https://doi.org/10.23925/2176-2724.2021v33i3p428-436

The intensity of vocal fatigue symptoms and acoustic parameters of teachers before and after vocal loading

Intensidade dos sintomas da fadiga vocal e parâmetros acústicos de professoras antes e após exposição vocal

Intensidade de los sintomas de fatiga vocal y parâmetros acústicos de las professoras antes y después de la carga vocal

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Abstract

Introduction: Vocal fatigue is a set of vocal symptoms manifested after prolonged and/or intense vocal use that is frequently observed in teachers. **Objective:** to describe and compare acoustic parameters and self-perception of vocal fatigue symptoms before and after a vocal exposure by the teacher in the occupational environment. **Methods**: 30 women, with an average of 40.37 years old, public school teachers, were submitted to the recording of acoustic parameters and self-perception evaluation of the intensity of vocal fatigue symptoms before and after vocal use in the classroom. The Advanced Mult-Dimensional Voice Programm (MDVP-Adv) was used to extract acoustic parameters. **Results**: only the SPI parameter of noise showed a significant decrease after vocal use (p=0.02). Symptoms of hoarseness,

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ADP: study design; methodology; data collection; critical review; guidance.
AFR, FFS: data collection; paper draft.
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Received: 06/08/2020
Accepted: 05/03/2021

vocal failures, sore/ burning throat, tiredness to maintain speech increased after occupational voice use. **Conclusion**: after occupational voice use, the SPI breathiness rate decreased and the vocal fatigue symptoms increased.

Keywords: Fatigue; Voice; Faculty; Dysphonia; Woman.

Resumo

Introdução: A fadiga vocal é um conjunto de sintomas vocais manifestados após o uso prolongado e/ou intenso da voz, algo amplamente observado em professores. **Objetivo:** descrever e comparar os parâmetros acústicos e de autopercepção dos sinais e sintomas da fadiga vocal antes e após a exposição vocal pelo professor no ambiente ocupacional. **Método:** 30 mulheres, com média de idade de 40,37 anos, professoras do ensino público que foram submetidas à extração dos parâmetros acústicos e autoavaliação da intensidade dos sintomas da fadiga vocal antes e depois do uso vocal em sala de aula. Foi utilizado o programa Advanced Mult-Dimensional Voice Programm (MDVP-Adv) na análise acústica. **Resultados:** apenas a medida de ruído (SPI) demostrou-se significante (p=0.02) nos parâmetros acústicos. Os sintomas de rouquidão, falhas na voz, ardência/ queimação na garganta, cansaço para manter a fala apresentaram aumento após o uso da voz ocupacional. **Conclusão**: houve diminuição da taxa de soprosidade (SPI) e aumento de alguns sintomas da fadiga vocal após o uso prolongado da voz no ambiente ocupacional por professoras.

Palavras-chave: Fadiga; Voz; Docentes; Disfonia; Mulheres.

Resumen

Introducción: La fatiga vocal es um conjunto de sintomas vocales que se manifiestan tras um uso vocal prolongado y /o intenso, ampliamente observado en los profesores.**Objetivo:** describir y comparar los parâmetros acústicos y la autopercepción de los sintomas de fatiga vocal antes y después de uma exposición vocal por parde del professor em el entorno ocupacional. **Métodos**: 30 mujeres, com um promedio de 40.37 años, los maestros de escuelas públicas fueron sometidos a extracción de parámetros acústicos y autopercépcion de la intensidad de los síntomas de fatiga vocal antes y después del uso vocal en el aula. Se utilizó el Advanced Mult-Dimensional Voice Programm (MDVP-Adv) para extraer los parâmetros acústicos. **Resultados**: el parâmetro de ruído SPI mostro uma disminución significativa después del uso vocal (p=0.02). Los sintomas de ronquera, fallas vocales, dolor de garganta/ ardor, cansancio para mantener el habla aumentaron después del uso de la voz ocupacional. **Conclusión**: después del uso ocupacional de la voz, el SPI disminuyó y los sintomas de fatiga vocal aumentaron.

Palabras clave: Fatiga; Voz; Docentes; Disfonía; Mujer.

Introduction

Voice, an indispensable instrument in the professional life of teachers[1], representing the basic tool for the development of work and reveals important information about the individual and its interference in one's life[2]. The teacher is one of the professions that use voice professionally, in which the risk for the development of vocal changes as a result of work is high[3,4], representing the most vulnerable group for the occurrence of dysphonia[5].

The lack of knowledge about vocal production and care can result in the improper use of voice in the occupational environment[6]. Associated with vocal ignorance, the work conditions (acoustics, noise competition, dust), and characteristics (long working hours, working time exposure to activity, multiple jobs) contribute to the performance of vocal abuse. The absence of favorable conditions for the adequate use of the voice can resonate on negative phonatory adjustments as a way to compensate for the unfavorable environment[2], such as speaking with strong intensity and with greater effort regarding the high level of environmental noise. This action can be considered a negative adjustment that can lead to an overload on the phonatory system, leaving it more susceptible to the

appearance of vocal changes[7], which can contribute to the loss of the ability to work[8].

The teacher's voice is a widely studied topic and it is discussed in the literature due to the large percentage of vocal complaints related to this category[9]. A study[10] demonstrated the presence of dysphonia among teachers, in which the mentioned symptoms varied according to the type, number, frequency, and reference period. The symptoms most frequently mentioned were hoarseness and vocal fatigue[10]. Women had a higher occurrence of vocal symptoms, as well as greater chances of developing vocal changes[11]. Carregosa et al[12] observed that women had greater complaints of vocal fatigue when applying the protocol of glottic function.

Vocal fatigue can be defined as the decline in vocal quality, breathing support, loss of voice control, kinesthetic and auditory tactile sensations, with a predominance of tiredness after prolonged use of voice[13]. The time taken for a vocally healthy individual to show symptoms of vocal fatigue varies between studies, however, Pellicani et al observed complaints of vocal fatigue and changes in acoustic parameters after 60 minutes of continuous speech test in habitual voice[14].

The appearance of symptoms of vocal fatigue can also be considered as a negative compensation due to the prolonged use of the voice[15,16], which can be a unique condition or a product of other voice disorders[17]. Regarding the manifestation of vocal fatigue related to gender, Chang and Karnell[18] reported that it occurs more quickly in women than in men.

Self-perceived protocols for vocal fatigue have been developed and validated to assess vocal fatigue[19-21]. These instruments analyze the frequency of the manifestation of its symptoms; however, they may not reveal the small changes in the intensity of these symptoms after a single moment of vocal exposure.

Studies that analyzed the behavior of the acoustic parameters of the voice observed an increase in the fundamental frequency (f0) after prolonged use of the voice[14, 22-24]. One hour of regular vocal use in women who are not voice professionals and without complaints of dysphonia revealed an increase in f0 and a decrease in NHR and SPI measurements[14].

It is believed that studying the acoustic behavior and the intensity of vocal fatigue symptoms in teachers will help us understand the possibilities of phonological adjustments of this professional class.

Thus, the present study aims to describe and compare the acoustic parameters and the self-reported intensity of the symptoms of vocal fatigue before and after exposure to the use of the voice.

Methods

This study was carried out following the Resolution MS / CNS / CNEP nº 196/96 from October 10, 1996, and it was approved by the Research Ethics Committee of the Universidade Federal de Sergipe, under the CAAE number 46774715.7.0000.5546 and carried out after the signature of the Informed Consent Form (ICF) by the participants. This is a cross-sectional, descriptive, quantitative, and analytical study.

Participation criteria

Thirty volunteer women teachers, aged between 23 and 50 years old, and who worked in the classroom of a public elementary and high school in the Brazilian Northeastern countryside, with or without complaints of vocal fatigue, participated in the study. Teachers who were absent from any of the evaluation stages, who had auditory, psychological, or neurological changes, confirmed diagnosis of laryngeal and vocal disorders, or who at the time of the evaluation had cold, had the flu or respiratory allergies, were excluded.

Teachers who reported not using their voice continuously for at least one hour (60 minutes) were not accepted to compose the sample. This period was used since studies involving prolonged use of voice observed an increase in phonatory effort and symptoms of vocal fatigue after one hour of vocal use[14]). Teachers who were readapted for other positions within educational institutions or whose sound record of the voice was classified as bad for a reliable acoustic analysis were also excluded, as in Titze et al[25].

To know the functional situation and the occupational environment in which voice is produced, it was decided to use questions from the Teacher's Vocal Production Condition protocol (CPV-p). In the present study, this instrument was used only to characterize the analyzed sample.

Teachers who agreed to participate in the study should attend on a scheduled date (Tuesday or Wednesday), in the morning, 20 minutes before

the start of classes so that records of vocal samples could be obtained before the beginning of vocal exposure and for completing the protocols.

After signing the Informed Consent Term (ICF), the teachers were submitted to an initial interview, in which information was verified for the real inclusion of participants in the research.

The capture of vocal samples and the application of the protocol of self-perception of symptoms of vocal fatigue were applied before and immediately after the class period.

Voice and speech samples were recorded in the teacher's work environment, in a room with monitored noise (less than or equal to 50dB), using a microphone (Arcano®) positioned 4cm away from the mouth, connected to the audio interface (M-Fast Audi®) and a Dell® notebook, using the SoundForge Audio Studio 10.0 software for recording purposes.

For the acoustic analysis, the sustained emission of the vowel /a/ in habitual frequency and intensity was used, in which the type of sound signal was analyzed[25]. Then, the acoustic parameters (Chart 1) of the fundamental frequency (f0), frequency disturbance, amplitude disturbance, and noise measurements were extracted using the Advanced Mult-Dimensional Voice Programm (MDVP-Adv) software, from Laboratório de Voz e Fala do Departamento de Oftalmologia, Otorrinolaringologia e Cirurgia de Cabeça e Pescoço da Universidade de São Paulo – Ribeirão Preto, carried out in a Dell® computer, Intel Core2 Duo processor. The initial and final portions of the sustained vowel were cut out so that the oscillating conditions did not interfere with the analysis.

Chart 1. Acoustic parameters evaluated before and after exposure to prolonged voice use.

Acoustic measures	Definitions
f0 (HZ)	Fundamental frequency
Fhi (HZ)	High emission frequency
Flo (HZ)	Low emission frequency
Frequency disturbance	
Vf0 (%)	Fo Variation
Jitt (%)	"Jitter" Percentage
Amplitude disturbance	
Vam (%)	Amplitude variation
Shim (%)	"Shimmer" Percentage
Noise Measurements	
NHR (n)	Harmonic-noise ratio
VTI (n)	Vocal turbulence rate
SPI (n)	Breathiness rate

*Based on Pellicani, Ricz and Aguiar-Ricz (2015)

For the analysis of self-perception of vocal signs and symptoms, the main signs and symptoms related to vocal fatigue described by Aguiar-Ricz and Pellicani[26] were used: hoarseness, breathiness, breaks in loudness, high pitch, low pitch, inefficient vocal projection, compensation with nasal resonance, reduced vocal intensity, laryngopharyngeal dryness, pain in the laryngopharyngeal region, difficulty while speaking, odynophonia, burning during phonation, odynophagia, pain/tension in the scapular and cervical girdle muscles, phonatory effort, need for laryngeal clearing/cleaning, tiredness to speak, pain in the musculature of the face, body fatigue.

Participants were instructed to rate each symptom they were experiencing at the exact moment of data collection. Each symptom was graded, with zero representing the absence of symptom manifestation, mild: from one to two, moderate: from three to seven, and intense: from eight to ten. This step was performed before and immediately after the period of vocal use in the classroom by the teacher.

The Screening Index for Voice Disorder (SIVD)[27] was used to identify teachers with a probable voice disorder. It is a reliable instrument used

as an indicator of predisposition to vocal disorders and it analyzes the presence of symptoms and their intensity. It is a validated instrument.

The SIVD[27] consists of 12 items (hoarseness, voice loss, breaking voice, low-pitched voice, phlegm, dry cough, cough with secretion, pain when speaking, pain when swallowing, secretion in the throat, dry throat, and strained speech) and it was used in the pre-occupational vocal use moment, where the participants should perform the markings according to the frequency "never", "rarely", "sometimes" or "always", where the last two correspond to one point each. The final score is obtained by adding "sometimes" and "always", which can vary from zero (0) to 12 points. The cut-off point that differentiates teachers with suggestive voice disorder is ≥ 5 points.

The tabulation was performed by creating a database in Excel for statistical analysis. The Shapiro-Wilk test was applied to verify the normality of the distribution, then the Wilcoxon test was applied to compare the data from before and after voice use in the work environment. The level of significance (p) for rejection of the null hypothesis, for all statistical tests, was always set at a value less than or equal to 0.05 (5%).

Results

Table 1 shows the characterization of the studied sample, according to evaluation items of the Condition of Vocal Production-Teacher protocol (CPV-p).

Table 1. Frequencies of the condition of vocal production-teacher (CPV-P) of the participating teachers.

CPV-P	Frequency (%)			
	Never	Rarely	Sometimes	Always
Noise at school	13.9	9.35	34.88	41.86
Presence of teacher meeting room	27.91	9.3	23.26	39.53
Stressfull work routine	9.3	11.63	58.14	20.93
Workgin also from home	9.3	4.65	27.91	58.14
Intense physical effort	16.28	25.58	44.19	13.95
Stressfull work environment	11.63	11.63	53.49	23.26
Work interference in health	23.26	16.28	48.84	11.63
Violence against the teacher	53.49	34.88	11.63	0
Yelling at work	9.3	16.28	62.79	11.63
Talking a lot at work	2.33	4.65	13.95	79.07
Preserves the voice when not in the presence of students	9.3	13.95	32.56	44.19
Received vocal guidance	32.56	23.26	27.91	16.28
Satisfaction regarding the voice	9.3	6.98	51.16	32.56
Missing work due to voice issues	69.77	18.6	11.63	0
Drinking water while using voice	2.33	18.6	25.58	53.49
Wakes up rested	6.98	20.93	41.86	30.23

The teachers were evaluated before and after a mean period of vocal use in the classroom of 150 minutes. Despite having established a minimum vocal use time of 60 minutes, the teachers had a minimum exposure of 120 minutes. The maximum was 240 minutes.

The Screening Index for Voice Disorder (SIVD) had an average of 4.96 symptoms, with a minimum of 0 and a maximum of 11.

The acoustic parameters Fo, Fhi, and Flo, as well as the frequency disturbances, amplitude disturbance, and noise measurements in the pre and post-prolonged use of the voice and its comparison, are available in Table 2. Only the noise measurement (SPI) showed a statistically significant difference (p = 0.02) after exposure to prolonged use of voice.

Table 2. Comparative analysis of acoustic parameters before and after vocal exposure.

Acoustic Variables	Pré				Pós				p-value
	Median	Std. Deviation	Min	Max	Median	Std. Deviation	Min	Max	
f0	180.35	20.66	130.09	207.52	183.98	19.05	144.73	210.87	0.53
Fhi	204.87	24.54	152.55	258.23	206.46	28.39	163.29	298.15	0.94
Flo	161.28	26.25	81.46	197.48	169.79	22.09	126.59	200.35	0.29
Vf0	3.13	5.61	0.873	30.4	1.92	0.89	0.66	4.79	0.50
Jitt	3.49	9.9	0.42	51.87	1.27	1	0.13	3.9	0.06
Vam	17.44	6.86	7.58	33.51	14.96	8.47	8.67	39.97	0.09
Shim	4.59	2.11	2.16	10.53	4.04	1.47	1.26	7.9	0.15
HNR	0.14	0.04	0.08	0.253	0.13	0.02	0.09	0.18	0.69
VTI	0.04	0.01	0.01	0.069	0.04	0.01	0.02	0.06	0.84
SPI	11.48	7.12	2.71	35.32	8.86	4.9	1.72	26.03	0.02*

Test: Wilcoxon ($p<0.05$).

Note: f0- fundamental frequency, Fhi- high emission frequency, Flo- low emission frequency, Vf0- f0 variation, Jitt – jitter percentage, Vam- amplitude variation, Shim- shimmer percentage, HNR- harmonic-noise ratio, VTI- vocal turbulence rate, SPI- breathiness rate.

The symptoms of vocal fatigue displayed changes after occupational vocal use for hoarseness ($p = 0.01$), breaking voice ($p = 0.05$), low-pitched voice ($p = 0.05$), burning and sore throat ($p = 0.02$), and strained speech ($p <0.0001$), as shown in Table 3.

Table 3. Comparative analysis of the symptoms of vocal fatigue before and after the class period with vocal use.

Self-perception variables	Time	Median	Std. Deviation	Min	Max	p-value
Hoarseness	Before	2.07	3.06	0	9	0.01*
	After	3.11	2.93	0	9	
Breathiness	Antes	2.48	2.56	0	7	0.2
	After	3.25	2.71	0	8	
Breaking voice	Antes	1.59	2.84	0	8	0.05*
	After	2.44	2.92	0	8	
High-pitched voice	Antes	0.55	2	0	8	0.4
	After	0.51	1.34	0	5	
Low-pitched voice	Antes	2.07	2.7	0	7	0.03*
	After	3.48	3.29	0	9	
Voice stuck in throat	Antes	2.03	3.04	0	9	0.2
	After	2.7	2.89	0	8	
Nasal voice	Antes	1.25	2.58	0	9	0.1
	After	1.77	2.62	0	9	
Weak voice	Antes	1.7	3.12	0	10	0.6
	After	1.81	2.67	0	9	
Dry Throat	Antes	2.14	2.78	0	9	0.07
	After	3.33	2.94	0	10	
Sore throat	Antes	1.4	2.56	0	9	0.3
	After	1.92	2.6	0	9	
Tiredness to start speaking	Antes	0.92	1.99	0	7	0.2
	After	1.33	2.33	0	8	
Pain when speaking	Antes	0.51	1.39	0	6	0.8
	After	0.85	1.74	0	6	
Sore / burning in the throat	Antes	0.59	1.75	0	7	0.02*
	After	1.55	1.96	0	7	

Self-perception variables	Time	Median	Std. Deviation	Min	Max	p-value
Pain when swallowing	Antes	0.59	1.84	0	8	0.1
	After	0.85	1.91	0	8	
Pain / tension in the shoulders and neck	Antes	3.48	3.05	0	9	0.7
	After	3.59	3.58	0	10	
Effort to speak	Antes	1.59	2.63	0	8	0.08
	After	2.14	2.76	0	9	
Cough / clearing throat	Antes	2.48	3.34	0	8	0.1
	After	2.96	3.09	0	10	
Strained speech	Antes	1.44	2.66	0	8	<0.0001
	After	3.03	3.49	0	9	

Test used: Wilcoxon ($p<0.05$).

Discussion

The research was carried out in the occupational environment, that is, in loco, before and after a period of vocal exposure by the teacher. The objective was to accompany the teacher in his work environment and in prolonged use of his voice, considering the self-assessment.

The acoustic parameters did not reveal major changes in voice behavior after occupational vocal exposure. It was expected to find a significant increase in fundamental frequency, as revealed in other studies of prolonged use of voice[14, 22-24], which many authors conditioned to the increase in the activity of the adductor muscles of the vocal folds[24]. The absolute numbers of vocal frequency measurements showed a not statistically significant increase.

The only acoustic measure that showed a reduction after vocal use was SPI. Studies indicate that this measure is considered a preceptor of breathiness and asthenia[28]. Pellicani, Ricz and Aguiar-Ricz[14] also observed a decrease in this measure and qualified it as a result of the increase in glottal adduction after prolonged use of the voice.

The decrease in SPI after using the voice in the occupational environment may suggest glottal adjustments such as increased glottic adduction. Perhaps, this slight change in laryngeal behavior is already enough to trigger the symptoms of vocal fatigue.

Also, the unsatisfactory conditions of the teachers' work environments are related to greater vocal illness[29]. Environmental aspects unfavorable to healthy vocal use were reported in the interview about the knowledge of the teachers' working conditions. Complaints of noise at school and talking a lot at work were mentioned by the teachers analyzed. Although the study did not aim at the correlation between the variables analyzed and the CPV-P, it is believed that these factors may be involved in the intensity of vocal fatigue symptoms.

Studies indicate the interference of auditory feedback in the control of vocal intensity and frequency[30]. Thus, there is a possibility that the increase in environmental noise leads to an increase in vocal intensity and, consequently, in the need for greater action by the laryngeal adductor musculature. Since teachers need to keep using the voice for a long time, the laryngeal behavior is adapted to the environment and, with this, it can have an impact on the increase in the symptoms of vocal fatigue.

The analysis of the results of the present study revealed an increase in the self-reported intensity of some symptoms of vocal fatigue after vocal exposure in the classroom. The teachers noticed an increased sensation of hoarseness, breaking voice, low-pitched voice, burning and sore throat, and strained voice.

These symptoms are similar to the ones observed in the voice disorder. Pellicani et al[31] suggest that the prolonged maintenance of vocal fatigue symptoms can trigger dysphonia and, consequently, voice disorder. The analysis of the frequency of the manifestation of the symptoms of the voice disorder was performed by the application of the ITDV, which was below the cut-off value for the studied sample.

Evaluations of vocal symptoms, using various instruments, are frequent in the teacher population. The symptoms analyzed by Araújo et al.[2] corroborate the present study since they observed reports of 69.1% in strained voice and 67.9% in hoarseness or

strained voice after the workday. Finally, the study by Simões and Latorre[7] showed a prevalence of hoarseness (54.1%), strained voice (51.4%), severe/acute variation (25.7%) and/or voice loss (18,9%), and pain when speaking (29.7%) and/or burning (25.7%) as some of the negative sensory symptoms perceived after prolonged use of the voice.

According to Pellicani, Ricz and Aguiar-Ricz[14] and Laukkanen[24], the use of the voice for a long time, especially by teachers, can result in the high frequency of complaints of tiredness and vocal fatigue, which in turn can result in dysphonia. Pellicani, Ricz and Aguiar- Ricz[14] observed a significant increase in phonatory effort after an hour-long reading test.

Self-assessment[20] proved to be effective in providing information on the characteristics and symptoms of vocal fatigue, as well as identifying individuals with and without vocal fatigue, using the Vocal Fatigue Index (VFI). This protocol has recently been translated and adapted into Brazilian Portuguese and it was also validated with new cut-off rates for the Brazilian population[19].

It is important to note that, due to the risks of the permanence of signs and symptoms of vocal fatigue and their aggravation after prolonged use of the voice, the participants in this study were referred to specialists after receiving feedback about their evaluation, providing free speech therapy service.

Verifying changes in vocal behavior after a period of vocal use is important to promote specific speech therapy actions regarding teachers. Thus, the present study showed that vocal use in the classroom for an average time of 150 minutes, until the first pause for an interval, can promote laryngeal adjustments measured by acoustic analysis and it can also increase the symptoms of vocal fatigue in teachers. For future research, it would be interesting to analyze the behavior of these variables regarding the days of the week, semester, and school year, to analyze longitudinally the behavior of vocal fatigue in teachers.

Conclusion

The assessment of vocal fatigue symptoms, after an average vocal exposure of 150 minutes, in public school teachers in the Brazilian Northeast countryside, revealed a decrease in breathiness rate (RLS) and an increase in the self-reported intensity of hoarseness, breaking voice, low-pitched voice, pain when speaking/sore throat, and strained voice symptoms.

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