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Quality of life in voice, perceptual-auditory assessment and voice acoustic analysis of teachers with vocal complaints

Qualidade de vida em voz, avaliação perceptivoauditiva e análise acústica da voz de professoras com queixas vocais

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ABSTRACT

Purpose: Correlating the Voice-Related Quality of Life (VRQOL), perceptual-auditory and acoustic assessment of teachers with vocal complaints. **Methods:** The study included 74 teachers aged between 20 and 62 years (mean 38.75 years). Self-assessment of VRQOL, voice perceptual-auditory assessment, acoustic voice analysis of glottal and spectrographic source, in narrowband (NB) and wideband (WB) and relevant statistical analysis were carried out. **Results:** There was a negative correlation between VRQOL and fundamental frequency (f0), maximum f0 and standard deviation of f0; roughness and amplitude variation. There was a positive correlation between VRQOL and darkening of the tracing around the vocal spectrogram, definition and number of harmonics in NB; overall degree of vocal and soft phonation index, presence of noise at high frequencies in the WB; overall degree of vocal disorders, darkening the 1st formant and higher definition of the 2nd formant in WB; breathiness and percentage jitter, absolute jitter, relative average of perturbation, smoothed pitch perturbation quotient, pitch perturbation quotient, soft phonation index, presence of noise at high frequencies in WB, replacement of harmonics by noise at high frequencies and all spectrogram in NB. **Conclusion:** The lower the f0, the greater the darkening tracing spectrographic, definition and number of harmonics, the higher the VRQOL related to voice. The perceptual-auditory and acoustic analysis showed significant correlations for the presence of aperiodic energy and instability of vocal signal. The perceptual-auditory, acoustic and VRQOL assessments were complementary in vocal characterization of teachers.

Keywords: Voice disorders; Faculty; Voice quality; Quality of life; Voice

RESUMO

Objetivo: Correlacionar a qualidade de vida em voz (QVV), avaliação vocal perceptivoauditiva e acústica de professoras com queixas vocais. **Métodos:** Participaram do estudo 74 professoras com idades entre 20 e 62 anos (média 38,75 anos). Foram realizadas autoavaliação da QVV, avaliação vocal perceptivoauditiva, análise vocal acústica de fonte glótica e espectrográfica, em banda estreita (EBE) e banda larga (EBL) e análise estatística pertinente. **Resultados:** Houve correlação negativa entre QVV e frequência fundamental (f0), f0 máxima e desvio padrão da f0; rugosidade e variação da amplitude. Ocorreu correlação positiva entre QVV e escurecimento do traçado em todo o espectrograma vocal, definição e número de harmônicos em EBE; grau geral de alteração vocal e índice de fonação suave, presença de ruído nas altas frequências na EBL; grau geral de alteração vocal, escurecimento do 1º formante e maior definição do 2º formante na EBL; soprosidade e *jitter* percentual, *jitter* absoluto, média relativa da perturbação, quociente de perturbação do *pitch* suavizado, quociente de perturbação do *pitch,* índice de fonação suave, presença de ruído nas altas frequências em EBL, substituição de harmônicos por ruído nas altas frequências e em todo espectrograma em EBE. **Conclusão:** Quanto menor a f0, maior o escurecimento do traçado espectrográfico, definição e número de harmônicos, maior a QVV relacionada à voz. As análises perceptivoauditiva e acústicas mostraram correlações importantes quanto à presença de energia aperiódica e instabilidade do sinal vocal. As avaliações acústica, perceptivoauditiva e de QVV relacionada à voz foram complementares na caracterização vocal das docentes.

Descritores: Distúrbios da voz; Docentes; Qualidade da voz; Qualidade de vida; Voz

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INTRODUCTION

The voice is an aspect that reveals the socio-emotional information of the individual, and is considered very important in human and professional relationships[1]. When it is related to the profession, the voice becomes even more important, since it is as a main element of work for part of the workforce of voice professionals. The best known representative of this class is the teacher[2].

The most common vocal complaints in teachers are aphonia, loss of voice, vocal tiredness and fatigue, dry throat, hoarseness, pain in the neck region, throat clearing and variation in vocal production. The most commonly found features in dysphonic individuals are muffled voice and no projection, speak for too long without rest, altered breathing pattern, cervical muscles hypertension, pitch change, becoming higher, suddenly, at the cry, and may be associated with anxiety and stress and other general health problems[2-4].

The activity carried out by teachers is considered risky when associated with unfavorable external and internal factors. Among the internal, they have been incorrect uses vocal and emotional factors and as external factors, the environmental can be cited, including working conditions. All these factors can cause vocal disorders to the teacher and also interfere with its quality of life[2,5].

Whereas the complaints and vocal disorders are often observed and pointed out by teachers, perceptual-auditory and acoustic assessments are required in order to detect changes, and application protocols structured to measure the impact of a vocal disorder in daily activities based on the vocal self-perception[6]. Among these, the Voice-Related Quality of Life Protocol (VRQOL) is one of the most widely used[7].

The perceptual-auditory assessment is considered the gold standard of vocal evaluation because characterizes the voice quality and quantifies its deviations and may be associated with the vocal tract physiology of the individual, however, it is also considered subjective, depending on the evaluator's experience[8,9]. Complementary to perceptual-auditory assessment and considered objective and non-invasive, it has been evaluating the acoustic voice parameters, useful for accurate diagnosis of voice disorders[10,11].

Given the above, this study aimed to correlate the voice-related quality of life, perceptual-auditory assessment and acoustic analysis of teachers voice with vocal complaints.

METHODS

Observational cross-sectional, analytical and quantitative study, carried out according to standard 466/12 of the National Research Ethics Commission, and approved by the Ethics Committee of *Universidade Federal de Santa Maria* (UFSM) under the Protocol 23081.016945/2010-76. The heads of educational institutions and participants were informed and signed the Institutional Authorization Form (IAF) and the Informed Consent (IC), respectively.

To select the sample, schools in the urban area of the municipality of *Rio Grande do Sul* were listed and numbered alphabetically. The list was randomized, setting up a new list by lot, from which a school was excluded every other. Schools that made up the final list, 15 have joined the IAF. Female teachers from primary schools were included, only the urban area, with the presence of vocal complaints, aged over 19 and less than 65 years and joined the IC.

Subjects were excluded that in the interview reported neurological, metabolic, endocrine, syndromes and/or psychiatric diseases; structural pathologies or laryngeal disorders; smoking habit or alcohol abuse; history of laryngeal surgery; phonological and/or otorhinolaryngological treatment for voice; allergic, respiratory or gastric crises, or hormonal dysfunction resulting from pregnancy or menstruation on the assessment day; hearing disorders detected in hearing screening.

To apply the sample selection criteria, subjects answered an interview protocol and underwent hearing screening only by airway, by scanning the pure tones in speech frequencies to 25 dB, with audiometer Amplivox® model A260/2011. The screening was held in a room with noise levels below 50 dB, measured by the sound pressure meter Instrutherm® model Dec-480. The subjects who failed the screening were retested and cases that failed again were excluded from the study and referred for full hearing evaluation.

Sixteen teachers were excluded in the interview by reports of endocrine disorders; 14 ones did not pass the hearing screening; seven have done speech therapy and/or otorhinolaryngological treatment for voice; four by smoking and three reports of neurological pathologies. Forty-seven subjects were lost by incomplete data; 40 for not having vocal complaints and three for being male. At the end, the sample consisted of 74 female teachers aged between 20 and 62 years (mean age: 38 years and 9 months), who passed for data collection made by the self-assessment of voice-related quality of life, auditory-perceptual voice assessment, acoustic analysis of glottal and spectrographic source of the voice.

All emissions were captured in quiet place inside the school, with ambient noise below 50 dB, measured by a level meter digital sound pressure, with teachers in the standing position.

For the acoustic analysis, the emission of the sustained vowel /a/ in habitual pitch and loudness was collected following a deep breath in maximum phonation time without using the expiratory reserve and, as standard, we used the less time of the vowel /a/ edited among all subjects, excluding the vocal attack and the end of the emission, resulting in a four-second analysis window.

For the perceptual-auditory voice analysis, as well as vowel /a:/ spontaneous speech were collected through the question, *"Tell me about the importance of voice for your profession"*, and standard phrases Consensus auditory-perceptual evaluation of voice (CAPE-V)[12], which should be carried out in speech rate, habitual pitch and loudness. The timestamp of spontaneous speech situation was not controlled. We used the visual-analogue CAPE-V protocol, allowing quantitative analysis[12].

All emissions were captured by professional digital recorder Zoom H4n, with quantization rate of 96 kHz and 96 kHz and 16-bits recording in 50% of the input level. The recorder was placed at an angle of 90° from the mouth of the subject, coupled with a professional microphone BEHRINGER® ECM 8000, with flat frequency capture range of 15-20 kHz, at a distance of four centimeters of the mouth, to emission vowels, and ten centimeters to the emission of phrases and spontaneous speech.

For the acoustic analysis of glottal source, Multi Dimension Voice Program Advanced software (MDVPA) Kay Pentax® with 44 kHz and 16-bits sampling rate was used. We opted for the analysis of measurements in group, seeking greater reliability of the data being analyzed: (1) frequency measurements: fundamental frequency (f0); maximum f0 (fhi); minimum f0 (flo); standard deviation of f0 (STD); (2) perturbation measurements of f0 at a short-term: relative average perturbation (RAP); percentage jitter (Jitt); absolute jitter (Jita); smoothed pitch perturbation quotient (sPPQ); pitch perturbation quotient (PPQ); coefficient of variation of f0 (vf0); amplitude perturbation measurement at a short-term: shimmer in dB (SHDB); shimmer percentage (Shim); coefficient of variation of amplitude (vAm); amplitude perturbation quotient (APQ); smoothed coefficient of variation of amplitude (sAPQ); (4) measures of noise: noise-harmonic ratio (NHR); smooth phonation index (SPI); voice turbulence index (VTI); (5) voice breaking steps: number of voice breaks (NVB); degree of voice breaks (DVB); (6) measures unvoiced segment: degree of unvoiced segment (DUV); number of unvoiced segment (NUV); (7) measures of sub-harmonic segments: numbers of sub-harmonic segments (NSH); degree of sub-harmonic components (DSH).

The spectrographic acoustic voice analysis was held in wideband filter (100 points - 646 Hz) and narrowband (1024 points - 63.09 Hz) with a sampling rate of 11 kHz and 16 bits in 5 kHz resolution, through the Real Time Spectrogram program (RTS) of Kay Pentax®. In espectrogram of wideband (WB), were evaluated: degree of darkening of the formants tracing (F) (1 formant = F1, F2 = Formant 2nd, 3rd Formant = F3, F4 = 4 Formant), high frequency and all the vocal spectrogram; presence of noise (around vocal spectrogram and at high frequencies); definition of F (F1, F2, F3 and F4), and regularity of the tracing. In espectrogram of narrowband (NB), the parameters were considered: degree of tracing darkening (high frequency and all vocal spectrogram); presence of noise (from the harmonics in all vocal spectrogram and at high frequencies); replacement noise harmonic (in all vocal spectrogram and at high frequencies); definition of harmonics; regularity of tracing; number of harmonics and the presence of sub-harmonics.

Voice samples and espectrogram without identification of the subject, in random order and with repetition of about 20% (for assessors reliability analysis), were sent separately for ten judges (five for each analysis) they were not study authors, with at least five years of experience. They also received espectrogram anchor in wideband and narrowband, considered normal, to guide their judgments[13,14].

The judges were blinded to the study objectives, the gender of the subjects, the replication of emissions and assessments carried out by other speech therapists, only on the average age of the subjects was informed them.

The voice samples were recorded on Digital Versatile Disc (DVD) 52x, 7 GB, with PCM audio format; 96 kHz; 16 bits; mono and converted to waveform extension. In the DVD, each folder correspond to samples of a subject. The judges were asked to listen to the voices many times as necessary, in a quiet ambient and with the computer in the settings: 16-bits, 96 kHz, making the evaluation in accordance with the CAPE-V protocol[12]. The loudness parameter has not been evaluated.

Then, statistical analysis was performed to verify the inter- and intra-evaluator reliability in spectrographic perceptual-auditory and acoustic analysis, using the Kappa coefficient. The ratings of the three speech therapists with greater intra-evaluator reliability were considered together, determining the predominant results in each CAPE-V parameter to the voice of each subject and each aspect of the analysis of espectrograms.

To check the voice-related quality of life, the teachers responded to the protocol "Voice-Related Quality of Life (VRQOL)"[7,15,16], composed of ten items covering two areas: the physical functionality and socio-emotional. They should answer it on a scale from 1 to 5, the frequency at which particular event occurred, where 1 was equivalent to "it never happens and it is not a problem" and 5 "it always really happens and it is a bad problem." The protocol provides a total score ranging from 0 to 100 (from the worst to the best quality of life) and a score for each area[5,15,16].

Data were statistically analyzed using the Pearson's correlation non-parametric test, adopting the significance level of 5%.

RESULTS

The higher the quality of life score in the social-emotional area, the lower the values of acoustic analysis of glottal source for f0, fhi and STD were and the greater the spectrographic values in narrowband filter to intensity of the tracing darkening in all vocal spectrogram, definition and harmonic number (Table 1).

There was no correlation between perceptual-auditory analysis and voice-related quality of life (Table 2).

There was a positive correlation between overall grade and the acoustic measurement of SPI noise, the darkening of the F1 spectrographic tracing, the presence of noise in the high frequency, and the definition of the first and second formants, in wideband filter. The roughness correlated positively with the measure of SPI noise, with the NHS sub-harmonic segments

Table 1. Correlation between acoustic analysis and voice-related quality of life of teachers with vocal complaints

Measurements				VRQOL		
				Socio-emotional	Physical	Total
MDVPA	Frequency	f0 (HZ)	Corr	-0.254	-0.126	-0.133
			p-value	0.028*	0.283	0.258
		fhi (Hz)	Corr	-0.327	-0.164	-0.181
			p-value	0.004*	0.161	0.121
		flo (Hz)	Corr	-0.077	-0.061	-0.015
			p-value	0.511	0.605	0.896
		STD (Hz)	Corr	-0.230	-0.098	-0.156
			p-value	0.048*	0.405	0.182
	Perturbation frequency	Jita (ms)	Corr	-0.097	-0.003	-0.064
			p-value	0.407	0.976	0.583
		Jitt (%)	Corr	-0.124	-0.027	-0.092
			p-value	0.290	0.818	0.435
		RAP (%)	Corr	-0.124	-0.030	-0.095
			p-value	0.289	0.797	0.417
		PPQ (%)	Corr	-0.151	-0.031	-0.102
			p-value	0.198	0.791	0.383
		sPPQ (%)	Corr	-0.160	-0.045	-0.118
			p-value	0.171	0.191	0.315
		vf0 (%)	Corr	-0.186	-0.067	-0.127
			p-value	0.111	0.566	0.278
	Perturbation amplitude	ShdB (dB)	Corr	-0.025	0.003	-0.026
			p-value	0.827	0.979	0.821
		Shim (%)	Corr	0.029	0.052	0.021
			p-value	0.805	0.654	0.852
		APQ (%)	Corr	0.015	0.034	0.005
			p-value	0.897	0.773	0.961
		sAPQ (%)	Corr	0.035	0.113	0.084
			p-value	0.764	0.333	0.472
		vAm (%)	Corr	-0.093	0.027	0.053
			p-value	0.428	0.818	0.650
	Noise	NHR	Corr	0.024	-0.050	-0.117
			p-value	0.832	0.666	0.318
		VTI	Corr	-0.045	-0.068	-0.108
			p-value	0.701	0.564	0.358
		SPI	Corr	-0.212	-0.117	0.113
			p-value	0.068	0.320	0.333
	Voice break	DVB (%)	Corr	0.070	0.166	0.160
			p-value	0.552	0.156	0.170
		NVB	Corr	0.070	0.166	0.160
			p-value	0.552	0.156	0.170
	Subharmonic segments	DSH (%)	Corr	0.025	0.062	0.023
			p-value	0.827	0.598	0.842
		NSH	Corr	0.006	-0.014	-0.059
			p-value	0.956	0.904	0.616
	Voiceless or unvoiced segments	DUV (%)	Corr	0.068	0.006	-0.037
			p-value	0.562	0.953	0.748
		NUV	Corr	0.005	-0.006	-0.042
			p-value	0.961	0.957	0.717

Table 1. Correlation between acoustic analysis and voice-related quality of life of teachers with vocal complaints (cont.)

Measurements				VRQOL		
				Socio-emotional	Physical	Total
Wide-band	Darkening of graph (0 to 10)	F1	Corr	0.182	0.159	0.147
			p-value	0.120	0.174	0.209
		F2	Corr	0.183	0.085	0.072
			p-value	0.118	0.466	0.537
		F3	Corr	0.178	0.121	0.153
			p-value	0.127	0.301	0.192
		F4	Corr	0.053	0.120	0.157
			p-value	0.650	0.308	0.181
		At high frequencies	Corr	0.019	0.023	0.059
			p-value	0.867	0.839	0.616
		Entire spectrogram	Corr	0.107	0.086	0.086
			p-value	0.362	0.465	0.461
	Presence of noise (0 to 10)	Entire spectrogram	Corr	0.225	0.098	0.075
			p-value	0.052	0.401	0.524
		At high frequencies	Corr	0.154	0.145	0.106
			p-value	0.189	0.216	0.365
	Definition F (0 to 10)	F1	Corr	0.153	0.045	0.061
			p-value	0.191	0.698	0.600
		F2	Corr	0.224	0.054	0.070
			p-value	0.054	0.642	0.553
		F3	Corr	0.129	0.050	0.087
			p-value	0.271	0.667	0.458
		F4	Corr	0.056	0.020	0.070
			p-value	0.631	0.864	0.551
	Graph uniformity (0 to 10)		Corr	0.119	-0.002	0.012
			p-value	0.309	0.986	0.914
Narrow-band	Darkening of the graph (0 to 10)	At high frequencies	Corr	0.217	0.156	0.152
			p-value	0.062	0.182	0.195
		Entire spectrogram	Corr	0.270	0.103	0.152
			p-value	0.019*	0.380	0.195
	Presence of noise (0 to 10)	In between harmonics	Corr	0.178	0.125	0.078
			p-value	0.127	0.285	0.506
		Entire spectrogram	Corr	0.147	0.070	0.033
			p-value	0.211	0.552	0.778
		At high frequencies	Corr	0.119	0.103	0.091
			p-value	0.308	0.379	0.437
	Substitution of harmonics for noise (0 to10)	Entire spectrogram	Corr	0.055	0.104	0.034
			p-value	0.638	0.375	0.770
		At high frequencies	Corr	0.055	0.065	0.021
			p-value	0.640	0.580	0.857
	Harmonic definition (0 to 10)		Corr	0.250	0.090	0.114
			p-value	0.031*	0.443	0.330
	Graph uniformity (0 to 10)		Corr	0.195	0.103	0.096
			p-value	0.095	0.379	0.084
	Number of harmonics (0 to 10)		Corr	0.317	0.179	0.202
			p-value	0.005*	0.128	0.084
	Presence of sub-harmonics (0 to 10)		Corr	0.065	-0.045	-0.056
			p-value	0.580	0.702	0.629

*Significant values ($p \leq 0.05$) – Pearson's correlation test

Note: Corr = correlation; MDVPA = Multi Dimension Voice Program Advanced; RTS = Real Time Spectrogram; VRQOL = Voice-Related Quality of Life; F = formant; f0 = fundamental frequency; fhi = maximum f0; flo = lowest f0; STD = Standard Deviation of Fundamental Frequency; RAP = Relative Average Perturbation; Jitt = Jitter Percentages; Jita = Absolute Jitter; sPPQ = Smoothed Pitch Perturbation Quotient; PPQ = Pitch Perturbation Quotient; vf0 = Fundamental Frequency Coefficient Variation; ShdB = Shimmer in dB; Shim = Shimmer Percentage; vAm = Peak Amplitude Variation; APQ = Amplitude Perturbation Quotient; sAPQ = Smoothed Amplitude Perturbation Quotient; NHR = Noise-Harmonic Ratio; SPI = Soft Phonation Index; VTI = Voice Turbulation Index; NVB = Number of Voice Breaks; DVB = Degree of Voice Break; DUV = Degree of Unvoiced Segments; NUV = Number of Unvoiced Segments; NSH = Number of Sub-harmonics; DSH = Degree of Sub-harmonic Components

Table 2. Correlation between perceptual-auditory assessment and voice-related quality of life of teachers with vocal complaints

Measurements			VRQOL		
			Socio-emotional	Physical	Total
CAPE-V	General degree	Corr	0.001	-0.140	-0.176
		p-value	0.988	0.234	0.133
	Roughness	Corr	0.104	-0.105	-0.137
		p-value	0.375	0.371	0.243
	Breathiness	Corr	-0.036	-0.176	-0.221
		p-value	0.756	0.133	0.057
	Tension	Corr	0.112	0.017	-0.014
		p-value	0.338	0.881	0.902
	Pitch	Corr	-0.131	-0.056	-0.042
		p-value	0.264	0.634	0.716

*Significant values (p≤0.05) – Pearson's correlation test
Note: VRQOL = Voice-Related Quality of Life; corr = correlation; CAPE-V = Consensus Auditory-Perceptual Evaluation of Voice

and the darkening and defining of the first formant tracing, and negatively correlated with the amplitude perturbation measurement vAm. Breathiness was positively correlated with perturbation measurements of jita, jitt, RAP, PPQ and sPPQ frequency, with the measure of SPI noise, with the presence of noise in the high frequency in wideband filter, and with the replacement of harmonics by noise at high frequencies and throughout spectrogram in narrowband filter. There was a positive correlation between stress and perturbation measurement of jita, jitt and RAP (p=0.046) frequency, presence of noise in the high frequency in wideband filter, and the presence of noise among the harmonics in narrowband filter (Table 3).

DISCUSSION

In the present study, it was observed that the higher the quality of life score in the social-emotional area is, the lower the values of glottal source of acoustic analysis for most frequency measures (f0, fhi and STD) (Table 1). The greater the STD and fhi measures are, greater variability of f0 and phonation instability is, which may result from changes mucosal vibration and/or lack of neuromuscular and/ or respiratory control, suggesting that the higher phonation stability is, the higher also the teachers' quality of life in social-emotional aspect[1,17,18]. Further, emotional stress situations may increase the variability of f0[17].

The higher quality of life scores in the social-emotional area also show correlation with lower values of f0 in teachers with vocal complaints analyzed. This may indicate that those which maintain lower f0, show greater quality of life in voice. The higher habitual f0 is, the greater the muscle tension and overload on the larynx is, it can generate the negative symptoms to speech and prejudice the communication[17].

The scores of the social-emotional area still had higher, the higher the darkening of the tracing in all vocal spectrogram, the definition of harmonics and the number of harmonics in NB (Table 1). The degree of darkening of the spectrographic tracing is related to sound pressure[17,18]. Considering that teachers need to exert control over the class and transfer the contents of the classes, it is believed that those who have some knowledge of vocal production and respiratory support and speak in strong loudness with the appropriate adjustments, present a higher quality of life in voice[3,19].

The definition of harmonics is related to its demarcation and symmetry and increased harmonic structure may result both of its production by the glottal source, favored by the intense mobilization of the mucosa, as its amplification by the vocal tract[18,20]. The richer and more defined the number set of harmonics is, better voice quality and the glottal closure is, conditions that enhance the resonance and facilitate vocal projection, generating a better quality of voice, which may have been reflected in higher scores of social-emotional area (Table 1)[18].

In this study, there was no significant correlation between the results of perceptual-auditory voice analysis and quality of life related to voice (Table 2). These data support the findings of other studies, which showed a complex and indirect relationship between actual vocal problems and the perception of the subjects, since the impact of dysphonia on quality of life depends on the individual characteristics and styles, by making them not to correlate with the severity or prognosis of voice disorder[3,21].

There was a positive correlation between the overall degree of voice alteration with SPI measure and the presence of noise at high frequencies in the WB, and expected that the greater the presence of aperiodic energy in the voice signal is, the higher the level of change is perceived[22] (Table 3). SPI analyzes the lack of high-frequency harmonic components, which may suggest, also, glottal closure changes with presence of breathiness. The lack, decreased, or replacement of high frequency

Table 3. Correlation between perceptual-auditory assessment and voice acoustic analysis of teachers with vocal complaints

Measurements				CAPE-V				
				General degree	Roughness	Breathness	Tension	Pitch
MDVPA	Frequency	f0 (HZ)	Corr	-0.063	-0.221	-0.089	-0.204	0.073
			p-value	0.590	0.058	0.446	0.080	0.531
		fhi (Hz)	Corr	0.001	-0.154	0.007	-0.116	0.193
			p-value	0.992	0.187	0.947	0.323	0.099
		flo (Hz)	Corr	0.022	-0.116	-0.088	-0.133	0.048
			p-value	0.852	0.321	0.453	0.256	0.683
		STD (Hz)	Corr	0.072	0.044	0.191	0.199	0.170
			p-value	0.539	0.704	0.102	0.087	0.146
	Perturbation frequency	Jita (ms)	Corr	0.155	0.181	0.248	0.241	0.069
			p-value	0.186	0.122	0.033*	0.038*	0.555
		Jitt (%)	Corr	0.183	0.185	0.272	0.230	0.096
			p-value	0.118	0.112	0.018*	0.048*	0.412
		RAP (%)	Corr	0.172	0.179	0.263	0.232	0.098
			p-value	0.141	0.126	0.023*	0.046*	0.402
		PPQ (%)	Corr	0.156	0.161	0.258	0.190	0.105
			p-value	0.181	0.170	0.025*	0.103	0.419
		sPPQ (%)	Corr	0.157	0.153	0.284	0.279	0.162
			p-value	0.179	0.191	0.013*	0.105	0.167
		vf0 (%)	Corr	0.080	0.048	0.182	0.219	0.194
			p-value	0.495	0.678	0.118	0.060	0.097
	Perturbation amplitude	ShdB (dB)	Corr	0.029	0.072	0.172	0.066	0.032
			p-value	0.802	0.541	0.142	0.572	0.781
		Shim (%)	Corr	0.032	0.055	0.187	0.078	0.011
			p-value	0.785	0.639	0.109	0.505	0.925
		APQ (%)	Corr	0.022	0.025	0.199	0.078	0.024
			p-value	0.847	0.828	0.087	0.506	0.836
		sAPQ (%)	Corr	0.008	-0.0445	0.168	0.131	0.067
			p-value	0.941	0.703	0.150	0.262	0.566
		vAm (%)	Corr	-0.191	-0.246	-0.095	-0.052	0.030
			p-value	0.101	0.034*	0.417	0.655	0.794
	Noise	NHR	Corr	0.095	0.130	0.139	0.124	0.125
			p-value	0.418	0.267	0.236	0.291	0.286
		VTI	Corr	0.171	0.147	0.166	0.091	0.131
			p-value	0.144	0.210	0.157	0.439	0.263
		SPI	Corr	0.278	0.243	0.278	0.121	0.106
			p-value	0.016*	0.036*	0.016*	0.303	0.367
	Voice break	DVB (%)	Corr	-0.104	-0.178	-0.164	-0.155	-0.127
			p-value	0.376	0.127	0.160	0.186	0.279
		NVB	Corr	-0.104	-0.178	-0.165	-0.155	-0.127
			p-value	0.376	0.127	0.160	0.186	0.279
	Subharmonic segments	DSH (%)	Corr	0.156	0.206	0.058	0.069	0.221
			p-value	0.181	0.076	0.623	0.554	0.058
		NSH	Corr	0.209	0.263	0.148	0.200	0.209
			p-value	0.073	0.023*	0.206	0.086	0.073
	Voiceless or unvoiced segments	DUV (%)	Corr	0.032	0.051	0.101	0.157	0.094
			p-value	0.784	0.663	0.388	0.180	0.422
		NUV	Corr	-0.019	-0.031	0.098	0.063	0.125
			p-value	0.871	0.792	0.404	0.593	0.287

Table 3. Correlation between perceptual-auditory assessment and voice acoustic analysis of teachers with vocal complaints (cont.)

Measurements				CAPE-V				
				General degree	Roughness	Breathness	Tension	Pitch
RTS Wide Band	Darkening of graph (0 to 10)	F1	Corr	0.295	0.237	0.103	0.205	0.016
			p-value	0.010*	0.041*	0.379	0.078	0.888
		F2	Corr	0.214	0.156	0.032	0.119	-0.049
			p-value	0.065	0.181	0.783	0.310	0.674
		F3	Corr	3.00	-0.025	-0.043	-0.046	-0.161
			p-value	0.826	0.723	0.712	0.685	0.168
		F4	Corr	0.073	0.076	0.103	0.006	-0.019
			p-value	0.536	0.517	0.377	0.958	0.871
		At high frequencies	Corr	0.190	0.168	0.200	0.196	-0.009
			p-value	0.103	0.150	0.086	0.093	0.939
		Entire spectrogram	Corr	0.141	0.043	0.044	0.060	-0.110
			p-value	0.229	0.714	0.707	0.607	0.350
	Presence of noise (0 to 10)	Entire spectrogram	Corr	0.148	0.163	0.206	0.138	-0.139
			p-value	0.206	0.163	0.077	0.239	0.236
		At high frequencies	Corr	0.255	0.226	0.254	0.299	0.074
			p-value	0.028*	0.052	0.028*	0.009*	0.526
	Definition of formants (0 to 10)	F1	Corr	0.380	0.304	0.135	0.276	0.117
			p-value	0.000*	0.008*	0.248	0.117	0.317
		F2	Corr	0.234	0.199	0.023	0.122	0.066
			p-value	0.044*	0.088	0.840	0.296	0.573
		F3	Corr	0.022	0.029	0.006	-0.005	-0.113
			p-value	0.851	0.806	0.959	0.963	0.334
		F4	Corr	0.150	0.131	0.083	-0.025	-0.078
			p-value	0.200	0.265	0.481	0.829	0.508
	Graph uniformity (0 to 10)		Corr	0.188	0.058	0.017	0.013	-0.054
			p-value	0.108	0.619	0.882	0.910	0.641
RTS Narrow Band	Darkening of graph (0 to 10)	At high frequencies	Corr	0.189	0.151	0.035	0.140	-0.029
			p-value	0.105	0.198	0.763	0.232	0.802
		Entire spectrogram	Corr	0.205	0.207	0.100	0.130	-0.074
			p-value	0.078	0.076	0.395	0.266	0.529
	Presence of noise (0 to 10)	In between harmonics	Corr	0.184	0.216	0.134	0.263	0.049
			p-value	0.114	0.063	0.252	0.023*	0.678
		Entire spectrogram	Corr	0.130	0.175	0.104	0.182	-0.005
			p-value	0.267	0.133	0.373	0.119	0.964
		At high frequencies	Corr	0.136	0.148	0.131	0.125	0.048
			p-value	0.246	0.205	0.263	0.287	0.682
	Substitution of harmonics for noise (0 to 10)	Entire spectrogram	Corr	0.227	0.195	0.244	0.168	-0.032
			p-value	0.051	0.094	0.035*	0.150	0.780
		At high frequencies	Corr	0.142	0.165	0.268	0.060	-0.091
			p-value	0.227	0.157	0.020*	0.605	0.438
	Harmonic definition (0 to 10)		Corr	0.118	0.161	0.025	0.105	0.089
			p-value	0.314	0.167	0.831	0.373	0.446
	Graph uniformity (0 to 10)		Corr	-0.076	-0.063	-0.140	-0.038	-0.000
			p-value	0.518	0.593	0.232	0.724	0.999
	Number of harmonics (0 to 10)		Corr	0.092	0.150	0.017	0.078	-0.025
			p-value	0.432	0.200	0.884	0.505	0.826
	Presence of sub-harmonics (0 to 10)		Corr	0.187	0.137	0.108	0.149	0.040
			p-value	0.110	0.242	0.359	0.204	0.731

*Significant values (p≤0.05) – Pearson's correlation test
Note: corr = correlation; MDVPA = Multi Dimension Voice Program Advanced; RTS = Real Time Spectrogram; CAPE-V = CAPE-V = Consensus Auditory-Perceptual Evaluation of Voice; F = formant; f0 = fundamental frequency; fhi = maximum f0; flo = lowest f0; STD = Standard Deviation of Fundamental Frequency; RAP = Relative Average Perturbation; Jitt = Jitter Percentages; Jita = Absolute Jitter; sPPQ = Smoothed Pitch Perturbation Quotient; PPQ = Pitch Perturbation Quotient; vf0 = Fundamental Frequency Coefficient Variation; ShdB = Shimmer in dB; Shim = Shimmer Percentage; vAm = Peak Amplitude Variation; APQ = Amplitude Perturbation Quotient; sAPQ = Smoothed Amplitude Perturbation Quotient; NHR = Noise-Harmonic Ratio; SPI = Soft Phonation Index; VTI = Voice Turbulation Index; NVB = Number of Voice Breaks; DVB = Degree of Voice Break; DUV = Degree of Unvoiced Segments; NUV = Number of Unvoiced Segments; NSH = Number of Sub-harmonics; DSH = Degree of Sub-harmonic Components

harmonics and noise by all spectrogram shows the existence of an aperiodic energy component, related to the noisy voice breathy and/or hoarse[17,18]. The overall degree change also correlated positively with the largest darkening of F1 and F2 greater definition of the WB and, according to the literature[17], serious formants with vertical striae are usually associated with rough/noisy emissions (Table 3).

The roughness is related to the presence of aperiodic energy generated by the mucosa vibration irregularity of the vocal folds, which can be associated with hoarseness and/or roughness[17,23]. In this research, the roughness correlated positively with suggestive measures of the presence of SPI NSH noise and positively too, with the largest and most darkening and definition of F1 (Table 3). The presence of sub-harmonic components (NSH) of low-intensity among harmonics indicates the presence of generalized noise, it could correspond also to the diplophonia or crepitation[18,22]. SPI suggests lack of harmonic energy at high frequencies, with change in glottal closure[18].

The biggest darkening and definition of F1 in roughness may be related to the fact that hoarseness is characterized by noise with energy at lower frequencies[17] - and can present with noise in the main formants of vowels[18] - and that the roughness is characterized by more serious formants[17].

Contrary to expectations, the roughness was negatively correlated with the variation of the amplitude (vAm), a shimmer suggestive measure of decrease, limitation or inconsistency of contact coefficient of the vocal folds, relating to the presence of breathiness or hoarseness by irregular vibration of the mucosa[17,18,24].

In this investigation, the auditory-perceptual parameter of breathiness correlated positively with pratically all measures of jitter or perturbation of f0 at a short-term (jita, jitt, RAP, PPQ and sPPQ); SPI; presence of noise at high frequencies in WB; substitution for harmonics by noise in the high frequency in all spectrogram in NB (Table 3). The breathiness characterized by the presence of noise bass frequencies to the emission due to the presence of soundless transglottic air[17] or noise between harmonics, replacement of harmonics by noise, noise in regions above 6 kHz[17,18] , agreeing with the findings.

The set of results shows, as it was explained earlier, the presence of aperiodic energy/noise and instability in the glottal signal, since the jitter measures related to the variation of f0 in consecutive cycles and may signalize erratic vibration patterns due to difficulties of control in phonation or respiratory level, indicating oscillatory instability of the vocal folds also for its biomechanical characteristics, and correlates of perception of dysphonia[17,18].

Also, the higher the SPI is, softer and fluid is phonation[18]. The breathy voice, although indicates the presence of background noise, can transmit the perceptual- auditory point of view, an idea of sensuality and softness due to the presence of soundless air[17,18,24]. Survey of dysarthric subjects found unstable spectrographic tracing in all cases and in most of them, no harmonics at high frequencies, presence of noise among harmonics, and these findings were related to the hoarse-breathy voices of the subjects[25], agreeing with the results of this study.

The compensatory vocal effort by teachers, by increasing the glottal adduction and hypertension of the extrinsic laryngeal muscles, can generate increased vocal strain, perceived aurally[17,24]. The strained or compressed voice leads to a restricted mucosa vibration and sudden vocal attacks, with increased muscle tension and subglottic pressure[17]. The tension can be considered a noise measure that brings aperiodic energy characteristics resulting from hypertension adductor muscles of the vocal folds[24], which may explain, in this study, the positive correlation tension findings with perturbation measures of f0 at a short-term or jitter (jita, jitt, PAR), the presence of noise at high frequencies in WB, presence of noise among harmonics in NB (Table 3).

Researchers found correspondence between perceptual--auditory assessment and acoustic analysis, showing correlation between the overall degree to VTI, NHR and SPI; roughness with NHR and breathiness and asthenia with SPI[26]. However, another study found no significant correlation between measures of f0, length frequency and of the first two formants and pitch, modulation and articulation[27]. In this work, there was a positive correlation between various data of the acoustic voice analysis and perceptual-auditory voice assessment (Table 3).

The findings of this research about teachers with vocal complaints are also consistent with those of a study of dysphonic voices, which found the following relations between perceptual-auditory and spectrographic vocal parameters: overall degree of dysphonia, roughness, breathiness and instability with irregular tracing of harmonics in the spectrogram, in 66% of evaluated cases; weak loudness with low degree of darkening of harmonics, in 87.5% of cases; sound breaks with failure in the continuity of the tracing, in 62.5%; overall degree of dysphonia and vocal instability with noise among the harmonics, 97.4%; overall degree of dysphonia and roughness with decreased in energy concentration in high frequency in 48.7%; overall degree of dysphonia and roughness with the presence of sub-harmonics in 79.5%[28].

These results reinforce the idea of complementarity between the perceptual-auditory and acoustic assessment, combined with the results of quality of life protocols for voice, like VRQOL in order to measure how much a vocal disorder interferes with daily activities, personal context, social and professional of the subject, especially in the case of teachers who depend on voice for their profession[29].

Studies show that the relation between voice and quality of life is complex and is not direct[3,30]. Thus, a multidimensional voice assessment of teachers with vocal complaints including the self-assessment of quality of life becomes important for the clinician can outline peculiarities and deepen their understanding of the relation between what the teacher with vocal complaints feels and what manifests in its voice and how this is reflected in its quality of life, so that the clinician can better diagnose it and treat it.

However, as a limitation of this study, there was not a group of teachers without vocal complaints, to compare the results. More explorations of this complementarity of information between voice perceptual-auditory and acoustic assessment, and quality of life related to voice must be carried out with different populations and control group, to obtain more scientific evidence to allow in the future the use of all or only one of them as reliable screening in cases of large groups to be evaluated.

CONCLUSION

In this group of teachers with vocal complaints, the smaller the frequency measures, the greater the darkening spectrographic tracing, definition and number of harmonics, the higher the quality of life related to voice. The results of perceptual-auditory voice analysis and acoustic analysis showed significant correlations for the presence of aperiodic energy and instability of vocal signal. The findings showed that the acoustic and perceptual-auditory vocal assessments and quality of life related to voice were complementary to characterize the vocal profile of teachers.

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