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Original articles

Multidimensional voice assessment: the immediate effects of Lax Vox® in singers with voice complaints

Ruliano Santana da Matta[1]
https://orcid.org/0000-0002-8639-7517

Marco Aurélio Rocha Santos[1]
https://orcid.org/0000-0002-6043-9758

Elisa Meiti Ribeiro Lin Plec[1]
https://orcid.org/0000-0003-1070-1954

Ana Cristina Côrtes Gama[1]
https://orcid.org/0000-0002-7814-5328

[1] Universidade Federal de Minas Gerais - UFMG, Faculdade de Medicina, Departamento de Fonoaudiologia, Programa de Pós-graduação em Ciências Fonoaudiológicas, Belo Horizonte, Minas Gerais, Brasil.

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Corresponding address:
Ruliano Santana da Matta
Avenida Alfredo Balena, 190 - sala 249, Santa Efigênia
CEP: 30130-100 - Belo Horizonte, Minas Gerais, Brasil,
E-mail: rulianomatta@gmail.com

ABSTRACT

Purpose: to multidimensionally assess the effect of the Lax Vox® vocal technique on singers with voice complaints.

Methods: a comparative intrasubject study that assessed 30 singers – 13 males and 17 females, aged 18 to 55 years – who self-reported voice complaints and had voice problems symptoms. The participants were submitted to voice assessment with perceptive-auditory, acoustic, aerodynamic, and electroglottographic voice analysis, as well as laryngeal assessment with high-speed videolaryngoscopy. The participants were assessed at two moments: 1) at the beginning of the data collection; and 2) five minutes after performing the Lax Vox® vocal technique. The groups were compared with appropriate statistical tests, with a 5% significance level.

Results: in the acoustic analysis, there was an increase in the fundamental frequency for males, after using the Lax Vox® vocal technique. In the aerodynamic assessment, there was an increase in the airflow mean values during vocalization, as well as in aerodynamic power after using the Lax Vox® vocal technique in both groups.

Conclusion: the Lax Vox® vocal technique, in the studied singers with a complaint of dysphonia, promoted an increase in the fundamental frequency, for males. In the aerodynamic parameters, in both sexes, it promoted an increase in the airflow and aerodynamic power.

Keywords: Voice; Dysphonia; Singing; Voice Disorders; Speech, Language and Hearing Sciences

INTRODUCTION

The speech-language-pathology treatment for dysphonia can take place either directly or indirectly. In the indirect approach, the professional instructs the patient with data for them to care for their voice, whereas in the direct approach, the speech-language-hearing therapist prescribes techniques and vocal exercises to achieve a better phonatory function[1,2].

In the direct approach, the semi-occluded vocal tract exercises (SOVTE) stand out. They consist of the partial occlusion of the oral cavity promoting a retroflex resonance – i.e., the energy produced by the vibration of the vocal folds returns to the glottis and expands the vocal tract, reducing their impact[3,4]. Also, the literature[3-6] reveals that the SOVTE separates the free edges of the vocal fold, balances the activation of the crico-thyroid and thyroarytenoid muscles, diminishes the threshold of subglottal air pressure to start phonation, and increases the inertia of the vocal tract[3]. There are various SOVTE, including lip vibration, tongue vibration, glottal firmness, labial fricatives, finger kazoo, nasal sound /m/ emission, tube phonation, Lax Vox®, and the blowing and high-pitched sound exercise[3-6].

Lax Vox® is a silicone tube measuring 35 cm in length by 9 to 12 mm in diameter, used in water-resistance therapy[5,7]. Some pieces of research have been conducted using water-resistance therapy with Lax Vox® and other tubes, verifying the acoustic, perceptive-auditory, aerodynamic, and electroglottographic parameters. Following the verification dynamics for the abovementioned parameters, a study[6] was carried out to determine the result of using tubes and straws, including Lax Vox®, submerged five centimeters into the water, comparing with the same process with the straw in the air, during a given period of speech-language-hearing therapy in people diagnosed with behavioral dysphonia. The authors concluded that both methods improved their vocal self-perception and decreased the phonatory effort, with no great differences between them[6].

A piece of research[5] with healthy speakers performed Lax Vox® technique along with other SOVTE and concluded that double-source exercises – i.e., using the vibration of the vocal folds simultaneously with the vibration of a semi-occluded medium (Lax Vox®, for instance) – increase the fundamental frequency (f_0) when compared with other SOVTE.

Similar papers[7-9] verified tubes immersed to different depths, using glass tubes and Lax Vox®. They concluded that there is a tendency to greater fatigue when the tube is immersed deeper into the water with voiced emission for three minutes. However, additional studies must be conducted to confirm this conclusion.

Other studies[10,11] analyzed Lax Vox® alone. One of them carried out speech-language-hearing therapy with Lax Vox® for three weeks in teachers without voice complaints and reported an improvement in the self-assessment, aerodynamic, and acoustic voice parameters[10]. Research with singers without voice complaints studied the immediate effects of Lax Vox® and observed positive effects on the acoustic analysis and voice self-assessment[11].

No research was found in the literature analyzing the effects of the Lax Vox® voice technique in singers with dysphonia with a multidimensional assessment of voice production. The assessment of all multidimensional voice data in the same sample can favor the analysis of the correlation between vocal, laryngeal, and aerodynamic aspects, allowing for a more encompassing functional assessment of the effect of this technique on the voice of singers with dysphonia.

The results of this research can contribute to the scientific knowledge of the effects of Lax Vox®, which is widely used by speech-language-hearing therapists, singing teachers, and occupational voice users. Hence, this research aimed to verify the immediate effect of the Lax Vox® technique on the voice of singers with voice complaints, with a multidimensional assessment, considering the acoustic and perceptive-auditory analysis of voice, and the electroglottographic, laryngeal, and aerodynamic assessment of phonation.

METHODS

This is a quasi-experimental, intrasubject comparative study, approved by the Research Ethics Committee of the *Universidade Federal de Minas Gerais* – UFMG, Minas Gerais, Brazil, under number 73545417.7.0000.5149. All the participants were informed of the objectives and procedures of the research and signed the informed consent form (ICF) after reading it and having their questions answered. All the stages of the research were conducted in the Functional Health Observatory (abbreviated OSF in Portuguese) at UFMG.

The study sample comprised 30 dysphonic, both amateur and professional, pop singers, 13 of whom were males aged 18 to 39 years (mean of 27 years), and 17 were females aged 18 to 55 years (mean of 28 years). The participants were recruited from pop music bands and groups from the city of Belo Horizonte, Minas Gerais. One of the researchers personally invited music groups from the city; hence, the sample was recruited by convenience.

Those included in the research were professional and amateur singers of both sexes with self-reported voice complaints and symptoms.

The voice complaint assessment considered the participants who had a negative voice quality self-perception (they referred to their voice as poor or very poor).

The presence of voice symptoms was represented by a total score of 16 points or more on the Voice Symptom Scale (VoiSS)[12]. The VoiSS is a voice self-assessment instrument encompassing information on the functioning and emotional and physical impact due to voice symptoms. This is a simple protocol, easy to apply and interpret, made up of 30 questions with four scores: Limitation, Emotional, Physical, and Total[12].

The research's exclusion criteria were people taking any type of systemic medication; smokers; people with laryngeal changes of neurological origin; women either pregnant or in her menstrual or premenstrual period; patients with airways infection; and those nauseated by the videolaryngoscopy.

Of the 13 male singers assessed, three were professional and 10, amateur singers, whose total VoiSS[12] score ranged from 16 to 76, mean of 34 points (SD = 16.7). The female group had 17 women – three professional and 14 amateur singers, whose total VoiSS[12] score ranged from 16 to 77 points, mean of 39 points (SD = 18.2). The classification as either amateur or professional singer was based on the participants' self-report. Those who sang as a secondary activity was considered an amateur singer, while the ones whose singing was their main paid occupation were considered professional singers[13].

All the participants underwent speech-language-hearing and otorhinolaryngologic assessment for the sample characterization.

The speech-language-hearing assessment comprised a perceptive-auditory voice analysis, conducted by one of the authors of this research, a voice specialist with more than five years' experience in the field. This analysis assessed the habitual sustained emission of the /a/ vowel, considering the general degree perceptive-auditory parameter of vocal change in a four-point scale (neutral, mild, moderate, and intense). All the participants had mildly to moderately changed voice quality.

The otorhinolaryngologic assessment was conducted by a single physician. The male singers, in the larynx examination, had irregularities in the middle third of the right vocal fold (N = 1); vocal fold hyperemia (N = 1); posterior triangular chink (N = 1); asymmetrical phase (N = 1), and examination with no significant changes (N = 9). In their turn, the women in the laryngeal assessment presented irregularities in the middle third (N = 3); interarytenoid edema (N = 1); medio-posterior triangular glottal chink (N = 1); polypoid edema (N = 1); vocal fold edema (N = 1), and examination with no significant changes (N = 10).

The data were collected in the Speech-Language-Hearing Functional Health Observatory (OSF) at the *Universidade Federal de Minas Gerais* (UFMG) between May and October 2018.

Assessment

The research's participants were submitted to two assessments in a single appointment lasting 45 minutes on average.

On the first stage, named assessment moment 1 (M1), the participant was submitted to 1) recording of the sustained /a/ vowel in their habitual tone and the linked speech of the days of the week for the acoustic and perceptive-auditory voice analysis; 2) electroglottographic assessment; 4) laryngeal assessment with high-speed videolaryngoscopy for perceptive-visual analysis of the laryngeal image; and 3) aerodynamic analysis.

At the end of the collection, the participants performed the Lax Vox® vocal technique supervised by one of the researchers. All the participants were instructed to perform the vocal technique standing and emit the sustained /u/ vowel in habitual frequency and intensity for five minutes[14].

Assessment moment 2 (M2) was the second stage, which took place immediately after performing the vocal technique. In it, each participant repeated all the procedures mentioned above (Figure 1).

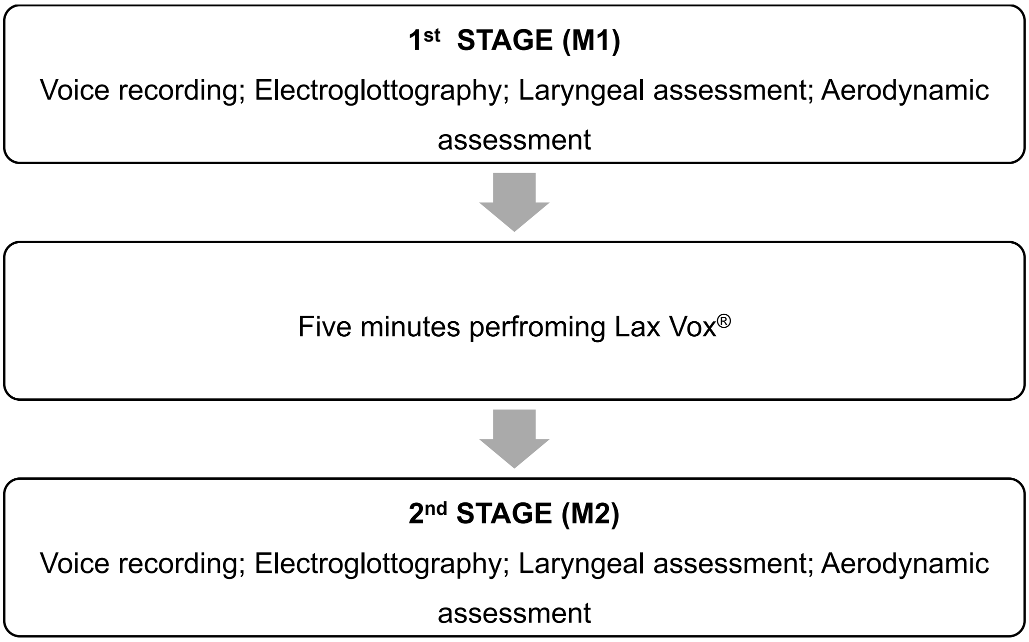

Figure 1. Flowchart of the stages developed in the research

Lax Vox® Vocal Technique

Lax Vox® vocal technique consists of phonation in a silicone tube with one end immersed in water. The silicone tube is 35 cm long and 9 to 12 mm in diameter, which is used with a standard 500 ml mineral water PET bottle filled with 15 cm of water. One end of the tube was placed between the participants' teeth, with lip closure, while the other end was positioned 3 cm below the water surface. All the participants were instructed to prolong the /u/ vowel emission in the silicone tube in their habitual frequency and continuous expiratory airflow (Figure 2).

Figure 2. Performing Lax Vox® technique

Dependent variables assessed

To analyze the immediate effect of Lax Vox® vocal technique on singers with voice complaints and symptoms, the following dependent variables were considered: 1) acoustic voice analysis; 2) perceptive-auditory voice quality analysis; 3) electroglottographic assessment; 4) visual analysis of laryngeal image; and 5) aerodynamic assessment. All collection procedures of the dependent variables are detailed below.

1. Acoustic Analysis

The acoustic voice analysis was performed with the Computerized Speech Lab (CSL) program from Kay Pentax®, model 6103, Multi-Dimensional Voice Program module (MDVP)[15], installed on a Dell® computer, model Optiplex GX260, with a professional sound card manufactured by DirectSound®, and unidirectional condenser microphone manufactured by Shure®.

For voice recording, the participants were instructed to prolong the habitual /a/ vowel full emission for three seconds and say the days of the week. The participants stood with their feet slightly apart and the microphone on a pedestal leveled with their mouth and 10 cm away from it. All the recordings were made in an acoustically treated environment.

The parameters chosen for the acoustic analysis were:

Fundamental frequency (f_0): mean of all the extracted periods of the frequency and the normal value indicated in the program's manual – 243.97 Hz for women and 145.22 Hz for men[15].

Jitter and pitch perturbation quotient (PPQ): parameters that measure the short-term pitch perturbation, expressed in percentages, whose normal values are respectively 0.63% and 0.36% for women, and 0.58% and 0.33% for men[15].

Shimmer and amplitude perturbation quotient (APQ): parameters that measure the short-term amplitude perturbation, expressed in percentages, whose normal values are 1.99% and 1.39% for women, and 2.52% and 1.98% for men[15].

Noise harmonic ratio (NHR): noise measurement that relates the harmonic component to the noise component of the acoustic wave. The normal value is 0.11 dB for women, and 0.12dB for men[15].

2. Perceptive-Auditory Analysis

For the perceptive-auditory analysis, all the voices recorded in both moments, M1 and M2, were randomized and presented to five speech-language-hearing pathologists with a minimum of three years' experience in perceptive-auditory analysis.

After listening to the voices of both groups, the speech-language-hearing pathologists analyzed the voices, comparing them with each other and using the GRBAS scale[16]. The recordings were edited in the Audacity 2.0.6 program. The first voice of each pair was randomly named "Voice A" and the second, "Voice B", not revealing whether it had been recorded before or after using the Lax Vox® technique.

The assessor listened to each participants' "Voice A" and "Voice B" and compared one to the other, considering whether the voice quality had remained unchanged, improved, or worsened. When the assessors observed any change in the voice, they marked two perceptive-auditory parameters related to voice change based on the GRBAS scale parameters.

The matched analysis of the voices was registered on the Auditory Voice Analysis answers protocol[17].

These answers were tabulated in the following categorization: if the voice was considered better after Lax Vox® = improved; if the voice was better before Lax Vox® = worsened; if both voices were considered similar = unchanged.

For intra-assessor agreement analysis, 20% of the voice samples were randomly replicated and blindly interpreted by the assessors at the moment of assessment. The intra-assessor agreement values were 88.8%, 80.5%, 65.7%, 64.3%, and 61.1% - i.e., four had a substantial degree and one, an almost perfect degree[18].

The perceptive-auditory results were analyzed considering the mode value of the answers given by the five speech-language-hearing judges.

3. Electroglottographic Assessment

The voice electroglottography (EGG) was assessed with the Electroglottography module of the CSL program, by Kay Pentax®, model 6103, installed on a Dell® computer model Optiplex GX260, with a professional sound card manufactured by Direct Sound®.

The participants were instructed to sit comfortably. After cleaning the neck skin with 70% alcohol, two electrodes were placed on the surface of the thyroid cartilage laminae and fastened to the neck with an elastic band. The electroglottography was analyzed with the closure quotient (CQ), which measures the relationship between the time of closure (Tc) and the total glottal cycle (Tc + To): CQ = Tc / (Tc + To). It is expressed in percentages (%) and, according to the program's manual, its reference values range from 40% to 60%[19] (Figure 3).

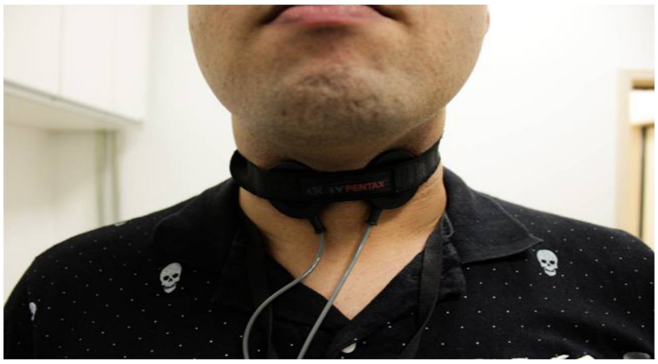

Figure 3. Placement of the electrodes to perform electroglottography

4. Laryngeal Assessment

The laryngeal assessment used the high-speed videolaryngoscopy performed with the SL equipment, by Kay Pentax®, model 6103. The examinations were made by a single otorhinolaryngologist, with the subjects seated and their head slightly inclined up and forward. The participant put the tongue out of their mouth with the physician's help, who pulled it with a gauze. Then, a rigid optic fiber was introduced through the mouth towards the larynx. During the examination, the participant was instructed to breathe naturally and then emit the /a/ and /i/ vowels in their habitual frequency and intensities.

The laryngeal images were examined before (M1) and after (M2) performing Lax Vox® technique and randomly (based on a draw) exhibited in pairs to four otorhinolaryngologists with over 10 years' experience in the field. For the perceptive-visual analysis, the otorhinolaryngologists answered in a protocol whether the second laryngeal image had improved, worsened, or remained unchanged in relation to the first one, considering the parameters of glottal coaptation and muco-undulatory movement amplitude. The analysis parameters were adapted from and based on other studies that used the high-speed videolaryngoscopy[20].

The intra-assessor agreement values were 87.7%, 71.5%. 71.3% and 53.3% – one had a moderate degree, two had a substantial degree, and one had an almost perfect degree[18]. For this analysis, 20% of the laryngeal image samples were randomly replicated and blindly interpreted by the assessors at the moment of assessment.

The mode of the answers of the four otorhinolaryngologist judges was considered for the laryngeal image visual assessment.

5. Aerodynamic assessment

The speech aerodynamic measures were assessed with the CSL program, by Kay Pentax®, model 6103, module PAS, installed on a Dell® computer model Optiplex GX260, with a professional sound card manufactured by Direct Sound®, attached to a silicone mask.

To collect the aerodynamic measures, the participants were instructed to repeatedly emit the /pa/ syllable in the habitual f_0, in a single exhalation. The aerodynamic parameters were picked up with a silicone face mask, placed over the participant's mouth. The mask was attached to a device linked to a pressure transducer. The intraoral pressure was measured with a polyethylene catheter with a narrow diameter, inserted through a lateral hole on the mask, placed on the center of the participant's tongue. The other end of the catheter was connected to a pressure transducer and a microphone, and all the signals emitted were recorded and analyzed by the program (Figure 4).

Figure 4. Aerodynamic assessment

For the analysis of the aerodynamic measures, the following parameters were selected, with their respective reference values for men and women, which are informed in the CSL manual, by Kay Pentax®[21].

Air pressure peak: This measure is the highest air pressure value observed in one or more plosive syllable, measured in cmH_2O (6.65 cmH_20 for women, and 7.55 cmH_2O for men).

Mean value of air pressure peak: The mean value of the air pressure peak, measured in cmH_2O (5.57 cmH_20 for women, and 6.058 cmH_2O for men).

Mean airflow during vocalization: The quotient between the total air volume exhaled and the duration of the voiced segments, measured in liters/second (0.11 l/s for women, and 0.12 l/s for men).

Aerodynamic power: The product between the mean value of air pressure peak, the voiced airflow, and the value of 0.09806, measured in watts (0.06 watts for women, and 0.09 watts for men).

Aerodynamic resistance: Defined as the results of the mean air pressure divided by the voiced airflow, measured in cmH_2O/liters/second (55.18 cmH_20/l/s for women, and 52.60 cmH_2O/l/s for men).

Acoustic immittance: Defined as the result of the mean air pressure divided by the voiced airflow, measured in dyne per second/cm_5. (56.27 dyns/cm_5 for women, and 53.64 dyns/cm_5 for men).

Aerodynamic efficiency: Non-dimensional value, defined in parts per million (ppm). It results from dividing the acoustic power by the aerodynamic power (103.66 ppm for women, and 45.81 ppm for men).

Data analysis

The data were statistically analyzed with the MINITAB statistical program, version 17. The variables were descriptively analyzed with the absolute and relative frequency distribution of the categorical variables and numerical synthesis measures of the quantitative variables. The intra-assessor agreement in the perceptive-auditory and laryngeal assessments were evaluated with AC1 statistics in the statistical program R. Based on the quantitative variables distribution analysis with the Kolmogorov-Smirnov test, the statistical test was defined to compare the groups before (M1) and after (M2) performing Lax Vox® vocal technique (the paired Student's t-test and Wilcoxon test). All the analyses considered the 5% significance level.

RESULTS

The results of the acoustic analysis of the 13 male singers with a complaint of dysphonia revealed an increase of the f_0 acoustic parameter after using the Lax Vox® vocal technique (Table 1).

The results of the perceptive-auditory analysis did not reveal any difference in the voice quality in either of the sexes (Table 2).

In the electroglottographic assessment, the results of the closure quotient (CQ) did not reveal a difference in either of the sexes after performing the Lax Vox® vocal technique (Table 3).

The results of the laryngeal assessment did not reveal any differences in either of the sexes after performing the Lax Vox® vocal technique (Table 4).

The results of the aerodynamic parameters of female and male singers are presented in Table 5. An increase is observed in the airflow and aerodynamic power mean values after performing the Lax Vox® vocal technique.

Table 1. Comparison of the acoustic voice parameters in the group of males and females, before and after performing Lax Vox® vocal technique

FEMALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
f_0 (Hz)	M1	213.59	28.14	0.08*
	M2	219.66	26.12	
Jitter(%)	M1	1.51	0.65	1.00**
	M2	1.61	0.91	
PPQ (%)	M1	0.89	0.37	1.00**
	M2	0.94	0.52	
Shimmer(%)	M1	4.36	1.10	0.44*
	M2	4.09	1.33	
APQ(%)	M1	3.07	0.76	0.31*
	M2	2.81	0.90	
NHR(dB)	M1	0.12	0.01	0.20*
	M2	0.12	0.02	
MALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
f_0 (Hz)	M1	114.04	14.01	**0.03***
	M2	120.53	14.05	
Jitter(%)	M1	0.76	0.47	0.67**
	M2	0.80	0.25	
PPQ (%)	M1	0.44	0.27	0.78**
	M2	0.46	0.15	
Shimmer(%)	M1	3.29	1.40	0.78*
	M2	3.21	1.17	
APQ(%)	M1	2.57	1.04	0.45*
	M2	2.43	0.79	
NHR(dB)	M1	0.13	0.01	0.88*
	M2	0.13	0.01	

Captions: M1: assessment moment 1; M2: assessment moment 2; SD: standard deviation; f_0: fundamental frequency; PPQ: pitch perturbation quotient; APQ: amplitude perturbation quotient; NHR: noise harmonic ratio;
*: paired Student's t-test; **: Wilcoxon test; bold: p-value $\leq$ 0.05.

Table 2. Comparison of the perceptive-auditory voice parameters in the group of males and females, before and after performing Lax Vox® vocal technique

Comparison of the voices before and after Lax Vox®				
			N	%
Females (N= 17)	GRBAS	Improved	2	11.8
		Worsened	2	11.8
		Unchanged	13	76.4
Males (N=13)	GRBAS	Improved	4	30.8
		Worsened	0	0
		Unchanged	9	69.2

Caption: GRBAS = Perceptive-Auditory Analysis Protocol

Table 3. Comparison of the electroglottographic closure quotient voice parameter in the group of males and females, before and after performing Lax Vox® vocal technique

FEMALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
Electroglottography (CQ)	M1	45.77	3.56	0.09*
	M2	44.36	4.91	
MALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
Electroglottography (CQ)	M1	45.23	4.04	0.84*
	M2	45.09	4.90	

Caption: M1: assessment moment 1; M2: assessment moment 2; SD: standard deviation; CQ: closure quotient; *: paired Student's t-test.

Table 4. Comparison of the perceptive-visual voice parameters in the group of males and females, at the two assessment moments

Glottal Coaptation		**Laryngeal image comparison**	
		N	**%**
Females (N= 17)	Improved	6	35.3
	Worsened	2	11.8
	Unchanged	9	52.9
Males (N=13)	Improved	2	15.4
	Worsened	1	7.7
	Unchanged	10	76.9
Muco-undulatory Movement		**Laryngeal image comparison**	
		N	**%**
Females (N= 17)	Improved	7	41.2
	Worsened	3	17.6
	Unchanged	7	41.2
Males (N=13)	Improved	4	30.8
	Worsened	2	15.4
	Unchanged	7	53.8

Table 5. Comparison of the aerodynamic voice parameters in the group of males and females, before and after performing Lax Vox® vocal technique

FEMALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
Air pressure peak (cmH2o)	M1	10.38	2.32	0.34*
	M2	10.69	2.61	
Mean value of the air pressure peak (cmH2o)	M1	9.61	2.18	0.16*
	M2	10.01	2.51	
Mean of the airflow during vocalization (lit/sec)	M1	0.15	0.08	**0.04***
	M2	0.17	0.07	
Aerodynamic power (watts)	M1	0.16	0.11	**0.02***
	M2	0.19	0.10	
Aerodynamic resistance (cmH2o/l/s)	M1	61.30	17.38	0.38*
	M2	58.26	19.10	
Acoustic impedance (dyns/Cm5)	M1	61.78	15.90	0.39*
	M2	59.41	19.48	
Aerodynamic efficiency (ppm)	M1	241.33	211.96	0.39**
	M2	308.32	470.73	
MALES				
Parameter	**Moment**	**Mean**	**SD**	**P-value**
Air pressure peak (cmH2o)	M1	9.96	1.77	0.08*
	M2	10.55	1.94	
Mean value of the air pressure peak (cmH2o)	M1	9.18	1.47	0.06*
	M2	9.78	1.71	
Mean of the airflow during vocalization (lit/sec)	M1	0.22	0.25	**0.03****
	M2	0.27	0.26	
Aerodynamic power (watts)	M1	0.24	0.30	**0.01****
	M2	1.31	3.82	
Aerodynamic resistance (cmH2o/l/s)	M1	65.19	38.17	0.06*
	M2	51.93	29.24	
Acoustic impedance (dyns/Cm5)	M1	66.42	38.89	0.26**
	M2	59.20	47.90	
Aerodynamic efficiency (ppm)	M1	125.03	91.49	0.67*
	M2	135.50	93.97	

Captions: M1: assessment moment 1; M2: assessment moment 2; SD: standard deviation;
*: paired Student's t-test; ** : Wilcoxon test; bold: p-value ≤ 0.05.

DISCUSSION

This research aimed to multidimensionally assess the immediate effects of the Lax Vox® vocal technique. The results suggest that the aerodynamic parameters were the ones that changed the most in dysphonic singers of both sexes after performing the vocal technique.

The literature[5-7,10,11,22-24] has been extensively researching the effects of Lax Vox® in dysphonic and non-dysphonic people who are not singers[5-7,10,22,23], in a computer model with a voice tract simulator[6], and non-dysphonic singers[11,24].

The results of the acoustic analysis suggest that the Lax Vox® vocal technique did not affect the voice of dysphonic female singers. In the men, there was an increase in the f_0, which can be explained by the fact that this is an acoustic parameter that changes when the voice is warmed up[5,11,25] by continuously performing the vocal technique. Although the group of female singers did not differ before and after performing Lax Vox®, the values of this acoustic measure increased.

Research[5,6,10] with longitudinal follow-up performing Lax Vox® vocal technique, either alone or in combination with other voice exercises, observed different results regarding the acoustic parameters of voice. Such differences can be explained by the diversity in time following up the participants and the different SOVTE approaches.

A study[6] had an eight-week follow-up with speech-language-hearing therapy, which used a water resistance technique with a plastic tube whose dimensions were similar to that of Lax Vox® in people with behavioral dysphonia. It did not observe any differences in the acoustic measures after the clinical treatment[6]. Another piece of research[5], with one-week follow-up performing vocal training with Lax Vox® combined with other voice exercises in people without voice complaints, observed an increase in f_0, as in this research. A study[10] with a three-week follow-up on female teachers without voice complaints using the Lax Vox® vocal technique observed an increase in f_0, maximum phonation time, self-perception of phonatory comfort, as well as an increase of seven semitones in the maximum phonatory range. Even though this research assessed the immediate effect of Lax Vox® vocal exercise on dysphonic singers, the results of research[5,6,10] with longitudinal follow-up reinforce the f_0 as the acoustic measure with the greatest changes after performing the SOVTE, as found in this study.

Research[11,22,26-28] assessing the immediate effects of Lax Vox® or other SOVTE also observed different results regarding the changes in the acoustic measures of voice. A study[28] with 30 singers using voice warm-up SOVTE observed an increase in f_0 after performing the voice techniques. Similar results were described in research with 23 opera singing students, which observed in the immediate effects of Lax Vox® the increase in f_0 and decrease in glottal-to-noise excitation ratio[11]. The analysis of the immediate effect of Lax Vox® on 30 subjects without voice changes did not observe any changes in the acoustic parameters of men's and women's voices[22] – neither did a study that assessed the ventilation mask SOVTE in dysphonic people[26] nor another one that assessed 24 people without voice changes with straw phonation SOVTE[27].

The f_0 seems to be the acoustic parameter most sensitive to the effects of vocal training with the Lax Vox® technique. The methodological differences concerning time to perform the vocal technique, sample type, and size, and types of programs used in the acoustic analysis can explain the differences observed in the various pieces of research.

In this research, the analysis of the perceptive-auditory assessment of voice did not find any differences in the voice quality of male and female singers after performing the Lax Vox® vocal technique. The results in the literature regarding the effects of Lax Vox® or other SOVTE in the voice quality are also divergent and can be explained by the methodological differences observed in the various studies analyzed.

Studies with longitudinal follow-up point to an improvement in the voice quality in the SOVTE with straw phonation and a decrease in the vocal disadvantage index in the voice of people with behavioral dysphonia[6], and a significant improvement in the voice intensity range of 30 students without voice complaint[28] and the perceptive-auditory parameter of voice roughness of teachers without dysphonia[10]. Research[11] that assessed the immediate effect of Lax Vox® did not observe differences in the voice quality of singers, as found in the present study.

The results in the literature suggest that Lax Vox® and other SOVTE need more time performing the technique to have positive effects on the voice quality of dysphonic or vocally healthy people.

The literature reveals that the SOVTE, such as Lax Vox®, promote a better source-filter interaction[4,5], which can have a positive impact on the resonance aspects of voice production. This research used the parameter analysis of the GRBAS scale in the perceptive-auditory assessment, as it privileges the voice aspects related to the glottal source[16]. It is important to conduct further studies, using other perceptive-auditory analysis protocols that assess the resonance aspects of voice, to analyze the actual impact performing Lax Vox® has on the voice of dysphonic singers.

Regarding the results of the electroglottography, this research observed that the Lax Vox® vocal technique does not have immediate effects on the closure quotient (CQ) measure. Research[29,30] suggests that the lower CQ value is related to a milder impact force between the vocal folds. The main changes caused by the SOVTE in the glottal cycles are[31]:

- The vocal folds are paralleled, not pressing the free edges;
- The collision force of the vocal folds is decreased by the slightly separate position they take;
- The acoustic inertia of the vocal tract decreases the phonation threshold pressure.

In this case, it can be supposed that the SOVTE, such as Lax Vox®, decrease the electroglottographic CQ measures, suggesting less friction between the vocal folds. Most of the results of the analyses of the electroglottographic CQ measures after performing the

SOVTE have no differences when analyzing people with no voice changes[5,27,32], with behavioral dysphonia[6], and singers[25]; all these results were similar to those in this research.

Research suggests that electroglottographic measures such as the CQ have individual variability[29], that the different programs that analyze these measures can interfere with the results[29], and that the SOVTE produce different results in the electroglottographic CQ measures[5,33]. All these methodological aspects can explain the differences observed in the literature.

In the laryngeal image assessment following Lax Vox®, no changes were observed regarding the muco-undulatory movement and the glottal coaptation. The groups of female and male singers had different laryngeal changes, which may have interfered with the results in this research. No studies assessing the immediate effect of Lax Vox® or other SOVTE on laryngeal images were found in the literature.

The analysis of the aerodynamic parameters, as they reflect the biomechanics of the vocal folds and the phonation breathing function, is important in speech-language-hearing assessment[34], especially in the SOVTE studies, which deal with the source-filter interaction and the vocal tract impedance variations when partially occluding the oral cavity[3].

In the assessment of the aerodynamic measures in this research, an increase is observed in the airflow and aerodynamic power measures after performing the Lax Vox® vocal technique. The literature[27,35] presents a similar result concerning the increase in the airflow measure after performing various SOVTE in people without dysphonia. Such results suggest that the immediate effect of the SOVTE vocal technique is an increase in the mean airflow values, probably due to a decrease in the vocal folds adduction force, as evidenced in studies with mathematical computer models[4] and excised canine larynxes[32]. Hence, they promote a greater airflow between the vocal folds.

Studies with an eight-week longitudinal follow-up using SOVTE vocal techniques in dysphonic subjects[6] and a six-week follow-up on people without voice changes[28] did not observe changes in the airflow measures at the end of the clinical treatment. These results suggest that airflow measures do not change after speech therapy with SOVTE. Research with a methodological design similar to that of this research with Lax Vox® is important to better understand these results.

Since the aerodynamic power is a parameter that depends on the air pressure measure and the voiced airflow[21], and the air pressure values did not change after performing Lax Vox®, it is feasible to suppose that the increase in this aerodynamic parameter is a consequence of the increased airflow values. No study was observed in the literature assessing this measure after performing the SOVTE.

It is important to highlight that the aerodynamic air pressure measure after performing SOVTE has been extensively studied in the literature[6,25-28]. The results either suggest a decrease in the air pressure values after performing the SOVTE[6,26,27] or do not observe significant differences in this aerodynamic parameter[25,28] after vocal therapy – a result similar to that of this research. Such disagreeing findings can be explained by the methodological differences between the pieces of research, particularly regarding the different programs that assessed voice aerodynamics.

The study was limited by the sample's comprising both amateur and professional pop singers, which may have had an impact on the results, considering the difference in singing voice training time between the two categories.

It is important to conduct future studies encompassing a perceptive-auditory assessment with resonance parameters and a larger and more homogeneous sample of singers with a laryngeal diagnosis, as they can provide a better understanding of the effects of the Lax Vox® vocal technique. Such a research is essential to furnish broader scientific ground for the speech-language-hearing interventions aiming to improve the voice performance of singers.

CONCLUSION

The multidimensional analysis of the immediate effect of the Lax Vox® vocal technique on singers with complaints of dysphonia reveals an increase in the fundamental frequency in men. In the aerodynamic voice parameters, it promotes an increase in airflow and aerodynamic power in both sexes.

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