RESEARCH ARTICLE

OPEN ACCESS

REVISTA RIICS Investigación e innovación en ciencias de la salud

Colombian College Professors Work-Related Health: Associations Between Stress and Voice Acoustics Parameters

Salud laboral de profesores universitarios colombianos: asociaciones entre estrés y parámetros acústicos de la voz

Andrés Carrillo-González[1,2], **Ángela Patricia Atará-Piraquive**[1], **Maryluz Camargo-Mendoza**[3], **Jeison Ramiro Hernández-Contreras**[4], **Lady Catherine Cantor-Cutiva**[5]

[1] *Department of Collective Health; Nursing Faculty; Universidad Nacional de Colombia; Bogotá; Colombia.*

[2] *Department of Psychology; Faculty of Social and Human Sciences; Fundación Universitaria del Área Andina; Pereira; Colombia.*

[3] *Department of Human Communication; School of Medicine; Universidad Nacional de Colombia; Bogotá; Colombia.*

[4] *Speech and Language Pathologist Program; School of Health; Universidad Manuela Beltrán; Bogotá; Colombia.*

[5] *Department of Communication Sciences and Disorders; The University of Iowa; Iowa City; United States.*

Correspondence
Andrés Carrillo-González.
Email: acarrillog@unal.edu.co

Cite like this
Carrillo-González A, Atará-Piraquive AP, Camargo-Mendoza M, Hernández-Contreras JR, Cantor-Cutiva LC. Colombian College Professors Work-Related Health: Associations Between Stress and Voice Acoustics Parameters. Revista de Investigación e Innovación en Ciencias de la Salud. 2025;7(1):1-16. e-v7n1a333. https://doi.org/10.46634/riics.333

Received: 07/09/2024
Revised: 08/11/2024
Accepted: 10/03/2024

Editor
Fraidy-Alonso Alzate-Pamplona, MSc.

Abstract

Introduction. Teachers have a high risk of developing voice disorders and high-stress levels due to their working conditions. Moreover, stress causes changes at a physiological level in different systems such as the cardiac, gastrointestinal, and respiratory systems. In the latter, the rate of airflow is increased producing significant changes in the acoustic parameters of the voice.

Methods. An exploratory, correlational, longitudinal study was conducted to investigate the association between perceived stress and three acoustic parameters related to voice perturbation and harmonicity (jitter, shimmer, and harmonics-to-noise ratio) among college professors. The study also aimed to explore potential changes in this association over the follow-up period. Twenty-four college professors participated in the study. Participants completed a questionnaire that gathered information on socio-demographic characteristics, working conditions, and stress perception. Voice samples were collected from each participant and subjected to acoustic analysis using Praat software. To examine the associations between stress levels and the acoustic parameters, generalized linear models (GLM) with a gamma distribution were employed.

Results. We found that professors with low stress levels had increased jitter and shimmer values; whereas participants with moderate and high stress levels had increased harmonics-to-noise ratio values compared to those with a lower stress level.

Declaration of interests
The authors have declared that there is no conflict of interest.

Data availability
All relevant data is in the article. For further information, contact the corresponding author.

Funding
None. The author received no specific funding for this work.

Disclaimer
The content of this article is the sole responsibility of the authors and does not reflect the official position of their institution, or the *Revista de Investigación e Innovación en Ciencias de la Salud*.

Contribution of the authors
Andrés Carrillo-González: Conceptualization, data curation, investigation, methodology, project administration, supervision, visualization, writing – original draft, writing – review & editing.
Ángela Patricia Atará-Piraquive: Writing – original draft, writing – review & editing.
Maryluz Camargo-Mendoza: Conceptualization, writing – original draft, writing – review & editing.
Jeison Ramiro Hernández-Contreras: Conceptualization, writing – original draft, writing – review & editing.
Lady Catherine Cantor-Cutiva: Conceptualization, data curation, formal analysis, investigation, methodology, supervision, visualization, writing – original draft, writing – review & editing.

Conclusions. Stress has an important effect on voice perturbation and harmonicity parameters. These results justify the design of interdisciplinary workplace interventions for voice disorders among teachers that include activities on stress management.

Keywords

Jitter; Shimmer; harmonics-to-noise ratio; stress; college professors.

Resumen

Introducción. Los docentes tienen un alto riesgo de desarrollar trastornos de la voz y niveles elevados de estrés debido a sus condiciones laborales. Además, el estrés provoca cambios a nivel fisiológico en diferentes sistemas, como el cardíaco, gastrointestinal y respiratorio. En este último, el flujo de aire se incrementa, lo que produce cambios significativos en los parámetros acústicos de la voz.

Método. Se realizó un estudio exploratorio, correlacional y longitudinal para investigar la asociación entre el estrés percibido y tres parámetros acústicos relacionados con la perturbación y la armonicidad de la voz (jitter, shimmer y harmonics-to-noise ratio) en profesores universitarios. El estudio también buscó explorar posibles cambios en esta asociación durante el período de seguimiento. Veinticuatro profesores universitarios participaron en el estudio. Los participantes completaron un cuestionario que recopiló información sobre características sociodemográficas, condiciones laborales y percepción del estrés. Se recolectaron muestras de voz de cada participante, las cuales fueron analizadas acústicamente utilizando el software Praat. Para examinar las asociaciones entre los niveles de estrés y los parámetros acústicos, se emplearon modelos lineales generalizados (GLM) con una distribución gamma.

Resultados. Encontramos que los profesores con bajos niveles de estrés tenían valores aumentados de jitter y shimmer, mientras que los participantes con niveles moderados y altos de estrés tenían valores aumentados del harmonics-to-noise ratio en comparación con aquellos con un nivel de estrés más bajo.

Conclusiones. El estrés tiene un efecto importante en los parámetros de perturbación y armonicidad de la voz. Estos resultados justifican el diseño de intervenciones interdisciplinarias en el lugar de trabajo para los trastornos de la voz entre los docentes, que incluyan actividades de manejo del estrés.

Palabras clave

Jitter; Shimmer; harmonics-to-noise ratio; estrés; profesores universitarios.

Introduction

Voice disorders and high-stress levels are two work-related conditions prevalent among teachers, with physical and psychological implications [1]. Voice is known as the vehicle of verbal communication, produced from the synergic work of five systems: neurological, respiratory, phonatory, resonant, and articulatory [2]. The voice involves three key components: the power source (airflow), the oscillator (vocal folds), and the resonator (vocal tract) [3]. Air compressed by the lungs is pushed through the larynx, causing the vocal folds to vibrate, producing sound. The shape and size of the vocal tract, along with articulatory movements, further refine the sound, influencing its quality and strength [3] and produce the desired pitch, loudness, and vocal quality [4].

Voice assessment includes acoustical analysis using parameters such as fundamental frequency (*fo*), Sound Pressure Levels (SPL), jitter, shimmer, and harmonics-to-noise ratio (HNR). These parameters help us to differentiate between normal and non-normal voice production [5]. However, to obtain comparable information, researchers and clinicians are advised to follow protocols for instrumental assessment of voice [6]. These protocols allow obtaining quantitative information that corresponds to auditory-perceptual parameters of vocal loudness (SPL and shimmer), pitch (*fo* and jitter), and quality (signal periodicity and/or spectral-based measures such as HNR), as recommended by the American Speech-Language-Hearing Association (ASHA) [6].

Stress is defined as a state of disharmony, or threatened homeostasis, related to individual, physiological, and biochemical aspects [7]. From a psychosocial perspective, stress is linked to external factors, such as stimuli and events that trigger the stress response [8], indicating a significant interrelationship between the environment and the individual. Stress causes physiological changes in several systems, including cardiovascular [9], respiratory [10], endocrine [11,12] and nervous systems [13]. These responses to stress will depend on their nature, intensity, and duration [13].

A comprehensive literature review [14] discussed the effects of stress on vocal parameters, noting that while there is evidence suggesting that stress can lead to changes in voice, such as increased *fo*, individual differences in stress response and the influence of parasympathetic factors complicate the ability to draw a universal conclusion. These stress-induced vocal changes are not limited to increases in *fo*, but also include alterations in subglottic pressure, jitter (especially when the sympathetic nervous system is blocked [15]) and shimmer. Stress has been associated with decreased maximum airflow rate, voice onset time, and vocal intensity [14], as well as increased tension in the cricothyroid muscle, and subglottal pressure [16]. Although there is no complete understanding of the association between stress and jitter, a relationship between these two variables can be hypothesized based on the findings of Giddens et al. [14]. They suggest that this association may be mediated by the sympathetic nervous system's effects on heart rate, blood pressure, and bronchodilation. Consequently, the mucosa of the vocal folds tends to elevate its movement frequency, leading to amplified disturbances attributed to heightened stiffness in the vocal folds [17]. Furthermore, stress can lead to a higher respiratory rate [18], causing people to breathe more times per minute. According to Dworkin [19], this disrupts the airflow stability and can result in physiological responses such as inflammation of the vocal folds. The sequential mechanisms of tissue inflammation involve diminished blood flow secondary to contraction or vasoconstriction of vessels, followed by vasodilation of small blood vessels. This vasodilation causes increased flow, erythema, localized heat, and increased mass and stiffness of the vocal folds, making the voice hoarse and with lower pitch [20]. In addition, these changes could cause decreased amplitude and create asymmetrical vibrations and turbulent airflow, potentially increasing measures of shimmer in individuals without [21]and with voice disorders [22].

The interplay between vocal health, stress, and working conditions is a critical area of study in occupational health and safety, especially for professions that rely heavily on vocal communication, such as teaching. These interactions can significantly impact an individual's overall health, job performance, and quality of life [1,23,24]. For instance, the literature indicates that workplace-related stressors, such as the number of students per class, the number of classes per week, and background noise levels may increase teachers' vocal effort and lead to vocal fatigue, which could result in reduced pitch [25]. Similarly, a recent study found that the presence of vocal fatigue was correlated with the duration of daily vocal rest breaks and hours of daily voice use at work among professional voice users [26]. It also suggests that longer periods of speaking at work could lead to increased discomfort and physical pain among workers. It is worth noting that stress has been identified as one of the factors most strongly correlated with voice symptoms in school teachers [23].

Furthermore, research has highlighted that college professors are exposed to several stressors, including intense workloads, classroom management challenges, demands of standardized testing, and a scarcity of resources [27,28]. This heightened stress not only adversely affects their mental and physical well-being but also manifests in vocal health problems. Indeed, studies have reported that professors with higher stress levels are twice as likely to report voice disorders compared to those with lower stress levels [24,29,30]. Among school teachers, those with higher stress levels are more likely to report voice symptoms and reduced voice-related quality of life than their less-stressed colleagues [31–33].

Voice acoustic parameters could be considered useful measures of stress levels and provide insight into the potential psychophysiological mechanisms underlying the voice stress response [34] by monitoring and measuring variations in voice associated with stress [35]. However, results are contradictory since some research has reported that *fo* was significantly lower when participants faced stressful situations [36], while other studies noted changes in *fo* without specifying the direction [37,38]. Other acoustic parameters, such as HNR and shimmer, have been associated with stress [37]. Considering that jitter reflects involuntary variations in *fo*, shimmer reflects amplitude disturbances [5], HNR quantifies the relative amount of additive noise in the speech signal [39], and these measures are non-intrusive and easy to collect; they are feasible to implement in everyday settings.

Since the relationship between stress and acoustic parameters like jitter, shimmer, and HNR is still unclear, this study aims (1) to investigate the association between self-reported stress levels with jitter, shimmer, and HNR among Colombian college professors and (2) to explore potential changes in this association over the follow-up period.

Methods

Study design and participants

This study had an exploratory, correlational, and longitudinal design with the participation of 24 college professors (12 men and 12 women). The sample size was calculated considering a prevalence of voice disorders in teachers of 69% and a prevalence of voice disorders in the general population of 36% [40], with an Alpha of 0.05 and a power of 80% (n = 16). Considering that this was a longitudinal study, collecting data at different points in time [41], the final sample size was estimated at 24 participants. All the participants met the inclusion criteria, which included being a college professor, having a smartphone and a laptop or desktop computer, and not having medically diagnosed problems of either stress-related or voice disorders. This study was approved by the institutional ethics committee (approval reference 014-19).

Data collection procedure

The data were collected between October and March, but each participant was followed for 15 days. Professors who agreed to participate in the study attended an initial meeting with the first author, where they were informed about the research goals, potential risks of the research, and the expected duration of the study. Afterward, all participants, who accepted to participate, signed the informed consent form, filled in an online survey, and recorded two voice samples (sustained vowels /a/ and /i/).

For this study, we created an online survey using Google Forms to evaluate the work-relatedness of voice disorders and stress levels among college professors. Google Forms was used because it holds certifications such as ISO 27001, ISO 27017, ISO 27018, SSAE16/ISAE 3402, and FedRAMP, which guarantee the confidentiality and privacy of the information collected and stored through this service. In order to guarantee the privacy of the information, we followed all necessary ethical guidelines from our institutional review board, which ensured compliance with data privacy regulations, including those pertaining to the General Data Protection Regulation. The survey was adapted following the English-Spanish-English translation protocol and content-validated by three expert judges. The initial section of the survey comprised fifteen questions adapted from questionnaires used in prior studies [42,43]. It covered various aspects, including socio-demographics (gender, age, marital status, and education level), working conditions (duration of voice usage at work, class size, and daily and weekly teaching load), lifestyle habits (smoking, alcohol consumption, and water intake), and health-related factors (respiratory and gastrointestinal issues, allergies, stress levels, and sleep duration and quality). The second section focused on assessing stress perception. In this part, participants responded to the following question: "Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?" [44]. This item was scored on a five-point Likert scale going from "not at all" (1) to "very much" (5). While the survey included inquiries about working conditions, lifestyle habits, and health-related factors, it is important to note that this manuscript's primary focus is the analysis of the relationship between stress and three voice acoustic parameters. Other research findings from the same data have been published elsewhere [45,46].

We assessed voice function by analyzing three specific voice acoustic parameters derived from two voice samples, namely the vowels /a/ and /i/. The inclusion of both vowels served multiple purposes. First, it allowed us to assess the consistency of stress effects across different vowel types, as the production of each vowel involves distinct articulatory and phonatory demands that can affect acoustic measures [47]. Second, this approach enhanced the robustness of our acoustic analysis.

The samples used for this article were obtained at two time points: at the beginning (baseline measurement) and after a 15-day follow-up period (follow-up measurement). The recordings made from day 2 to day 14 were recorded under different conditions and, therefore, were not included. This longitudinal approach allowed us to assess the stability of the stress-voice relationship and control for intra-individual variability. It also helped to capture the temporal dynamics of stress and voice function, which can fluctuate due to various factors (work demands, environmental factors, and individual coping mechanisms). However, although participants did not practice the specific vocal tasks analyzed in this manuscript, the repeated assessments might have influenced vocal performance.

The voice recordings took place in the Laboratory of Health and Safety at Work in the Faculty of Nursing of the Universidad Nacional de Colombia. Participants were located inside a soundproof booth. They were instructed to take a deep breath and produce a sustained vowel sound, first /a/, at a conversational pitch and loudness, aiming for maximal duration without leaving any residual air. This process was repeated three times. Subsequently, participants were asked to replicate the same procedure, this time producing the vowel /i/. To ensure consistency, all recordings were conducted under controlled conditions (same environment, time of day, microphone, and consistent distance between the speaker and the microphone). Consequently, variations in SPL were not considered. Voice recordings were made employing a unidirectional microphone, the AUDIOART ART-139, characterized by a frequency response range spanning from 50Hz to 15KHz, a sensitivity of -53 ± 3dB, and an impedance of 600Ω ± 30% (at 1KHz). All recordings were sampled at a frequency of 44,100 Hz. Participants were instructed to maintain a consistent distance of five centimeters between their mouth and the microphone throughout the recording sessions. According to Švec et al. [48], to keep the measurement inaccuracy below ±1dB, the variation of the mouth-to-microphone distance should be kept below ±12%, whereas at 5 cm, the distance variation should be less than 0.6 cm. The participants had a marked ruler to measure the distance from the microphone to the mouth. The recordings were performed by the first author with the collaboration of Speech-language pathology trainees. The first author also ensured that participants maintained the mouth-microphone distance using the ruler.

Data processing and acoustic analysis

Three dependent variables were defined: jitter, shimmer, and HNR, which are continuous variables. Then, three independent variables were defined: stress levels, measurement time point, and vowel type. Stress levels were categorized on a five-point scale ranging from 1 to 5. The measurement time point was dichotomized as baseline or follow-up. Vowel type was also dichotomized, distinguishing between the vowels /a/ and /i/. We selected jitter, shimmer, and HNR based on their recognized effectiveness in distinguishing normal voices from pathological voices, as reported in previous studies [49,50]. The voice acoustic analysis was conducted using *Praat* software (version 6.1.04). The middle 3 seconds of the longest sustained vowel productions were used to calculate jitter, shimmer, and HNR. We excluded the initial and final portions of the production from the analysis to mitigate any onset and offset effects, aiming for a more consistent assessment of perturbations as suggested by Watts et al. [51].

Statistical analysis

All statistical analyses were conducted using SPSS version 24.0 [IBM Corp]. The results of the Shapiro-Wilk test indicated that the data did not follow a normal distribution. Therefore, differences in jitter, shimmer, and HNR among participants were assessed using the Kruskal-Wallis test. Furthermore, Generalized Linear Models (GLM) with a gamma distribution were employed to examine the associations between jitter, shimmer, and HNR with stress levels. The strength and direction of the associations between independent variables (predictors) and the dependent variable (outcome) were expressed as beta (B) values along with their respective standard errors (SE). A negative beta estimate ($B < 0$) means that there is a negative association or relationship between the predictor variable and the outcome variable. A positive beta estimate ($B > 0$) means that there is a positive association or relationship between the predictor variable and the outcome variable. The magnitude of the beta value indicates the strength of the association. Larger absolute values of beta (whether positive or negative) indicate a stronger association between the predictor and the outcome, while smaller absolute values suggest a weaker association.

AI use disclosure

Claude 3.5 Sonnet was used to proofread and enhance the writing by providing suggestions for sentence structure and grammatical improvements. No content was generated by any AI tool.

Results

Occupational demographic information of professors

Participant attrition was 0%. The participants had an average age of 45 years, with an age range covering 42 years. A total of 91% of the male population reported using their voice in occupational settings for six hours or less per day, while 67% of women indicated using their voice for more than six hours daily. Concerning the number of days per week that teachers use their voice for work, most men (83%) stated using it for more than four days, whereas 62% of women mentioned using their voice for four days or less. On average, teachers experience was 16 years ($\sigma = 10.4$). Most of both women (67%) and men (83%) reported having 30 or fewer students per class.

Regarding individual conditions, 75% of the female population mentioned consuming three or more glasses of water daily, in contrast to 50% of men. Among health-related factors, the most prevalent conditions included rhinitis (29%), respiratory allergies (21%), gastroesophageal reflux (17%), and hypertension (8%). It is noteworthy that the male population reported a higher number of prior health conditions (58%) compared to the female population (42%). Additionally, an equal proportion (83%) of both men and women mentioned not using medications frequently. Lastly, 88% of teachers indicated that they do not participate in extracurricular activities that involve extra vocal demand, while the remaining 12% mentioned activities such as singing, performing, and family dynamics.

Differences in jitter, shimmer, and HNR among college professors with different stress scores

The results show that the average stress score among the participants was 2.26 (SD = 0.79) which would fall above the midpoint between "not at all" and "slightly". However, there were participants who scored a level 5 of stress, which means a high perception of this aspect that could be associated with the workload of their activities.

All measures of voice acoustic parameters were under the reference values of healthy voices. Table 1 presents the mean values of jitter, shimmer, and HNR for each stress level. It was observed that jitter in seconds was significantly higher (B = 0.000026) among professors with a stress level of 2 (slightly). Additionally, shimmer in decibels (dB) was found to be significantly higher (B = 0.03) for teachers with a stress level of 1 (not at all). In terms of HNR, teachers with a stress level of 5 (very much) exhibited significantly higher HNR values, with a mean of 29.1.

Table 1. Mean values of jitter, shimmer, and HNR per stress levels.

Voice acoustic parameters	Reference values parameters	Stress levels				
		1 (not at all)	2	3	4	5 (very much)
Jitter (%)	<0.72	0.4	0.4	0.4	0.4	0.4
Jitter (sec)	< 0.000067	0.000019	0.000026*	0.000015	0.000018	0.000018
Shimmer (dB)	<0.29	0.3*	0.2	0.2	0.2	0.2
HNR (dB)	>18.71	21.7	22.0	25.2*	23.6	29.1*

Note. * p-value ≤ 0.05.

Relationship between stress and duration and perturbation parameters of voice

Table 2 presents the results of the multivariate analysis examining the relationship between jitter, shimmer, HNR, and stress levels. If we compare the baseline with the follow-up, there was a statistically significant reduction at the end of the study in the Jitter % (B = -0.30; p = 0.00), Jitter sec (B = -0.37; p = 0.02) and Shimmer dB (B = -0.22; p = 0.01). Regarding the production of vowels, there was a significant reduction of the vowel /i/ compared to the vowel /a/in the acoustic parameters of Jitter % (B = -0.39; p = 0.00) and Shimmer (B = -0.31; p = 0.00) and an increase in the HNR (B = 0.16; p = 0.00). Participants who scored moderate to high-stress levels (levels 3, 4, and 5) had slightly lower values of Shimmer (dB) compared to those with no stress (level 1) (B = -0.55 p = 0.00; -0.41 p = 0.00; -0.53 p = 0.01, respectively). Participants who scored moderate stress (level 3) had slightly higher HNR (dB) values compared to those with reported no stress (level 1) (B = 0.14; p = 0.04).

Table 2. Relationship between jitter [%], Shimmer [dB], and HNR [dB] with stress levels.

Parameter	Jitter (%)			Jitter (sec)			Shimmer (dB)			HNR (dB)		
	Beta	SE	p-value	Beta	SE	p-value	Beta	SE	p-value	Beta	SE	p-value
Baseline Measure (day 1)	Reference Category			Reference Category			Reference Category			Reference Category		
Follow-up Measure [day 15]	-0.30	0.07	0.00*	-0.37	0.16	0.02*	-0.22	0.08	0.01*	0.03	0.05	0.59
Vowel /a/	Reference Category			Reference Category			Reference Category			Reference Category		
Vowel /i/	-0.39	0.06	0.00*	-0.25	0.14	0.08	-0.31	0.06	0.00*	0.16	0.05	0.00*
Stress Level = 1	Reference Category			Reference Category			Reference Category			Reference Category		
Stress Level = 2	0.21	0.08	0.01*	0.42	0.18	0.02*	-0.08	0.08	0.33	0.00	0.06	0.95
Stress Level = 3	-0.08	0.09	0.38	-0.38	0.21	0.07	-0.55	0.10	0.00*	0.14	0.07	0.04*
Stress Level = 4	-0.06	0.10	0.59	-0.06	0.23	0.81	-0.41	0.11	0.00*	0.08	0.08	0.28
Stress Level = 5	-0.08	0.18	0.65	-0.15	0.42	0.71	-0.53	0.19	0.01*	0.29	0.14	0.51

Note. * p-value ≤ 0.05.

Discussion

This study aimed to identify the relationship between stress and three voice acoustic parameters related to perturbation and harmonicity of voice (jitter, shimmer, and HNR) among college professors. Two main results were found. First, teachers with lower stress levels had increased shimmer (stress level 1) and jitter (stress level 2) values compared to participants with higher perceived stress levels. Second, teachers with medium and high levels of stress (3 and 5) had higher HNR compared with those with lower stress levels (1 and 2).

Our first result disagrees with previous research [14] that reported that high levels of stress were associated with high values of disturbance of the *fo* and SPL; instead, we found that lower stress levels were associated with slightly greater perturbations in vocal frequency and amplitude, as indicated by higher jitter and shimmer values. A possible explanation for these results is that low-stress levels may be associated with small intrinsic vocal fold tension and vibration amplitudes causing more variability in mucosal movement resulting in greater perturbation [52]. Regarding jitter, our results suggested a decrease in this parameter with higher scores of self-reported stress levels. This is, less stress causes more frequency perturbance, which may be explained by an increased cricothyroid muscle contraction and fluctuations in subglottic pressure affecting the regularity of vocal folds vibration [21,34,53]. Recently, Kappen et al. [54] found an association between jitter and changing mood in the context of psychosocial stress. In this way, it seems likely that high jitter scores may help to identify changes in the level of vocal quality due to incipient stress in teachers. Another possibility may be due to the way college professors perceive stress. This perspective could be influenced by various factors, such as workload, academic demands, and pressure to achieve professional goals. In addition, the individual characteristics of each professor, such as their level of resilience and stress management skills, could affect their perception and personal experience [55]. Previous research has indicated that jitter is strongly influenced by individual variations in stress reactivity [17], reflecting the body's capacity or propensity to respond to stressors. It is important to note that the perception of stress among college professors may vary, as their evaluation was based on subjective self-report questionnaires, which may not align precisely with objective stress appraisals. Additionally, the absence of exposure to simulated stress-inducing situations in the participants of this study limits our ability to exercise more control over this variable, which should be considered a limitation. Future studies could consider determining physiological targets to contrast the results of this study.

Concerning the relationship between HNR and stress, we found that participants with medium and high-stress levels had higher values of HNR. Although all the participants' values of HNR were within the range of "normal" voice (despite the level of perceived stress), these increments may be associated with the activation of the sympathetic nervous system and the release of cortisol and noradrenaline that trigger different changes in the body (e.g., increased heart and respiratory rate, increased alertness) [56]. In this sense, by increasing the flow of expelled air and its frequency, greater energy is produced in the vibration and periodicity of the vocal folds. Therefore, generating high values of HNR is associated with a harmonic and sonorous voice [57]. In this way, despite the statistical association found, the self-perception of medium and high levels of stress would not show in our study that it is affecting harmonicity or sonority of the voice, and even less so when at a medium-high level (level 4) we did not find any association.

Furthermore, "higher" values of jitter, shimmer, and HNR in the vowel /i/ compared to the vowel /a/, and in the last measure compared with the first one may be an indication of greater laryngeal control during the voice production, probably due to having repeated the assessments previously. Participating professors might have become more aware of their voices when carrying out these tasks [58]. It is worth remembering that while participants recorded their voices throughout the 15-day follow-up period, the nature of the recordings differed. On days 1 (baseline measurement) and 15 (follow-up measurement), participants provided samples of sustained vowels, whereas on days 2 to 14, they produced reading samples. This variation in recording type suggests that any observed changes are unlikely to be due to a training effect. Instead, they may reflect an increased awareness of vocal production among the teachers throughout the study. Also, the difference in HNR for the vowels can be explained by the energetic differences in each vowel's harmonic components [59]. The overall value of the HNR of the signal varies because different vocal tract configurations involve different amplitudes for the harmonics [60]. The vowel /a/ has generally lower HNR than the /i/ and /u/ vowels [61]. The vowel /a/ presents a constriction in the pharynx and an expansion near the lips, while the vowel /i/ requires a constriction near the lips and an expansion near the larynx [5]. Therefore, the vowel /i/ involves a more closed position of the mouth and front of the tongue in contrast to the vowel /a/. These articulatory characteristics require greater laryngeal control and precise adjustment of the vocal folds, which can improve voice production parameters (jitter, shimmer, and HNR) [62].

This study provides valuable insights into the relationship between stress levels and voice acoustics. Our findings suggest that lower stress levels are associated with increased jitter and shimmer, indicating that acoustic parameters of voice perturbation and harmonicity may be sensitive to perceived psychological tension. These parameters could potentially serve as reliable indicators of emotional states. The research points to an interaction between vocal quality and the presence of stress, which may have implications for work performance. This aligns with previous research that demonstrated that when evaluated together, voice disorders and work-related stress had a stronger association with decreased work ability compared to when these factors were assessed separately [63].

To conclude, these findings underscore the complex interplay between psychological stress, vocal characteristics, and professional performance. They highlight the potential utility of voice analysis as a non-invasive tool for stress assessment in professional settings, particularly among educators. Furthermore, they emphasize the importance of considering both vocal health and stress management in efforts to improve work performance and overall well-being among college professors.

Limitations and future research

As with all studies, we acknowledge some limitations due to the lack of detailed data on teaching (vocal) demands at the time of the study, the specific timing within the academic semester, and the variety of extracurricular voice use outside of occupational duties. Additionally, the differences in reported voice use between men and women may have affected the results. Previous research has shown that women tend to experience vocal fatigue more frequently than men, and age has also been identified as a contributing factor [64]. These gender-based and age-related differences could potentially influence the relationship between stress and voice acoustics. Moreover, we recognize that we did not account for the association between SPL and stress levels, nor the relationship between SPL and jitter, shimmer, and HNR in our analysis. Although the results are unlikely to change significantly, incorporating these factors would have provided a more robust interpretation. Another limitation is the presence of external factors that, while not the primary focus of our research, may have influenced the results. Although we did not examine these factors in detail, their potential impact on stress levels and voice acoustics should be considered when interpreting our findings. These external factors could include environmental conditions, personal life stressors, or other work-related variables not captured in our study.

Future research in this area could take several directions to build upon our findings. Firstly, a more comprehensive exploration of external variables could provide additional clarity on their relationships and impacts. Secondly, incorporating more objective measures to quantify stress levels would enhance the robustness of the results. Another valuable path would be to conduct a more thorough analysis of gender and age-related differences in voice use and their relationship to stress. Finally, employing a larger and more diverse sample size would increase the generalizability of the findings, potentially uncovering patterns or associations that may not be apparent in smaller, more homogeneous groups. These approaches would collectively contribute to a deeper understanding of the complex interplay between voice parameters, stress, and demographic factors among college professors.

Despite these limitations, the absence of such detailed information does not undermine the validity of the associations observed in line with our exploratory goals. On the contrary, the findings of this study highlight the need to consider stress and voice disorders as interrelated issues rather than separate entities, particularly in the context of teachers' occupational health.

Conclusions

Addressing stress and its impact on vocal function holistically can lead to more effective prevention and treatment strategies for teachers. By incorporating stress reduction techniques such as mindfulness, cognitive-behavioral therapy, and relaxation exercises into vocal health programs we could mitigate the physiological impacts of stress on the vocal folds. Moreover, educational institutions should recognize the dual burden of stress and voice disorders on teachers and implement supportive measures, such as reasonable teaching loads, access to vocal health resources, and professional development opportunities focused on stress management. By adopting a comprehensive approach that acknowledges the interplay between stress and voice, we can improve the overall well-being and professional longevity of educators.

References

1. Vertanen-Greis H, Löyttyniemi E, Uitti J. Voice disorders are associated with stress among teachers: A cross-sectional study in Finland. J Voice [Internet]. 2020;34(3):488.e1-488.e8. doi: https://doi.org/10.1016/j.jvoice.2018.08.021

2. Sataloff RT. Voice Science. 2nd ed. San Diego: Plural Publishing, Inc.; 2017. 347 p.

3. Stemple JC, Roy N, Klaben BK. Clinical Voice Pathology: Theory and Management. 6th ed. San Diego: Plural Publishing, Inc.; 2018. 540 p.

4. Desjardins M, Bonilha HS. The Impact of Respiratory Exercises on Voice Outcomes: A Systematic Review of the Literature. J Voice [Internet]. 2020;34(4):648.e1-648.e39. doi: https://doi.org/10.1016/j.jvoice.2019.01.011

5. Cobeta I, Núñez F, Fernández S. Patología de la voz. Valencia: Marge Médica Books; 2013. 625 p.

6. Patel RR, Awan SN, Barkmeier-Kraemer J, Courey M, Deliyski D, Eadie T, et al. Recommended Protocols for Instrumental Assessment of Voice: American Speech-Language-Hearing Association Expert Panel to Develop a Protocol for Instrumental Assessment of Vocal Function. Am J Speech Lang Pathol [Internet]. 2018;27(3):887-905. doi: https://doi.org/10.1044/2018_AJSLP-17-0009

7. Chrousos GP, Gold PW. The concepts of stress and stress system disorders. Overview of physical and behavioral homeostasis. JAMA [Internet]. 1992;267(9):1244-52. doi: https://doi.org/10.1001/jama.267.9.1244

8. Naranjo Pereira ML. Una revisión teórica sobre el estrés y algunos aspectos relevantes de éste en el ámbito educativo. Rev Educación [Internet]. 2009;33(2):171-90. doi: https://doi.org/10.15517/revedu.v33i2.511

9. Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation [Internet]. 1999;99(16):2192-217. doi: https://doi.org/10.1161/01.CIR.99.16.2192

10. American Psychological Association (APA) [Internet]. Worcester: APA; c2024. Stress effects on the body; 2018 Nov 1 [updated 2023 Mar 8]; [about 5 screens]. Available from: https://www.apa.org/topics/stress/body

11. Tilbrook AJ, Turner AI, Clarke IJ. Effects of stress on reproduction in non-rodent mammals: the role of glucocorticoids and sex differences. Rev Reprod [Internet]. 2000;5(2):105-13. doi: https://doi.org/10.1530/ror.0.0050105

12. Brown-Grant K, Harris GW, Reichlin S. The effect of emotional and physical stress on thyroid activity in the rabbit. J Physiol [Internet]. 1954;126(1):29-40. doi: https://doi.org/10.1113/jphysiol.1954.sp005189

13. Yaribeygi H, Panahi Y, Sahraei H, Johnston TP, Sahebkar A. The impact of stress on body function: A review. EXCLI J [Internet]. 2017;16:1057-72. doi: https://doi.org/10.17179/excli2017-480

14. Giddens CL, Barron KW, Byrd-Craven J, Clark KF, Winter AS. Vocal indices of stress: a review. J Voice [Internet]. 2013;27(3):390.e21-29. doi: https://doi.org/10.1016/j.jvoice.2012.12.010

15. Giddens CL, Barron KW, Clark KF, Warde WD. Beta-adrenergic blockade and voice: a double-blind, placebo-controlled trial. J Voice [Internet]. 2010;24(4):477-89. doi: https://doi.org/10.1016/j.jvoice.2008.12.002

16. Zhou G, Hansen JHL, Kaiser JF. Nonlinear feature-based classification of speech under stress. IEEE Transactions on Speech and Audio Processing [Internet]. 2001;9(3):201-16. doi: https://doi.org/10.1109/89.905995

17. Zhang Z. The Physical Aspects of Vocal Health. Acoust Today [Internet]. 2021;17(3):60-8. doi: https://doi.org/10.1121/AT.2021.17.3.60

18. Widjaja D, Orini M, Vlemincx E, Van Huffel S. Cardiorespiratory dynamic response to mental stress: a multivariate time-frequency analysis. Comput Math Methods Med [Internet]. 2013;2013:451857. doi: https://doi.org/10.1155/2013/451857

19. Dworkin JP. Laryngitis: types, causes, and treatments. Otolaryngol Clin North Am [Internet]. 2008;41(2):419-36. doi: https://doi.org/10.1016/j.otc.2007.11.011

20. Lima Neto JL, Fonseca ARB da, Tavares ELM, Gramuglia ACJ, Martins RHG. Reinke Edema: Factors that Interfere with Vocal Recovery after Surgery. Int Arch Otorhinolaryngol [Internet]. 2023;27(1):e77-82. doi: https://doi.org/10.1055/s-0042-1743463

21. Mendoza E, Carballo G. Acoustic analysis of induced vocal stress by means of cognitive workload tasks. J Voice [Internet]. 1998;12(3):263-73. doi: https://doi.org/10.1016/S0892-1997(98)80017-9

22. Lin FC, Chen SH, Chen SC, Wang CT, Kuo YC. Correlation Between Acoustic Measurements and Self-Reported Voice Disorders Among Female Teachers. J Voice [Internet]. 2016;30(4):460-5. doi: https://doi.org/10.1016/j.jvoice.2015.05.013

23. Rantala LM, Hakala SJ, Holmqvist S, Sala E. Connections Between Voice Ergonomic Risk Factors and Voice Symptoms, Voice Handicap, and Respiratory Tract Diseases. J Voice [Internet]. 2012;26(6):819.e13-819.e20. doi: https://doi.org/10.1016/j.jvoice.2012.06.001

24. Carrillo-Gonzalez A, Camargo-Mendoza M, Cantor-Cutiva LC. Relationship Between Sleep Quality and Stress with Voice Functioning among College Professors: A Systematic Review and Meta-analysis. J Voice [Internet]. 2021;35(3):499.e13-499.e21. doi: https://doi.org/10.1016/j.jvoice.2019.11.001

25. Calvache C, Rincón-Pinilla MP, Cantor-Cutiva LC. Work-Related Vocal Challenges of Online Teaching: A Study of Female College Professors. J Voice [Internet]. Forthcoming 2023 Aug 1. doi: https://doi.org/10.1016/j.jvoice.2023.04.011

26. Kıncal İ, Irklı FA. Vocal Fatigue and Its Relationship with Vocal Hygiene and Work-Related Factors in Professional and Nonprofessional Voice Users: A Multiple Linear Regression Model Study. J Voice [Internet]. Forthcoming 2024 May 24. doi: https://doi.org/10.1016/j.jvoice.2024.05.001

27. Walia P, Tulsi PK. Emotional intelligence and occupational stress of college teachers. Journal of Organisation and Human Behaviour [Internet]. 2014;3(1):33-9. Available from: http://www.publishingindia.com/johb/48/emotional-intelligence-and-occupational-stress-of-college-teachers/293/2162/

28. Durán Urón AE, Jimeno Martínez MG, Rodríguez Barraza DS, Meléndez Serrano AI, Palacios Alvarado W, Mendoza Cáceres DA. Condiciones acústicas en las aulas de clase: Una revisión de la literatura. Investigación e Innovación en Ingenierías [Internet]. 2021;9(2):79-90. doi: https://doi.org/10.17081/invinno.9.2.4908

29. Kooijman PGC, de Jong FICRS, Thomas G, Huinck W, Donders R, Graamans K, et al. Risk factors for voice problems in teachers. Folia Phoniatr Logop [Internet]. 2006;58(3):159-74. doi: https://doi.org/10.1159/000091730

30. Vertanen-Greis H, Löyttyniemi E, Uitti J. Voice Disorders are Associated with Stress Among Teachers: A Cross-Sectional Study in Finland. J Voice [Internet]. 2020;34(3):488.e1-488.e8. doi: https://doi.org/10.1016/j.jvoice.2018.08.021

31. Cantor-Cutiva LC, Dalmasso M del C, Malebrán Bezerra de Mello MC. Association between voice symptoms and college professors home working conditions during online classes in times of COVID-19 pandemic. Rev Investig Innov Cienc Salud [Internet]. 2022;4(1):62-72. doi: https://doi.org/10.46634/riics.124

32. Cantor-Cutiva LC. Relationship Between Room Acoustics with Voice Symptoms and Voice-Related Quality of Life Among Colombian School and College Teachers During Online Classes in Times of COVID-19 Pandemic. J Voice [Internet]. 2024;38(5):1115-9. doi: https://doi.org/10.1016/j.jvoice.2022.03.008

33. Besser A, Lotem S, Zeigler-Hill V. Psychological stress and vocal symptoms among university professors in Israel: Implications of the shift to online synchronous teaching during the COVID-19 pandemic. J Voice [Internet]. 2022;36(2):291.e9-291.e16. doi: https://doi.org/10.1016/j.jvoice.2020.05.028

34. Van Puyvelde M, Neyt X, McGlone F, Pattyn N. Voice Stress Analysis: A New Framework for Voice and Effort in Human Performance. Front Psychol [Internet]. 2018;9. doi: https://doi.org/10.3389/fpsyg.2018.01994

35. Sondhi S, Khan M, Vijay R, Salhan AK, Chouhan S. Acoustic analysis of speech under stress. Int J Bioinform Res Appl [Internet]. 2015;11(5):417-32. doi: https://doi.org/10.1504/IJBRA.2015.071942

36. Van Lierde K, Van Heule S, De Ley S, Mertens E, Claeys S. Effect of psychological stress on female vocal quality. A multiparameter approach. Folia Phoniatr Logop [Internet]. 2009;61(2):105-11. doi: https://doi.org/10.1159/000209273

37. Kappen M, van der Donckt J, Vanhollebeke G, Allaert J, Degraeve V, Madhu N, et al. Acoustic speech features in social comparison: how stress impacts the way you sound. Sci Rep [Internet]. 2022;12(1):22022. doi: https://doi.org/10.1038/s41598-022-26375-9

38. Mongia PK, Sharma RK. Estimation and Statistical Analysis of Human Voice Parameters to Investigate the Influence of Psychological Stress and to Determine the Vocal Tract Transfer Function of an Individual. Journal of Computer Networks and Communications [Internet]. 2014;2014:290147. doi: https://doi.org/10.1155/2014/290147

39. Ferrand CT. Harmonics-to-noise ratio: an index of vocal aging. J Voice [Internet]. 2002;16(4):480-7. doi: https://doi.org/10.1016/S0892-1997(02)00123-6

40. Sliwinska-Kowalska M, Niebudek-Bogusz E, Fiszer M, Los-Spychalska T, Kotylo P, Sznurowska-Przygocka B, et al. The prevalence and risk factors for occupational voice disorders in teachers. Folia Phoniatr Logop [Internet]. 2006;58(2):85-101. doi: https://doi.org/10.1159/000089610

41. Sampieri RH, Collado CF, Lucio PB. Metodología de la investigación. 6th ed. México City: McGraw-Hill Education; 2014. 600 p.

42. Angelillo M, Di Maio G, Costa G, Angelillo N, Barillari U. Prevalence of occupational voice disorders in teachers. J Prev Med Hyg [Internet]. 2009;50(1):26-32. doi: https://doi.org/10.15167/2421-4248/jpmh2009.50.1.152

43. Chen SH, Chiang SC, Chung YM, Hsiao LC, Hsiao TY. Risk factors and effects of voice problems for teachers. J Voice [Internet]. 2010;24(2):183-92. doi: https://doi.org/10.1016/j.jvoice.2008.07.008

44. Elo AL, Leppänen A, Jahkola A. Validity of a single-item measure of stress symptoms. Scand J Work Environ Health [Internet]. 2003;29(6):444-51. doi: https://doi.org/10.5271/sjweh.752

45. Carrillo-González A. Caracterización de la relación sueño y estrés con el funcionamiento vocal en docentes universitarios [master's tesis]. Bogotá: Universidad Nacional de Colombia; 2020. 131 p. Available from: https://repositorio.unal.edu.co/handle/unal/79154

46. Rincón-Pinilla MP, Carrillo-González A, Cantor-Cutiva LC. Effect of Sleep Quality and Duration on Jitter, Shimmer, and Harmonics-to-Noise Ratio among Colombian University Professors. Rev Chil Fonoaudiol [Internet]. 2023;22(1):1-10. doi: https://doi.org/10.5354/0719-4692.2023.66884

47. Wilder L. 2 - Articulatory and Acoustic Characteristics of Speech Sounds. In: Massaro DW, editor. Understanding Language. An Information-Processing Analysis of Speech Perception, Reading, and Psycholinguistics [Internet]: New York: Academic Press; 1975. p. 31-76. doi: https://doi.org/10.1016/B978-0-12-478350-8.50007-6

48. Švec JG, Granqvist S. Tutorial and Guidelines on Measurement of Sound Pressure Level in Voice and Speech. J Speech Lang Hear Res [Internet]. 2018;61(3):441-61. doi: https://doi.org/10.1044/2017_JSLHR-S-17-0095

49. Brockmann-Bauser M, Beyer D, Bohlender JE. Clinical relevance of speaking voice intensity effects on acoustic jitter and shimmer in children between 5;0 and 9;11 years. Int J Pediatr Otorhinolaryngol [Internet]. 2014;78(12):2121-6. doi: https://doi.org/10.1016/j.ijporl.2014.09.020

50. Lathadevi HT, Guggarigoudar SP. Objective Acoustic Analysis and Comparison of Normal and Abnormal Voices. Journal of Clinical and Diagnostic Research. 2018;12(12):MC01-4. doi: https://doi.org/10.7860/JCDR/2018/36782.12310

51. Watts CR, Awan SN. Laryngeal Function and Voice Disorders. Basic Science to Clinical Practice. 1st ed. New York: Thieme; 2019. 302 p.

52. Brockmann M, Storck C, Carding PN, Drinnan MJ. Voice loudness and gender effects on jitter and shimmer in healthy adults. J Speech Lang Hear Res [Internet]. 2008;51(5):1152-60. doi: https://doi.org/10.1044/1092-4388(2008/06-0208)

53. Kirchhübel C, Howard DM, Stedmon AW. Acoustic Correlates of Speech when Under Stress: Research, Methods and Future Directions. IJSLL [Internet]. 2011;18(1):75-98. doi: https://doi.org/10.1558/ijsll.v18i1.75

54. Kappen M, Hoorelbeke K, Madhu N, Demuynck K, Vanderhasselt MA. Speech as an indicator for psychosocial stress: A network analytic approach. Beh Res Methods [Internet]. 2022;54(2):910-21. doi: https://doi.org/10.3758/s13428-021-01670-x

55. Soares MB, Mafra SCT, de Faria ER. Factors associated with perceived stress among professors at a federal public university. Rev Bras Med Trab [Internet]. 2019;17(1):90-8. doi: https://doi.org/10.5327/Z1679443520190280

56. Flaten MA, Al'absi M. Neuroscience of Pain, Stress, and Emotion. Psychological and Clinical Implications. Amsterdam: Elsevier; 2016. 312 p. doi: https://doi.org/10.1016/C2013-0-16065-5

57. Teixeira JP, Oliveira C, Lopes C. Vocal Acoustic Analysis – Jitter, Shimmer and HNR Parameters. Procedia Technology [Internet]. 2013;9:1112-22. doi: https://doi.org/10.1016/j.protcy.2013.12.124

58. Behlau M, Moreti F, Pecoraro G, Behlau M, Moreti F, Pecoraro G. Customized Vocal Conditioning for Singing Professional Voice Users – Case Report. Rev CEFAC [Internet]. 2014;16(5):1713-22. doi: https://doi.org/10.1590/1982-021620147113

59. Teixeira JP, Fernandes PO. Jitter, Shimmer and HNR Classification within Gender, Tones and Vowels in Healthy Voices. Procedia Technology [Internet]. 2014;16:1228-37. doi: https://doi.org/10.1016/j.protcy.2014.10.138

60. Boersma P. Accurate short-term analysis of the fundamental frequency and the harmonics-to-noise ratio of a sampled sound. Proceedings of the Institute of Phonetic Sciences [Internet]. 1993;(17):97-110. Available from: https://www.fon.hum.uva.nl/archive/1993/1993-ifaproc17-Boersma.pdf

61. Teixeira JP, Fernandes PO. Acoustic Analysis of Vocal Dysphonia. Procedia Computer Science [Internet]. 2015;64:466-73. doi: https://doi.org/10.1016/j.procs.2015.08.544

62. Higgins MB, Netsell R, Schulte L. Vowel-related differences in laryngeal articulatory and phonatory function. J Speech Lang Hear Res [Internet]. 1998;41(4):712-24. doi: https://doi.org/10.1044/jslhr.4104.712

63. Vertanen-Greis H, Löyttyniemi E, Uitti J, Putus T. The interaction between voice disorders and stress for work ability of teachers. Logoped Phoniatr Vocol [Internet]. 2022;49(1):11-6. doi: https://doi.org/10.1080/14015439.2022.2085787

64. Hunter EJ, Banks RE. Gender Differences in the Reporting of Vocal Fatigue in Teachers as Quantified by the Vocal Fatigue Index. Ann Otol Rhinol Laryngol [Internet]. 2017;126(12):813-8. doi: https://doi.org/10.1177/0003489417738788

Andrés Carrillo-González, Ángela Patricia Atará-Piraquive,
Maryluz Camargo-Mendoza,
Jeison Ramiro Hernández-Contreras,
Lady Catherine Cantor-Cutiva

Salud laboral de profesores universitarios colombianos: asociaciones entre estrés y parámetros acústicos de la voz

Colombian College Professors Work-Related Health: Associations Between Stress and Voice Acoustics Parameters

Revista de investigación e innovación en ciencias de la salud
vol. 7, no. 1, a333, 2025
Fundación Universitaria María Cano,
ISSN-E: 2665-2056

DOI: https://doi.org/10.46634/riics.333