions for populations at risk of voice disorders. Another noteworthy issue regarding forward head positioning is that some professional voice users employ this technique during performance and report relative satisfaction with an apparent increase in vocal range. Unfortunately, this sensation is not sustainable in the long term because it results from increased vocal effort in this position and ultimately adversely affects voice quality. Therefore, the optimal head and neck position—referred to by several voice researchers, including Richard Miller, as the "noble posture"—is one in which the head and neck are aligned with the trunk and pelvis (23).

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Authors' Contribution

Conceptualization and Design: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Funding Acquisition: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Administrative, Technical, and Material Support:

Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Data Collection: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Analysis and Interpretation of Results: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Statistical Expertise: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Manuscript Preparation: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Critical Review of Scientific Content: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Final Approval of the Manuscript for Submission: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

Responsibility for the Integrity of the Study Process from Inception to Publication and Response to Reviewers' Comments: Fariba Mojiri, Parvin Shakeri, Ebrahim Sadeghi-Demneh

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Conflict of Interest

The authors did not have a conflict of interest.

References

1. Harford EE, Holt LL, Abel TJ. Unveiling the development of human voice perception: Neurobiological mechanisms and pathophysiology. *Curr Res Neurobiol*. 2024; 6: 100127.
2. Cardoso R, Lumini-Oliveira J, Meneses RF. Associations between posture, voice, and dysphonia: a systematic review. *Journal of Voice*. 2019; 33(1): 124.
3. Godino-Llorente JJ, Saenz-Lechon N, Osma-Ruiz V, Aguilera-Navarro S, Gómez-Vilda P. An integrated tool for the diagnosis of voice disorders. *Medical engineering & physics*. 2006; 28(3): 276–89.
4. Porcaro CK, Singer C, Djokic B, Danesh AA, Tappen R, Engstrom G. Perceived voice disorders in older adults and impact on social interactions. *Perspectives of the ASHA Special Interest Groups*. 2021; 6(1): 143–50.
5. Huston MN, Puka I, Naunheim MR. Prevalence of voice disorders in the United States: a national survey. *The Laryngoscope*. 2024; 134(1): 347–52.
6. Zhang Z. Mechanics of human voice production and control. *J Acoust Soc Am*. 2016; 140(4): 2614.
7. Josep V-R, Laura G-S, Jesús V-G. Relations between Dysphonia and Personality: An Approximation from Gray Theories. *Journal of Voice*. 2024; 38(2): 542.
8. Amir O, Noam G, Primov-Fever A, Epstein R, Alston M, Gutman I. Voice disorders and personality: New steps on an old path. *Journal of Voice*. 2023.
9. Ranjbar PA, Alnouri G, Vance D, Park J, Suresh A, Acharya P, et al. The Prevalence of Esophageal Disorders among Voice Patients with Laryngopharyngeal Reflux—A Retrospective Study. *Journal of Voice*. 2022; 36(3): 410–2.
10. Sataloff RT, Hawkshaw MJ, Gupta R. Laryngopharyngeal reflux and voice disorders: an overview on disease mechanisms, treatments, and research advances. *Discovery medicine*. 2010; 10(52): 213–24.
11. Snow G, Guardiani E. Movement disorders and voice. *Otolaryngologic Clinics of North America*. 2019; 52(4): 759–67.
12. Dursun G, Karatayli-Ozgunsoy S, Ozgunsoy OB, Tezcaner ZC, Coruh I, Kilic MA. Influence of the macroscopic features of vocal fold polyps on the quality of voice: a retrospective review of 101 cases. *ENT: Ear, Nose & Throat Journal*. 2010; 89(3).
13. Rubin JS, Blake LM, Kanona H. The effects of posture on voice. *Treatment of Voice Disorders*. 2017:153–63.
14. Cirilo TAS, Oliveira VGd, Ceniz AA, Tanigute CC, Fernandes ACN, Silva Emd. Singers' postural alignment and vocal quality. *Audiology-Communication Research*. 2021; 26: e2499.

15. Longo L, Di Stadio A, Ralli M, Marinucci I, Ruoppolo G, Dipietro L, et al. Voice parameter changes in professional musician-singers singing with and without an instrument: The effect of body posture. *Folia Phoniatrica et Logopaedica*. 2020; 72(4): 309–15.
16. Peultier-Celli L, Audouin M, Beyaert C, Perrin P. Postural control in lyric singers. *Journal of Voice*. 2022; 36(1): 141.
17. Wilson Arboleda BM, Frederick AL. Considerations for Maintenance of Postural Alignment for Voice Production. *Journal of Voice*. 2008; 22(1): 90–9.
18. Miller R. *Solutions for singers: Tools for performers and teachers*: Oxford University Press; 2004.
19. McKinney JC. *The diagnosis and correction of vocal faults: A manual for teachers of singing and for choir directors*: Waveland Press; 2005.
20. Cardoso R, Meneses RF, Lumini-Oliveira J, Pestana P, Guimaraes B. Associations between teachers' posture, muscle tension and voice complaints. *Journal of Voice*. 2021; 35(6): 933.
21. Rantala L, Sala E, Kankare E. Teachers' working postures and their effects on the voice. *Folia Phoniatrica et Logopaedica*. 2018; 70(1): 24–36.
22. Gilman M, Johns MM. The effect of head position and/or stance on the self-perception of phonatory effort. *Journal of Voice*. 2017; 31(1): 131.
23. Behrman A. Common practices of voice therapists in the evaluation of patients. *J Voice*. 2005; 19(3): 454–69.
24. Arboleda BMW, Frederick AL. Considerations for maintenance of postural alignment for voice production. *Journal of Voice*. 2008; 22(1): 90–9.
25. Fachinatto APA, de Campos Duprat A, e Silva MA, Bracher ESB, de Carvalho Benedicto C, Luz VBC, et al. Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*. 2015; 29(5): 645.
26. Nacci A, Fattori B, Mancini V, Panicucci E, Matteucci J, Ursino F, et al. Posturographic analysis in patients with dysfunctional dysphonia before and after speech therapy/rehabilitation treatment. *Acta Otorhinolaryngol Ital*. 2012; 32(2): 115–21.
27. Pettersen V, Westgaard RH. The Activity Patterns of Neck Muscles in Professional Classical Singing. *Journal of Voice*. 2005; 19(2): 238–51.
28. Van Houtte E, Van Lierde K, Claeys S. Pathophysiology and Treatment of Muscle Tension Dysphonia: A Review of the Current Knowledge. *Journal of Voice*. 2011; 25(2): 202–7.
29. Kennard EJ, Lieberman J, Saaid A, Rolfe KJ. A Preliminary Comparison of Laryngeal Manipulation and Postural Treatment on Voice Quality in a Prospective Randomized Crossover Study. *Journal of Voice*. 2015; 29(6): 751–4.
30. Kooijman PGC, de Jong FICRS, Oudes MJ, Huinck W, van Acht H, Graamans K. Muscular Tension and Body Posture in Relation to Voice Handicap and Voice Quality in Teachers with Persistent Voice Complaints. *Folia Phoniatrica et Logopaedica*. 2005; 57(3): 134–47.
31. Story BH. Mechanisms of Voice Production. *The Handbook of Speech Production*. 2015. p. 34–58.
32. Roy N. Functional dysphonia. *Current Opinion in Otolaryngology & Head & Neck Surgery*. 2003; 11(3): 144–8.
33. Traser L, Burdumy M, Richter B, Vicari M, Echternach M. The Effect of Supine and Upright Position on Vocal Tract Configurations during Singing—A Comparative Study in Professional Tenors. *Journal of Voice*. 2013; 27(2): 141–8.
34. Castillo-Allendes A, Delgado-Bravo M, Ponce AR, Hunter EJ. Muscle Activity and Aerodynamic Voice Changes at Different Body Postures: A Pilot Study. *Journal of Voice*. 2025; 39(2): 439–47.
35. Barrett E, McCreesh K, Lewis J. Reliability and validity of non-radiographic methods of thoracic kyphosis measurement: a systematic review. *Manual therapy*. 2014; 19(1): 10–7.
36. Li G, Hou Q, Zhang C, Jiang Z, Gong S. Acoustic parameters for the evaluation of voice quality in patients with voice disorders. *Annals of Palliative Medicine*. 2021; 10(1): 13036–136.
37. San Agustin CT, Wilmarth MA, Raymond J, Hilliard T. The amount and variation of craniovertebral angle changes in college-aged students using one-strapped and two-strapped backpacks and bags. *Orthopaedic Practice*. 2003; 15(3): 30–3.
38. Lau M, Chiu TTW, Lam T-H. Measurement of craniovertebral angle with electronic head posture instrument: criterion validity. *Journal of rehabilitation research and development*. 2010; 47(9): 911–8.
39. Park J, Kim J, Kim J, Kim K, Kim N, Choi I, et al. The effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles and depression. *Advanced Science and Technology Letters*. 2015; 91(3): 12–7.
40. Quek J, Pua Y-H, Clark RA, Bryant AL. Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults. *Manual Therapy*. 2013; 18(1): 65–71.
41. Strimpakos N. The assessment of the cervical spine. Part 1: Range of motion and proprioception. *Journal of Bodywork and Movement Therapies*. 2011; 15(1): 114–24.
42. Clarkson HM. *Musculoskeletal Assessment: Joint Range of Motion and Manual Muscle Strength*: Lippincott Williams & Wilkins; 2000.
43. Capon T. Standardised anatomical alignment of the head in a clinical photography studio. A comparison between the Frankfurt Horizontal and the natural head position. *Journal of visual communication in medicine*. 2016; 39(3-4): 105–11.
44. Maryn Y. Practical Acoustics in Clinical Voice Assessment: A Praat Primer. *Perspectives of the ASHA Special Interest Groups*. 2017; 2(3): 14–32.
45. Chiu C, Weng Y, Chen B-w. Tongue Postures and Tongue Centers: A Study of Acoustic-Articulatory Correspondences across Different Head Angles. *Frontiers in Psychology*. 2022; Volume 12 - 2021.

46. Zhang Z. Mechanics of human voice production and control. *The Journal of the Acoustical Society of America*. 2016; 140(4): 2614–35.
47. Brockmann-Bauser M, Bohlender JE, Mehta DD. Acoustic Perturbation Measures Improve with Increasing Vocal Intensity in Individuals With and Without Voice Disorders. *Journal of Voice*. 2018; 32(2): 162–8.
48. Chhetri DK, Park SJ. Interactions of subglottal pressure and neuromuscular activation on fundamental frequency and intensity. *The Laryngoscope*. 2016; 126(5): 1123–30.
49. Lin E, Jiang J, Noon SD, Hanson DG. Effects of head extension and tongue protrusion on voice perturbation measures. *Journal of Voice*. 2000; 14(1): 8–16.
50. Vilkman E, Sonninen A, Hurme P, Körkkö P. External laryngeal frame function in voice production revisited: a review. *Journal of Voice*. 1996; 10(1): 78–92.
51. Węglarz K, Wszolek W, Hemmerling D. Effect of changing body position on selected voice parameters. *Vibrations in Physical Systems*. 2022; 33(3).
52. Zhang Z. Contribution of laryngeal size to differences between male and female voice production. *The Journal of the Acoustical Society of America*. 2021; 150(6): 4511–21.
53. Knight EJ, Austin SF. The effect of head flexion/extension on acoustic measures of singing voice quality. *Journal of Voice*. 2020; 34(6): 964.
54. Salahzadeh Z, Maroufi N, Ahmadi A, Behtash H, Razmjoo A, Gohari M, et al. Assessment of forward head posture in females: observational and photogrammetry methods. *Journal of back and musculoskeletal rehabilitation*. 2014; 27(2): 131–9.
55. Teixeira JP, Oliveira C, Lopes C. Vocal Acoustic Analysis – Jitter, Shimmer and HNR Parameters. *Procedia Technology*. 2013; 9: 1112–22.
56. Maryn Y, Roy N, De Bodt M, Van Cauwenberge P, Corthals P. Acoustic measurement of overall voice quality: a meta-analysis. *The Journal of the Acoustical Society of America*. 2009; 126(5): 2619–34.