Spectrographic voice measures, vocal complaints and occupational data of elementary school teachers

Medidas vocais espectrográficas, queixas vocais e dados ocupacionais de professoras do ensino fundamental

Mediciones espectrográficos de la voz, quejas vocales y datos ocupacionales en los maestros de educación básica

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Abstract

Introduction: DOccupational voice disorders in teachers are common and are associated with physical, social, environmental, organizational and psychological factors. **Objective:** To describe and correlate spectrographic voice measures, vocal complaints and occupational data of elementary school teachers. **Materials and methods:** Cross-sectional quantitative study in which 98 teachers, aged between 20 and 60 years old (mean 37.93 years) participated. The sustained vowel /a/ emission was collected and analyzed through spectrographic vocal analysis with narrowband and broadband and Real Time Spectrogram software by Kay Pentax®. Data were analyzed by ANOVA and Pearson tests, adopting a 5% significance level. **Results:** Teachers without vocal complaints displayed more regular traces in spectrographic narrowband filter, and it was observed a positive correlation between the length of professional experience and the presence of noise between the harmonics and the darkening of the trace at high frequencies and all over the spectrogram with narrowband filter. **Conclusion:** Teachers who had no vocal complaints showed a more defined spectrogram trace, also causing increase in noise between the harmonics and darkening of stroke at high frequencies and around spectrogram with increasing the time

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Conflict of interests: *No*
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Received: *26/05/2014;* **Accepted:** *10/02/2015*

of practice, suggesting that the spectrograph narrowband can be used as a complement to differentiate teachers with and without vocal complaints, and also to verify that work experience of teachers together with their idiosyncrasies and inappropriate working conditions for vocal health can lead to a disease that compromises voice quality.

Keywords: speech acoustics; teachers; occupational health; voice

Resumo

Introdução: *Distúrbios vocais ocupacionais são comuns em professores e estão associados a fatores físicos, sociais, ambientais, organizacionais e psicológicos.* ***Objetivo:*** *Descrever e correlacionar medidas vocais espectrográficas, queixas vocais e dados ocupacionais de professoras do ensino fundamental.* ***Material e método:*** *Estudo transversal de caráter quantitativo do qual participaram 98 professoras, com idades entre 20 e 60 anos (média 37,93 anos). Coletou-se a emissão sustentada da vogal /a/ submetida à análise vocal espectrográfica em filtro de banda estreita e de banda larga pelo programa Real Time Spectrogram da Kay Pentax®. Os dados foram analisados pelos testes ANOVA e Correlação de Pearson, adotando-se o nível de significância de 5%.* ***Resultados:*** *As professoras sem queixas vocais apresentaram traçado espectrográfico mais regular no filtro de banda estreita, havendo correlação positiva entre o tempo de atuação profissional e a presença de ruído entre os harmônicos e o escurecimento do traçado nas altas frequências e em todo espectrograma em filtro de banda estreita.* ***Conclusão:*** *As professoras que não apresentavam queixas vocais mostraram traçado espectrográfico mais definido, ocorrendo também aumento de ruído entre os harmônicos e escurecimento do traçado nas altas frequências e em todo espectrograma, conforme o aumento do tempo de atuação profissional, sugerindo que a espectrografia de banda estreita pode ser utilizada como análise complementar na diferenciação de docentes com e sem queixas vocais e que o tempo de atuação profissional do docente com suas idiossincrasias e sem as adequadas condições laborais de saúde vocal pode ocasionar a presença de distúrbio na qualidade vocal.*

Palavras chave: *acústica da fala; docentes; saúde do trabalhador; voz*

Resumen

Introducción*: Trastornos vocales son lesiones ocupacionales comunes en los profesores y se asocian con factores físicos, sociales, ambientales, de organización y psicológicos.* ***Objetivo:*** *Describir y correlacionar mediciones espectrográficas de la voz, quejas vocales y datos ocupacionales de profesoras de primaria.* ***Materiales y métodos:*** *Estudio analítico de corte transversal observacional de carácter cuantitativo en que participaron 98 profesoras de primario de edades comprendidas entre 20 y 60 años (media 37,93 años). Se recolectó la emisión de la vocal sostenida /a/ para someter a análisis espectrográfico de voz en banda estrecha y banda ancha por el programa Real Time Spectrogram de Kay Pentax®. Los datos fueron analizados por ANOVA y por el test de correlación de Pearson, con adopción de un nivel de significación del 5%.* ***Resultados:*** *Profesoras sin quejas voz presentaron un trazado espectrográfico más regular en el filtro de banda estrecha, también se observó una correlación positiva entre el tiempo de experiencia profesional y la presencia de ruido entre armónicos y el oscurecimiento del trazado en altas frecuencias y en todo el espectrograma con filtro de banda estrecha.* ***Conclusión:*** *Las profesoras que no tenían quejas vocales mostraron trazado espectrográfico más definido, y también hubo un aumento del ruido entre armónicos y el oscurecimiento de trazados en las frecuencias altas y en todo el espectrograma de acuerdo con el aumento del tiempo de experiencia, lo que sugiere que el espectrograma de banda estrecha puede ser utilizado como un complemento para diferenciar los profesores con y sin quejas de voz, y que el tiempo de experiencia del profesor, con sus idiosincrasias y sin las condiciones adecuadas de trabajo de salud vocal, puede dar lugar a la presencia de un trastorno que afecte la calidad de la voz.*

Palabras claves: *acústica del habla; docentes; salud laboral; voz.*

Introduction

Voice professionals constantly use their voices and are negatively impacted in work by voice changes. Among these professionals, one can highlight the teachers, whose occupation makes use of the spoken voice, and consequently, this leads the professional class to present a higher incidence of vocal disorders[1-3].

Vocal disorders are the most common occupational multifactorial changes among teachers and are usually associated with intense vocal demand, physical, social, environmental, organizational and psychological factors, and may be exacerbated by other factors such as neurological, syndromic or psychiatric diseases; problems related to general health: allergy, respiratory, gastric or metabolic disorders; hormonal dysfunctions; smoking and drinking, as well as hearing dysfunctions[2-5].

Surveys show that there is a prevalence of voice disorders in female teachers, indicating that women have a predisposition due to the anatomical configuration of the larynx, excess activities, close proximity of their fundamental frequency (F0) with children's and their predominance in the teaching profession[6,7].

Elementary school teachers present aggravating circumstances, as a result of children's age and personality at this school level, and this can make them more susceptible to stress and vocal competition due to classroom noises[6], which justifies the choice of assessing female elementary school teachers in this study.

In the teaching profession, dysphonia can bring a wide range of implications for quality of life and affect in different ways the professional performance, as the voice is a constitutive component of teacher's identity as a worker and causes impact on learners[8,9].

In speech therapy, there are different methods that can be used for voice assessment, among them, one can highlight the spectrogram analysis of speech, an objective and non-invasive process to extract defined patterns of voice signs, allowing greater accuracy in the diagnosis of vocal changes[7,10,11]. Despite the fact that the perceptive-auditory analysis is still considered prevailing and requires fewer resources to be executed, it is believed that research is needed to examine other evaluation methods that are scarce in Brazilian specialized literature, such as spectrogram analysis of speech.

From the spectrogram analysis, the specialist can infer aspects of the vocal tract during the emission. However, despite being an objective assessment, the spectrogram requires a visual-perceptual analysis, being influenced by the evaluator's experience[12].

A study that correlated spectrogram and perceptive-auditory data from dysphonic voices found correlations and complementarity between the two assessments[13]. Teachers' spectrogram analysis has been insufficiently studied in the national specialized literature, with only recent works finding changes after vocal program improvement[14,15], and there is a lack of research on teachers' spectrographic characteristics.

Thus, the present study aimed at describing and correlating voice spectrographic measurements with the presence of vocal complaints and occupational data from elementary school teachers.

Materials and methods

An analytic observational, cross-sectional study, of quantitative type, approved by the Ethics Committee of the authors' institution of origin 23081.016945/2010-76. The heads of educational institutions received the necessary clarifications regarding the research and were requested to read and sign the Institutional Authorization Form (IAF); participants were informed and invited to sign the Informed Consent Form (ICF), in compliance with the practice recommended in standard 466/12 of the National Research Ethics Commission. The study target population comprised elementary school teachers, living in the urban area of a city located in the inland of the state of Rio Grande do Sul.

In order to make the sample homogeneous, the city was divided into regions (Central, Central East, Midwest, East, West, North and South). Three lists were drawn up for each region, one for each education network (municipal, state or private). Schools were arranged in alphabetical order on the lists, from which one in two schools were excluded, characterizing the random selection method, remaining 77 schools at the end of this stage: 19 state, 31 municipal and 27 private. Shortly after, these schools were reassembled in a single list in ascending order, once again drawn randomly,

regardless of the education network and region, with 15 adhering to the TAI and composing the sample of schools participating in the survey (seven private, five state and three municipal).

The following criteria were established for the creation of teacher sample: elementary school teachers (1st to 9th grade); women; over 19 and below 60 years of age; adherence to the IC. Exclusion criteria were: clinical history of allergic crisis; respiratory, gastric or hormonal dysfunction resulting from pregnancy, premenstrual or menstrual period on the day of the assessments; case reports of neurological, metabolic, endocrine, syndromic and/or psychiatric diseases; case reports of structural pathologies or laryngeal dysfunction; smoking, and/or drinking; history of laryngeal surgery and/or head and neck surgery; no past or current speech language therapy and audiology and/or otorhinolaryngological treatment for voice; hearing disorders detected during the screening.

A questionnaire was applied to volunteer teachers to collect personal data such as age and gender, activities, general and vocal health, to select those that met all the previously specified criteria. The presence or absence of vocal complaints was also investigating, as subjects were requested to mark the corresponding field ("yes" or "no"). In addition, a hearing screening was performed with pure tone scanning, at frequencies of 500, 1000, 2000, 4000 Hz and 25 dB, only through the air, using audiometer *Amplivox*, model A260, 2011. This procedure was carried out in a quiet room at the school, with noise levels below 50dB, verified by the digital sound pressure meter Instrutherm, model DEC-480. Teachers who did not hear the pure tone at 25dB were retested, and those who failed the retest were excluded from the study and referred for a complete hearing evaluation.

At the end, 16 teachers were excluded due to case reports of endocrine disorders; 14 failed the hearing screening; seven that previously received speech language therapy or audiology or otorhinolaryngological treatment and three due to neurological diseases were also excluded; four due to smoking habits; three due to case reports of neurological disorders; one because of her age. 55 subjects were lost due to incomplete data in the questionnaire and eleven for being men. Thus, the study sample consisted of 98 teachers, aged between 20 and 57 years old (mean of 37.93 years).

Data collection comprised, besides personal and occupational data, general and vocal health, the vocal spectrographic evaluation. Teachers were requested to remain in the standing position and sustain the vowel /a/ at usual pitch and loudness levels, after a deep breath, for maximum phonation time, without making use of the expiratory reserve[7,10]. Each emission was collected three times, the attempt with the longest time was considered. A professional digital recorder Zoom model H4n was used, with quantization rate of 96 kHz and 16 bits, and recording input level set to 50%, coupled with a professional microphone Behringer ECM 8000 omnidirectional, with a ruler-flat frequency response from 15 Hz to 20 Hz. The recorder with the attached microphone was fixed to pedestal and placed at a distance of 4 cm and 90° angle to the subject's mouth, in a school room with ambient noise levels below 50 dB SPL (sound pressure level), measured through digital sound pressure level meter.

For spectrographic analysis, the edited version of the sustained vowel /a/ emission, excluding the vocal attack and end of the emission, was used to avoid the influence of natural periods of voice instability. The shortest maximum phonation time edited of all the teachers was four seconds, which is the standard time for the acoustic spectrographic analysis window.

The spectrography was performed in a narrowband filter of 1024 points (63,09Hz) and a broadband filter of 100 points (646Hz), with a 11 kHz and 16 bits sampling rate and a 5 kHz resolution, through the use of Real Time Spectrogram software (RTS) Kay Pentax®.

The parameters evaluated in the narrowband filter were: intensity of the trace line color (at high frequencies and in all the vocal spectrogram); presence of noise (between the harmonics, in all vocal spectrogram and at high frequencies); substitution of harmonics by noise (in all the vocal spectrogram and at high frequencies); definition of harmonics; trace regularity; number of harmonics and the presence of sub-harmonics. In broadband filter, the following parameters were evaluated: intensity of the trace line color of the formants (F) (1st formant - F1, 2nd formant - F2, 3rd formant - F3, 4th formant - F4, at high frequencies and in all the vocal spectrogram); presence of noise (in all the vocal spectrogram and at high frequencies); definition of F (F1, F2, F3 and F4) and trace regularity.

The spectrograms were individually analyzed by five speech therapists, using a 10 cm-ruler as a linear analog scale, in which the score could range from zero to ten, and where the most coherent option in relation to the spectrogram analysis should be marked7. The spectrograms were printed and arranged in random order, with repetition of approximately of 20% (for the reliability analysis performed by evaluators). The judges also received a standard "anchor spectrogram" of the emission, to guide their analysis, and were blinded to: research objectives, gender of participants, and replication of the emissions and assessments of other speech therapists, being informed only about the age group of the subjects.

The degree of intensity of the trace line color (of the F, the high frequencies and the entire spectrogram) ranged from black (intense), which corresponds to ten on the scale, to light gray (low intensity) that corresponded to zero. Noise appears in spectroscopy as a shaded, drizzled or dotted image; thus zero corresponded to the absence of noise and ten to total presence. The definition of F and harmonics was based on their visibility; therefore, sharp definition, demarcation and symmetry corresponded to ten and no visibility corresponded to zero. The trace regularity corresponded to ten when clear stability and continuity were displayed, and zero when maximally irregularity was observed. In the item "substitution of harmonics by noise", the score was zero when there was no substitution and ten to indicate a total substitution. For the number of harmonics, zero indicated absence and ten when the spectrographic image was completely filled by harmonics. Regarding the "presence of sub-harmonics" item, zero represented the absence and ten the presence of sub-harmonics in the entire spectrogram[7,16].

After spectrogram evaluation, statistical analysis was performed in order to verify intra and inter-evaluator reliability through the Kappa coefficient, considering the following ratings: between 0.8 and 1 almost perfect reliability; between 0.6 and 0.79, good; between 0.4 and 0.59, moderate; between 0.2 and 0.39, regular; between zero and 0.19, poor; between zero and -1 no reliability. The answers of the evaluation of three speech therapists displaying greater reliability were considered together (0.40), then the average for each parameter analyzed was calculated.

Data were statistically analyzed through ANOVA and Spearman correlation tests, adopting a 5% significance level.

Results

The average working day of the analyzed group of teachers was 6.98 hours per day, and they have been working in the teaching profession for approximately 12.57 years. Most of them presented vocal complaints (75.51%, n = 74).

Table 1 shows that the teachers without vocal complaints showed more regular spectrographic trace lines with narrowband filter.

TABLE 1 – association between vocal complaint and spectrogram analysis

			Vocal complaint	Average	Median	Standard Deviation	p-value
Broadband	Trace darkening (0 a 10)	First formant	AC	4,08	4,00	0,24	0,424
			PC	4,31	4,00	0,14	
		Second formant	AC	4,33	4,00	0,28	0,978
			PC	4,32	4,00	0,16	
		Third formant	AC	3,37	3,00	0,25	0,883
			PC	3,42	3,00	0,14	
		Fourth formant	AC	2,41	2,00	0,24	0,745
			PC	2,32	2,00	0,14	

Broadband	Trace darkening (0 a 10)	frequencies	PC	1,58	1,00	0,23	0,701
			AC	1,69	1,00	0,13	
		All over the vocal spectrogram	PC	4,25	4,00	0,20	0,473
			PQ	4,08	4,00	0,11	
	Presence of noise (0 a 10)	All over the vocal spectrogram	AC	3,79	3,00	0,17	0,814
			PC	3,74	4,00	0,10	
		At high frequencies	AC	4,04	4,00	0,19	0,162
			PC	3,73	4,00	0,10	
	Definition of formants (0 a 10)	First formant	AC	5,33	6,00	0,30	0,062
			PC	6,00	6,00	0,17	
		Second formant	AC	5,33	6,00	0,33	0,185
			PC	5,85	6,00	0,19	
		Third formant	AC	4,12	4,00	0,32	0,089
			PC	4,76	5,00	0,18	
		Fourth formant	AC	3,25	3,00	0,33	0,453
			PC	3,54	3,50	0,19	
	Trace regularity (0 a 10)		AC	5,37	5,00	0,21	0,086
			PC	5,80	6,00	0,12	
Narrow band	Trace darkening (0 a 10)	At high frequencies	AC	2,37	2,00	0,40	0,279
			PC	1,86	1,00	0,23	
		All over the vocal spectrogram	AC	4,83	5,00	0,28	0,270
			PC	4,47	4,00	0,16	
	Presence of noise (0 a 10)	Between harmonics	AC	2,75	2,00	0,33	0,957
			PC	2,73	3,00	0,18	
		All over the vocal spectrogram	AC	3,37	3,00	0,31	0,585
			PC	3,18	3,00	0,18	
		At high frequencies	AC	2,87	3,00	0,28	0,715
			PC	2,76	3,00	0,16	
	Substitution of harmonics by noise (0 a 10)	All over the vocal spectrogram	AC	1,96	2,00	0,16	0,114
			PC	2,26	2,00	0,09	
		At high frequencies	AC	2,37	2,00	0,19	0,155
			PC	2,70	3,00	0,11	
	Definition of harmonics (0 a 10)		AC	6,25	6,00	0,23	0,111
			PC	5,81	6,00	0,13	
	Trace regularity (0a 10)		AC	6,66	7,00	0,21	0,037*
			PC	6,14	6,00	0,12	
	Number of harmonics (0 a 10)		AC	5,33	5,00	0,35	0,359
			PC	5,09	5,00	0,20	
	Presence of sub-harmonics(0 a 10)		AC	1,08	1,00	0,20	0,119
			PC	0,72	0,00	0,11	

*Statistically significant values (p≤0.05) – ANOVA Test

Caption: AC=absence of complaints; PC=presence of complaints.

As can be seen in **Table 2**, as the length of professional experience increases, also the trace lines darkens at high frequencies and in all the spectrogram, as well as increases the presence of noise between the harmonics, with narrowband filter.

TABLE 2 – correlation between age, length of professional experience and daily voice use and results of the vocal spectrogram analysis

		Female		Age	Length of professional experience (years)	Daily voice use (hours)
Broad band	Trace darkening (0 a 10)	First formant	corr	0,064	0,047	0,116
			p-value	0,528	0,640	0,225
		Second formant	corr	0,016	0,024	0,086
			p-value	0,868	0,814	0,396
		Third formant	corr	-0,037	0,079	0,060
			p-value	0,714	0,434	0,551
		Fourth formant	corr	-0,020	0,025	0,103
			p-value	0,841	0,799	0,309
		At high frequencies	corr	0,109	0,122	0,010
			p-value	0,284	0,228	0,921
		All over the vocal spectrogram	corr	0,015	0,062	0,137
			p-value	0,880	0,539	0,176
	Presence of noise (0 a 10)	All over the vocal spectrogram	corr	-0,024	0,055	-0,026
			p-value	0,811	0,585	0,797
		At high frequencies	corr	-0,031	0,049	-0,132
			p-value	0,757	0,629	0,194
	Definition of formants (0 a 10)	First formant	corr	0,141	0,078	0,068
			p-value	0,165	0,440	0,501
		Second formant	corr	0,119	0,133	0,179
			p-value	0,241	0,191	0,076
		Third formant	corr	0,009	0,083	0,170
			p-value	0,928	0,415	0,093
		Fourth formant	corr	-0,032	-0,028	0,174
			p-value	0,751	0,780	0,085
	Trace regularity (0 a 10)		corr	0,031	0,073	0,104
			p-value	0,758	0,469	0,306
Narrow band	Trace darkening (0 a 10)	At high frequencies	corr	0,058	0,207	-0,008
			p-value	0,565	0,040*	0,933
		All over the vocal spectrogram	corr	0,089	0,213	0,032
			p-value	0,380	0,034*	0,750
	Presence of noise (0 a 10)	Between harmonics	corr	0,123	0,273	0,030
			p-value	0,224	0,006*	0,769
		In all the vocal spectrogram	corr	0,059	0,186	-0,008
			p-value	0,560	0,065	0,930
		At high frequencies	corr	-0,037	0,058	-0,115
			p-value	0,711	0,567	0,259

Banda Estreita	Substitution of harmonics by noise (0 a 10)	All over the vocal spectrogram	corr	-0,074	0,064	-0,054
			p-value	0,467	0,529	0,595
		At high frequencies	corr	-0,097	0,009	-0,050
			p-value	0,340	0,925	0,623
	Definition of harmonics (0 a 10)		corr	0,033	0,028	0,072
			p-value	0,724	0,784	0,479
	Trace regularity (0 a 10)		corr	0,062	0,105	0,014
			p-value	0,543	0,303	0,884
	Number of harmonics (0 a 10)		corr	0,091	0,176	0,148
			p-value	0,368	0,082	0,143
	Presence of sub-harmonics (0 a 10)		corr	0,192	0,237	0,045
			p-value	0,057	0,118	0,658

Statistically significant values (p≤0.05) – Spearman rank correlation Test

Caption: corr = coefficient of correlation

Discussion

The spectrogram analysis of speech proves to be useful as a tool for vocal assessment in speech therapy. It is considered noninvasive and details the sound signal generation process, providing an indirect estimation of vocal folds vibratory patterns and producing characteristics referring to the vocal tract shape and its modifications, also in the absence of laryngeal injuries[11,12,17].

Results show that teachers who do not have voice complaints present a greater regularity of spectrographic trace with the narrowband filter (Table 1), in comparison with teachers displaying voice complaints. These data suggest that individuals with vocal complaints may be developing voice disorders, resulting in a less defined spectrographic trace, in agreement with a survey that found that teachers with voice disorders present an increased frequency of changes in the spectrogram trace regularity. A research on the relationship between perceptive-auditory and spectrographic data showed correlation between the presence of dysphonia and hoarseness/roughness on perceptual analysis with spectrographic parameters of harmonics irregular trace[13].

Regarding the correlation between the professional and vocal characteristics, increases in noise between the harmonics, the darkening intensity of traces at high frequencies and the entire spectrogram with narrowband filter were observed as increased the length of professional experience (Table 2). In normal voices, increased darkening of traces at high frequencies and in all the spectrogram suggests greater sound pressure[13] and loudness, and an increase in the number of harmonics suggests a richer and more balanced vocal resonance[18,19].

However, increased darkening of the spectrographic traces can occur with an increase in the sound pressure, commonly found in teachers due to aggravating factors derived from the classroom environment and elementary school children's age profile and personality, also including the vocal competition in the classroom. With the presence of children, classrooms present high background noise, between 50 and 80 dB, generally exceeding the standard established by the American National Standard Institute (ANSI) [6,18,20,21]. Excessive noise leads teachers to raise loudness and pitch, reaching around [9,1] dB and a half octave above their vocal pattern, in order to, with this adjustment, supervise the students and explain the educational contents, showing that the increase in teachers' voice loudness is proportional to the increase in the classroom noise levels[8,20,21]. In contrast, the increase in voice loudness levels without knowledge of voice physiology and production and the use of inadequate respiratory support may lead to the emergence of dysphonia, caused by vocal hyperfunction[22,23].

High noise levels in the classroom, associated with a long teaching career, can generate increased sound pressure, loudness and vocal effort,

especially in professionals that have a great vocal demand and little or no knowledge of vocal health, as in the case of teachers, who are in contact with school noise on a daily basis[18,24]. Consequently, with the increase in vocal noise throughout the professional life the vocal quality may become worse, contributing to the prevalence of dysphonia among teachers[16].

Studies that correlated perceptive-auditory and spectrographic data found a relationship between the presence of noise in the harmonics and perceptive-auditory parameters of dysphonia, hoarseness, roughness and/or vocal instability[13,18]. Research with 88 teachers showed that 64.77% reported current or past vocal problems and, among the reported symptoms, the most frequent were hoarseness, vocal fatigue and dry throat[25]. In another survey, teachers frequently reported increased loudness, hoarseness and vocal tension[26]. It is believed that the elevated presence of noise in the harmonics proportionally to the time of work experience can affect various levels, generating vocal symptoms and influencing the acoustic perceptive-auditory characteristics, derived from physiological compensation in the vocal apparatus, which in this case are the hyperfunctional. Laryngeal hyperfunction that increases inasmuch as the professional experience increases may be responsible for air leakage during phonation, reducing loudness, elevating aperiodicity and instability during phonation, and may cause vocal fatigue symptoms.

After a two-month vocal improvement program with teachers, the spectrographic analysis was used to verify vocal changes emerging from the therapeutic process, with a higher amount and definition of harmonics, reduced noise between the harmonics and increased sound pressure observed by the darkening of the trace[14]. Another work[15] applied the vocal spectrographic acoustic analysis with glottal and perceptual-auditory source in teachers before and after the improvement program, and found frequency range extension, indicating greater use of this significant resource, besides the increase in the first vowels formants /i/ and /u/ after the intervention, which suggests improved articulatory adjustment. In other perceptive-auditory and acoustic parameters, there were no changes.

Results obtained in the aforementioned studies[14,15] show that if the teachers that took part in the survey obtained greater knowledge about vocal health and the professional voice use, applying vocal warming up and cooling down exercises since the beginning of the teaching career and having access to more suitable working conditions to perform teaching activities, voice changes found here would have not been verified. Thus, the scientific findings highlight the need to implement vocal health programs geared towards voice professionals, especially the teachers' class, seeking for optimization of vocal resources.

It is suggested to carry out studies using spectrographic analysis that takes into account women's endocrine stages, thus seeking to verify if the perimenopause and menopause transition period influences acoustic aspects.

Conclusions

Elementary school teachers evaluated who had no vocal complaints showed more defined spectrographic traces; an increase in noise between the harmonics and darkening of the trace at high frequencies and all over the spectrogram was observed in a direct relation to a longer professional career time, suggesting that the spectrograph narrowband can be used as a complement to differentiate teachers with and without vocal complaints, and also to verify that work experience of teachers together with their idiosyncrasies and inappropriate working conditions for vocal health can lead to a disease that compromises voice quality.

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