Voiced High-frequency Oscillation and LaxVox: Analysis of Their Immediate Effects in Subjects With Healthy Voice

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Summary: Objectives. The aim of this study was to analyze the immediate effects of voiced high-frequency oscillation (VHFO) and LaxVox exercises in vocally healthy subjects.

Methods. Thirty adult subjects (15 women, 15 men) with no history of dysphonia or vocal complaints participated in the study. The subjects performed VHFO and LaxVox techniques for 3 minutes in a random order, with a washout period of 7 days. They answered a questionnaire for vocal/laryngeal intensity symptoms, and had maximum phonation time (MPT) /a/, /s/, /z/, and number counting measured. The vowel /a/ was also recorded before and after both techniques for acoustic analysis. After both techniques, the subjects answered a questionnaire about vocal, laryngeal, respiratory, and articulatory sensations. Data were analyzed using the Wilcoxon, and paired *t* and chi-square tests were used ($P < 0.05$), as required.

Results. There was an increase in high loudness symptom after LaxVox in women, whereas there was a decrease in painful throat, irritated throat, and low loudness symptoms after VHFO in men. After LaxVox, the MPT of /z/ increased in women and after VHFO, the MPT of /s/, /z/, and number counting increased in men. The fundamental frequency variability increased in women after VHFO. The sensations remained unchanged in both groups following the two exercises in women and men.

Conclusions. VHFO and LaxVox techniques had similar effects on vocal and laryngeal symptoms, as a matter of fact, in terms of phonatory and acoustic measures. With regard to vocal symptoms, VHFO showed better immediate effects in men than in women. As a result, the hypothesis H0 is partially refuted.

Key Words: Semioccluded vocal tract exercises−LaxVox−Voiced high-frequency oscillation−Voice−Voice therapy.

INTRODUCTION

Vocal exercises used in voice training aim to improve the physiology of voice production to increase vocal resistance.[1] In fact, vocal exercises promote a balance at breathing, glottal, and resonance/articulatory levels, increase the intrinsic laryngeal muscle tonus and endurance, and improve mucosal undulating movements by changing the impedance, thus, providing a complete glottal closure normotensively.[2−4] Thus, this work leads to a balance between the aerodynamic and myoelastic forces of the larynx and in turn improves voice quality.[5]

The techniques advised for vocal training include semioccluded vocal tract exercises (SOVTEs), which use a semiocclusion of the vocal tract.[4,6] The main objective of these exercises is to improve the source-filter interaction.[6] This can be explained by the change in impedance and increase in inertive reactance of the vocal tract.[6,7] Moreover, it opposes the subglottic airflow that reduces the phonation threshold pressure and avoids the vocal folds stress during phonation.[6,8] There are a number of SOVTEs including lips and tongue trill, fricative sounds, humming, hand over the mouth, finger kazoo, and tubes and straw phonation.[6,7,9−11]

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Phonation into tubes is a therapeutic and training technique, which can be used in subjects with voice pathologies and in subjects who wish to improve their voices.[4,12−15]

A SOVTE tested recently in dysphonic and nondysphonic subjects was the voiced oral high-frequency oscillation (VOHFO) procedure using the New Shaker (NCS Indústria e Comércios de Produtos Hospitalares LTDA, São Paulo, SP, Brazil) device.[16] The New Shaker is a portable device for oral high-frequency oscillation (OHFO) implementation. The OHFO therapeutic use allows airflow braking by successive interruptions to its passage and leads to a high-frequency oscillation.[17,18] The main objective of OHFO is to debug the airways by fast backward and forward movement of small air volumes. This technique is used in respiratory physiotherapy practice.[19]

The New Shaker device consists of a mouthpiece at its one end, and a perforated cover at its other end. It comprises a valve made from a high-density stainless steel sphere resting on a circular cone.[20] As the subject blows through the device, the stainless-steel sphere breaks the airflow leading to a 15-Hz oscillation and oscillates the larynx.[17−19] OHFO was previously performed using another device known as flutter; it was used in Switzerland in the 1980s, and had similar objective and effects. However, in the more recent times, the New Shaker is commonly used.[21−24]

To understand the effect of OHFO on voice quality in patients with dysphonia, Saters et al[16] used it in a voiced manner with the New Shaker device. The authors named their technique VOHFO. They compared the effect of this technique in dysphonic and nondysphonic subjects and found that it improved the source-filter balance and the severity of vocal and laryngeal symptoms in both groups.

There are no other studies using the VOHFO technique in voice training. Thus, there is a need for analyzing its effects and comparing them with those of the LaxVox technique. This will help in understanding the applications of VOHFO and will increase therapeutic resources in voice clinics. For simplicity and ease of understanding, henceforward, it should be called as voiced high-frequency oscillation (VHFO).

The present study aimed to address the following question: "Do VHFO and LaxVox techniques have same effects on vocal and laryngeal symptoms, acoustic and phonatory measures, and self-assessment in healthy individuals without dysphonia?" We hypothesized that (1) H0: there are no differences between VHFO and LaxVox techniques regarding the effects on vocal and laryngeal symptoms, acoustic and phonatory measures, and self-assessment, and (2) H1: there are differences between VHFO and LaxVox techniques regarding the effects on vocal and laryngeal symptoms, acoustic and phonatory measures, and self-assessment.

METHODS

Design

This study was a clinical trial with a randomized cross-over design.

Ethical aspects

The research was approved by the institutional research ethics committee (protocol 1.051.511) and was conducted in agreement with the Health National Council (Resolution 466/12). All subjects signed a free informed consent term after the researcher explained about the study.

Sample

Fifteen men (average 25.1 years) and 15 women (average 24.1 years) participated in the study. They aged between 18 and 45 years old.

All volunteers were selected from several regions of Bauru city in the state of São Paulo, and recruited via telephone calls to select those who were interested. A structured interview was conducted using the following inclusion criteria: age between 18 and 45 years, healthy and without dysphonia, and no smoking habits. Participants with upper airways infections such as influenza or allergic crisis and with thyroid gland changes, hormonal changes, and heart and lung problems were excluded. These precautions were taken to isolate confounding variables.

Outcome variables analysis

The outcome variables were as follows: vocal and laryngeal intensity symptoms (if presented), maximum phonation time (MPT), acoustic measures, and the items of a questionnaire regarding sensations, which covered voice, larynx, breath, and articulatory aspects.

Research team

The research team was composed of three speech pathologists; researcher 1 was responsible for voice recording before and after the implementation of VHFO and LaxVox, researcher 2 was responsible for the questionnaire regarding sensations and vocal/laryngeal intensity symptoms, and researcher 3 was responsible for the interventions and group allocation.

Researchers 1 and 2 were blinded to group allocation, and researcher 3 was blinded to the evaluation of outcome variables.

Procedures

Assessment was done before and after the two techniques as follows.

The vocal and laryngeal symptoms intensity was measured using a continuous visual analogical scale (VAS). On VAS, the extreme right position indicated no symptoms intensity, and the extreme left position indicated symptoms with worse intensity. For each symptom, the subjects were instructed to mark on the VAS corresponding to the intensity of the symptom at that moment (before and after each technique). The subjects could signal at any point on the scale.

The symptoms analyzed were as follows: throat burning, tightness, dry throat, painful throat, itchiness, sensible throat, irritated throat, lump in the throat, hoarseness, aphonia, voice failure, breathlessness, low pitch, high pitch, low loudness, high loudness, effort when speaking, and fatigue while speaking.

The voice was recorded in an acoustically treated room. Researcher 1 asked for the vowel /a/ at a habitual pitch and loudness (three times) for 5 seconds. The recorder equipment used was a professional audio editing software, *Sound Forge* version 7.0 (Sony Creative Software Inc, Middleton, WI) with a 44.1-Hz sampling rate, monochannel, 16-Bit microphone AKG, model C 44 PP (AKG Acoustics GmbH, Vienna, Austria) interfaced to a computer with Creative Sound Blaster model Audigy II (Creative Technology Ltd, Jurong East, Singapore). To run the acoustic analysis, the *Multidimensional Voice Program* software, Model 5105 (Kay Elemetrics Corporation, Lincoln Park, NJ) was used. The best vowel /a/ produced was chosen for analysis. The first and the last second from vowel emission was discarded, and then fundamental frequency, jitter, shimmer, noise-to-harmonics ratio, fundamental frequency variability (F_0V), soft phonation index, and voice turbulence index were analyzed.

In addition, MPT was measured using the same software and voice recording equipment. The MPT measures (in seconds) were obtained on the basis of the maximum production of /a/, /s/, /z/, and number counting after a deep breath.

Implementation of VHFO and LaxVox techniques

All subjects performed both VHFO and LaxVox techniques with a washout period of 1 week, to avoid any residual effect. At the first meeting, researcher 3 assigned the subjects to perform the two techniques in a random order using sealed envelopes. Each envelope contained the name of the technique to be performed first. The second technique was performed 1 week later.

For the implementation of both techniques, the subjects were asked to sit with an orthotic position, with calm breathing, and their neck and shoulders relaxed.

FIGURE 1. Subject position during voiced high-frequency oscillation implementation with New Shaker device.

For LaxVox implementation, the water bottle was filled to two thirds of its capacity (510 mL) with water, and the subjects were oriented to keep the LaxVox (silicone tube with 35 cm and 9 mm of internal diameter) 2 cm below the water surface.[14,25] Next, the subject took a deep breath and produced the vowel /u/ at a habitual pitch and loudness making bubbles into the water for 3 minutes.

For VHFO, the subjects were asked to hold the New Shaker device between their lips and parallel to the ground while looking at the horizon. Then the researcher asked the subjects to take a deep breath and produce vowel /u/ at a habitual pitch and loudness, making the steel ball move (Figure 1). This procedure took 3 minutes.[16]

Statistical analysis

Statistical analyses were performed using *Statistica* software, version 10 (Stat Soft Inc., Tulsa, OK). Vocal and laryngeal intensity symptoms, MPT, and acoustic analysis are dependent variables, so the Shapiro-Wilk W test was applied to verify the normality ($P \geq 0.05$) of the data. Next, it was observed that for vocal and laryngeal symptoms, a nonparametric test should be applied, and for MPT and acoustic analysis, a parametric test should be applied. The measures of sensations are independent variables, so a nonparametric test should be applied.

Changes in the vocal and laryngeal symptoms before and after both techniques were compared using the Wilcoxon test. Changes in MPT and acoustic measures were compared using a paired *t* test. Lastly, changes in sensations after both techniques were analyzed using the chi-square test. The significance level was set at $P < 0.05$.

RESULTS

The intensity of vocal and laryngeal symptoms before and after VHFO for women and men are shown in Figures 2 and 3, respectively. There was a significant decrease in the following symptoms in men: painful throat ($P = 0.028$), irritated throat ($P = 0.043$), and low loudness ($P = 0.043$). However, there were no significant changes in the aforementioned symptoms in women.

After LaxVox implementation, there was a significant increase in the high loudness symptom ($P = 0.043$) in women (Figure 4), but not in men (Figure 5).

In women, there were no changes in the MPT after VHFO, but there was an increase in the MPT of /z/ ($P = 0.04$) after LaxVox (Table 1). In men, there was an increase in the MPT of /s/ ($P = 0.03$), /z/ ($P = 0.00$), and the number counting ($P = 0.02$) after VHFO. However, after LaxVox, there were no significant changes in these measures in men (Table 2).

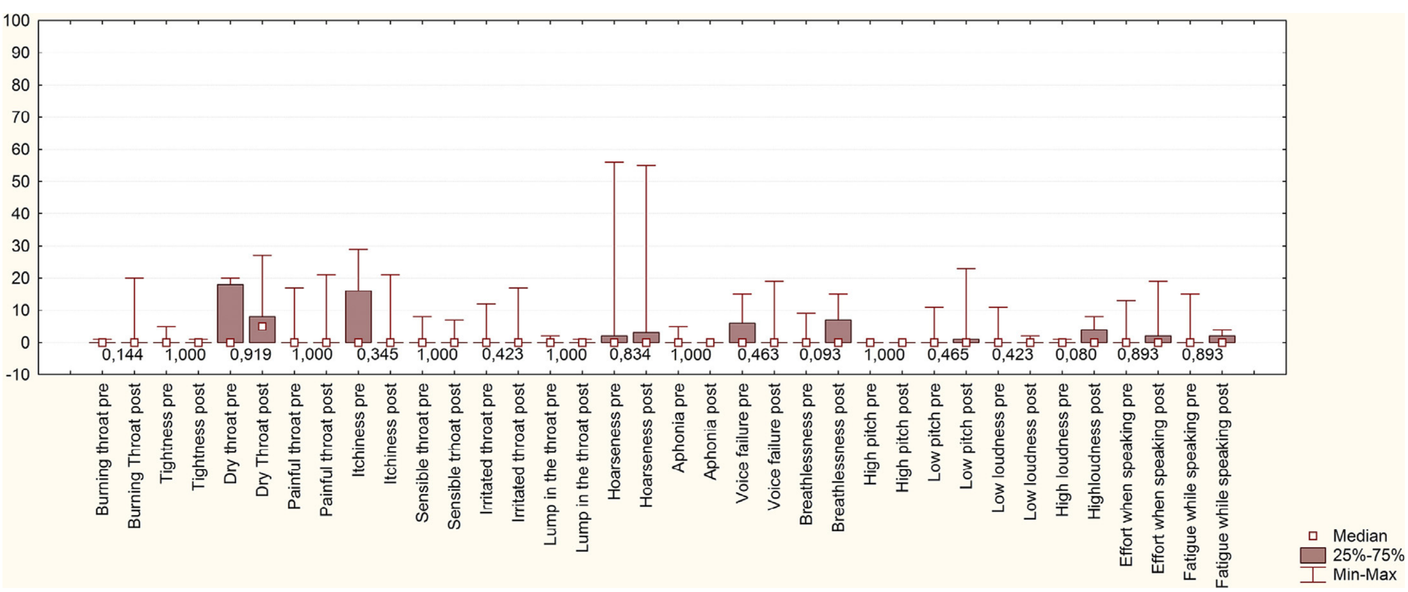

FIGURE 2. Box plot related to intensity of vocal and laryngeal symptoms analysis (values in millimeters) before and after voiced high-frequency oscillation implementation by women.

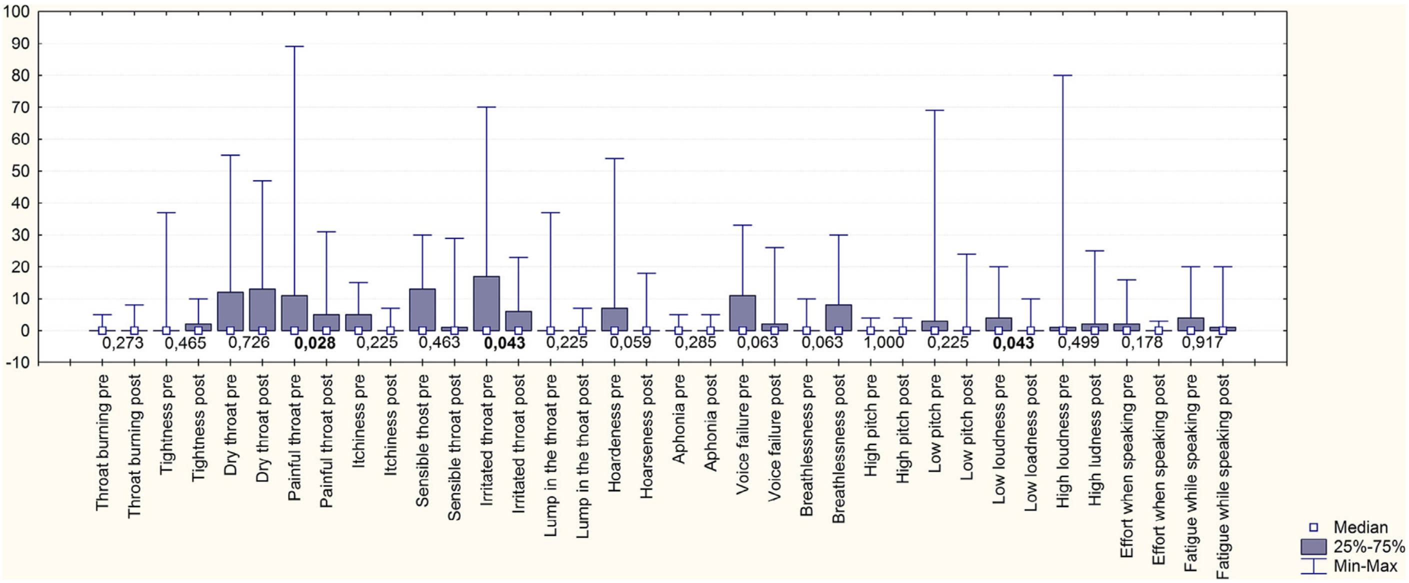

FIGURE 3. Box plot related to intensity of vocal and laryngeal symptoms analysis (values in millimeters) before and after voiced high-frequency oscillation implementation by men.

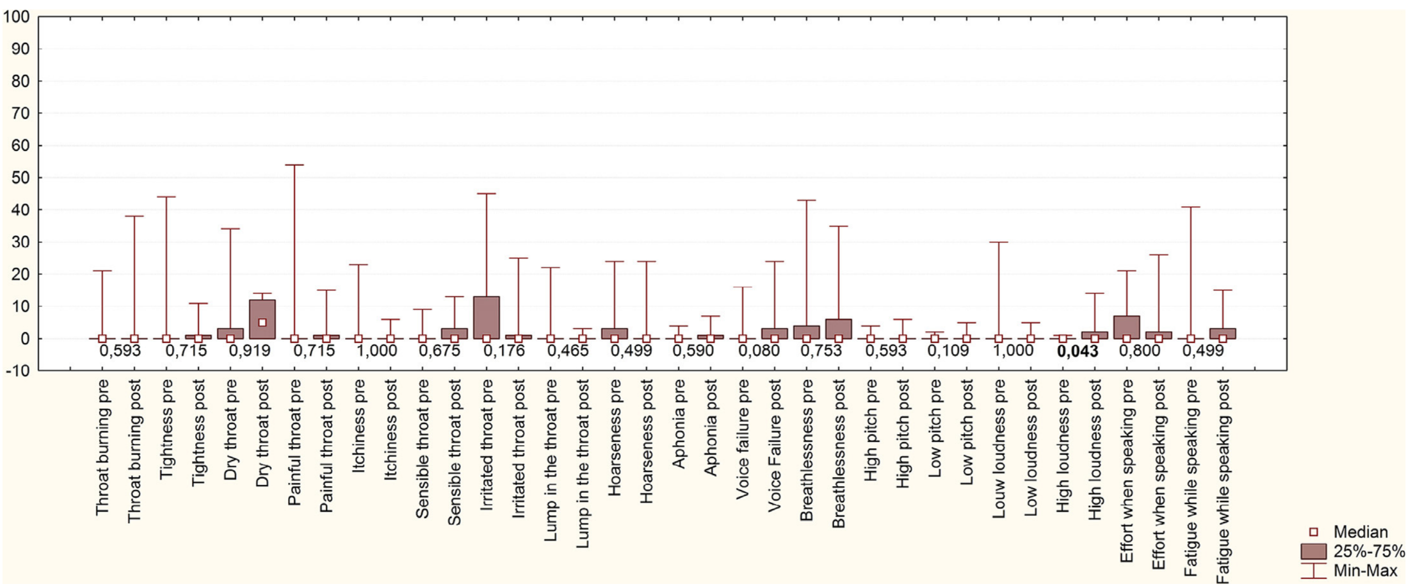

FIGURE 4. Box plot related to intensity of vocal and laryngeal symptoms analysis (values in millimeters) before and after LaxVox implementation by women.

Among the acoustic measures, there was only an increase in the fundamental F_0V in women after VHFO (Table 3). In men, the acoustic measures remained unchanged after both techniques (Table 4).

There were no significant differences in the self-assessment of sensations between men and women (Table 5). However, all subjects affirmed that voice could be produced more easily and firmly, and was soft and constant after both LoxVox and VHFO.

DISCUSSION

This study aimed to verify and compare the immediate effects of VHFO and LaxVox techniques on voice and laryngeal symptoms, acoustic and phonatory measures, and self-assessment.

SOVTEs modify the vocal tract impedance due to an increase in the inertive reactance. Thus, the two systems can exchange energy like a feedback.[26] The semiocclusion can be done using oral articulators such as lips and tongue or using tools, such as straws, resonance tubes, and fingers.[27,28] Moreover, both LaxVox and VHFO techniques have a common characteristic, that is, the static intraoral pressure component produced by semiocclusion. Previous studies[7,29,30] have shown that SOVTEs can be divided into two groups based on the number of oscillatory sources: one vibratory source (steady exercise) and two vibratory sources (fluctuating exercise). Both

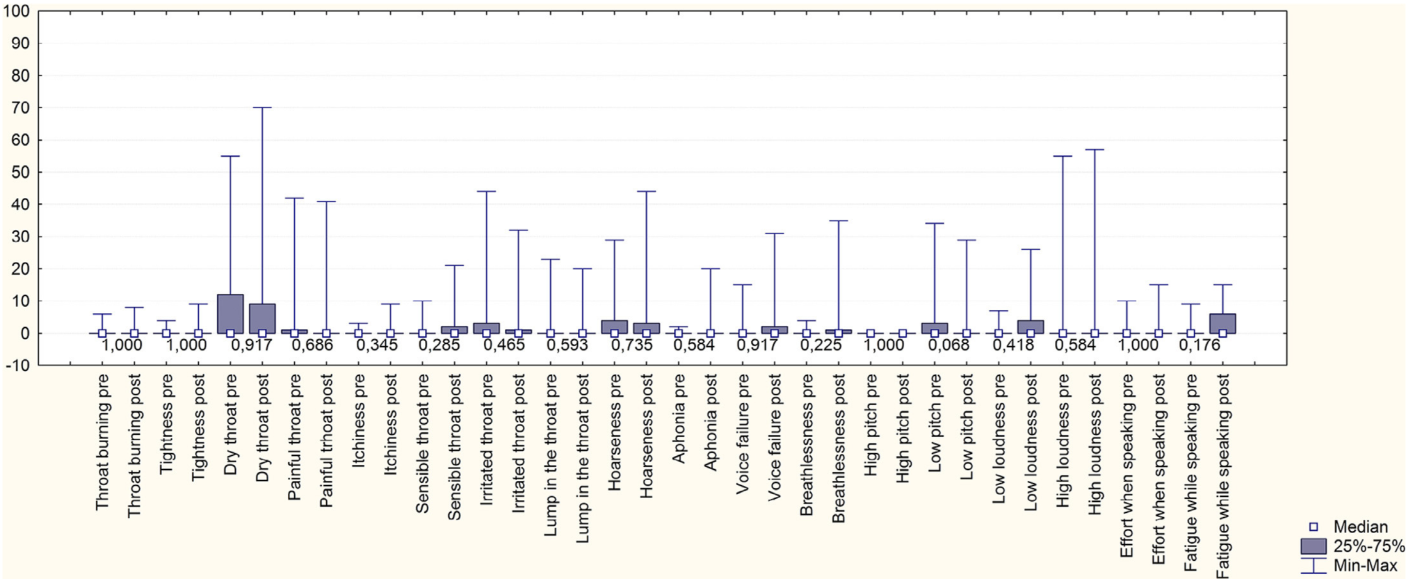

FIGURE 5. Box plot related to intensity of vocal and laryngeal symptoms analysis (values in millimeters) before and after LaxVox implementation by men.

techniques analyzed in this study have a secondary vibration source, and hence are classified as fluctuating exercises.

Despite the participants in this study being vocally healthy, it was decided to investigate the presence of vocal and laryngeal symptoms to verify if these techniques could worsen any symptom. On the other hand, it is possible that vocally healthy subjects have negative vocal and laryngeal symptoms, even without dysphonia.

After performing VHFO, there was a considerable intensity decrease in the painful throat, irritated throat, and low loudness symptoms in men, and an increase in the high loudness symptom in women after LaxVox. These changes could be

TABLE 1.
Mean and SD of the Values, in Seconds, of MPT Before and After Application of the VHFO and LaxVox Technique in Women

MPT Women	VHFO Pre Mean (SD)	VHFO Post Mean (SD)	*P* Value	LaxVox Pre Mean (SD)	LaxVox Post Mean (SD)	*P* Value
/a/	15.13 (4.24)	13.93 (3.36)	0.258	14.06 (3.88)	14.0 (3.27)	0.923
/s/	15.26 (6.27)	15.86 (6.05)	0.613	14.73 (6.36)	14.86 (4.7)	0.882
/z/	14.93 (4.55)	14.53 (4.12)	0.598	14.6 (5.7)	16.4 (5.24)	**0.041***
Number counting	18.86 (5.3)	18.26 (4.6)	0.439	17.93 (4.47)	18.4 (5.98)	0.629

Note: paired *t* test ($P < 0.05$).
* indicates significant differences.
Abbreviation: SD, standard deviation.

TABLE 2.
Mean and SD of the Values, in Seconds, of MPT Before and After Application of the VHFO and LaxVox Technique in Men

MPT Men	VHFO Pre Mean (SD)	VHFO Post Mean (SD)	*P* Value	LaxVox Pre Mean (SD)	LaxVox Post Mean (SD)	*P* Value
/a/	16.13 (5.33)	16.86 (4.96)	0.531	17.2 (5.88)	17.86 (6.68)	0.611
/s/	18.0 (8.7)	20.2 (9.77)	**0.033***	17.26 (7.26)	18.93 (11.17)	0.196
/z/	17.8 (6.62)	20.2 (7.01)	**0.008***	18.46 (7.02)	20.04 (10.5)	0.181
Number counting	19.26 (8.13)	22.13 (8.94)	**0.022***	19.13 (5.27)	22.33 (12.92)	0.298

Note: paired *t* test ($P < 0.05$).
* indicates significant differences.
Abbreviation: SD, standard deviation.

TABLE 3.
Mean and SD of the Acoustic Parameters After VHFO and LaxVox Implementation in Women

Acoustic Parameters	Pre-VHFO Mean (SD)	Post-VHFO Mean (SD)	*P* Value	Pre-LaxVox Mean (SD)	Post-LaxVox Mean (SD)	*P* Value
F0	155.13 (57.05)	156.44 (55.76)	0.380	153.85 (58.59)	151.93 (56.79)	0.140
Shimmer	3.36 (1.35)	3.22 (1.25)	0.986	3.47 (1.17)	3.06 (1.05)	0.225
Jitter	1.23 (1.1)	1.2 (0.73)	0.103	1.28 (0.75)	1.25 (0.82)	0.534
NHR	0.11 (0.03)	0.12 (0.02)	0.057	0.11 (0.03)	0.11 (0.03)	0.214
F_0V	1.11 (0.53)	1.45 (0.62)	**0.028***	1.50 (0.54)	1.39 (0.74)	0.612
VTI	0.04 (0.01)	0.04 (0.01)	0.072	0.04 (0.01)	0.04 (0.01)	0.517
SPI	11.54 (6.15)	15.40 (8.95)	0.178	13.16 (8.34)	17.51 (13.36)	0.272

Note: paired *t* test ($P < 0.05$).
* indicates significant differences.
Abbreviations: F0, fundamental frequency; F_0V, fundamental frequency variability; SPI, soft phonation index; VTI, voice turbulence index.

related to the greater impedance created by these techniques, which allows for a reinforcement of the vocal fold vibration by the increased subglottic pressure.[11,31] The change in vocal tract impedance lowers the phonation threshold pressure, providing vocal economy,[13] and thus allowing the production of a high sound pressure level with less vocal overload.[7,32] In other words, both VHFO and LaxVox provide the production of more sonorous voice with less discomfort.

With regard to the MPT, after LaxVox implementation, there was a significant increase in the MPT of /z/ in women. This suggested that LaxVox technique could improve glottal closure. However, future studies should explore this in dysphonic individuals.

The VHFO technique caused an increase in the MPT of /s/, /z/, and the number counting in men. This technique increases respiratory compliance (lung expansion capacity),[18]

TABLE 4.
Mean and SD of the Acoustic Parameters After VHFO and LaxVox Implementation in Men

Acoustic Parameters	Pre-VHFO Mean (SD)	Post-VHFO Mean (SD)	*P* Value	Pre-LaxVox Mean (SD)	Post-LaxVox Mean (SD)	*P* Value
F0	112.81 (22.08)	117.35 (34.76)	0.311	110.57 (23.28)	110.72 (23.86)	0.921
Shimmer	3.88 (1.58)	3.63 (1.26)	0.527	3.79 (1.4)	3.28 (0.96)	0.086
Jitter	1.38 (1.44)	1.0 (0.66)	0.404	1.09 (0.77)	1.14 (0.9)	0.800
NHR	0.11 (0.02)	0.12 (0.01)	0.085	0.12 (0.03)	0.11 (0.02)	0.115
F_0V	1.51 (1.20)	1.09 (0.49)	0.244	1.32 (0.62)	1.40 (0.74)	0.590
VTI	0.03 (0.01)	0.04 (0.01)	0.100	0.03 (0.01)	0.03 (0.01)	0.199
SPI	29.26 (20.30)	32.56 (17.69)	0.342	21.38 (11.85)	25.31 (13.30)	0.062

Note: paired *t* test ($P < 0.05$).
Abbreviations: F0, fundamental frequency; F_0V, fundamental frequency variability; SPI, soft phonation index; VTI, voice turbulence index.

TABLE 5.
Percent Values After Both Techniques Implementation in Women and Men at self-reported Sensations: Voice, Larynx, Breathing, and Articulation

	Post-VHFO						Post-LaxVox							
	W			M			W			M			*P* Value	
Sensations	+	−	=	+	−	=	+	−	=	+	−	=	W	M
Voice	73.3	6.6	20.0	66.6	13.3	20.0	80.0	6.6	13.3	60.0	6.6	33.3	0.654	0.590
Larynx	40.0	20.0	40.0	33.3	13.3	53.3	26.6	13.3	53.3	26.6	13.3	60.0	0.713	0.906
Breathing	46.6	26.6	26.6	40.0	33.3	26.6	53.3	26.6	20.0	26.6	26.6 6	46.6	0.675	0.511
Articulation	53.3	46.6	0	26.6	6.6	66.6	60.0	0	40	26.6	0	73.3	0.712	0.564

Note: chi-square test ($P < 0.05$).
Abbreviations: +, positive; −, negative; =, no difference; M, men; W, women.

and provides a better balance between the lung aerodynamics and myoelastic forces of the larynx such as SOVTEs. This may explain the increase in the MPT in men observed in this study. We suggest that, an improvement in these parameters indicate the subjects' capacity to control phonation and breathing in the connected speech process.[33]

After VHFO implementation, there was an increase in F_0V in women. This was suggestive of higher vocal instability immediately after the technique, which did not occur in men. VHFO is a fluctuating exercise, which means that it has greater massage effect. Hence, it may cause vocal instability immediately after.

Positive voice-related sensations were observed after VHFO and LaxVox in both men and women, even though the findings were not statistically significant. Other authors who studied SOVTE reported similar findings.[15] These results may be related to the changes in vocal fold vibration patterns caused by the altered vocal tract impedance. Previous studies have shown that individuals with normal voice present clearer, brighter, and more sonorous voice sensations after performing semioccluded treatment exercises.[7,8] We found similar results in our subjects after VHFO.

This study has some limitations. There is a lack of knowledge about the resistance degree to which VHFO causes in the vocal tract unlike it does in resonance tubes.[13,15,30] This knowledge could clarify our findings, and future studies are required to address this. Future studies should also investigate the optimum time of execution for the VHFO technique because it is an unprecedented technique in voice therapy. Optimizing the execution time is important because women and men need different times to perform some techniques[5] to obtain positive effects on voice quality and the vocal tract. Furthermore, because we enrolled healthy individuals, there were no major negative complaints related to the larynx and voice. However, the importance of the present study lies in the basic understanding that VHFO does not harm voice quality, and may have effects similar to those of LaxVox. Hence, VHFO can be used in vocal training. However, future studies are warranted to investigate the application of VHFO in dysphonic individuals for better understanding of its effects on voice changes and applicability in voice therapy. Lastly, research studies comparing VHFO with other SOVTEs, using a computerized model and with participation of other areas such as engineering, or using electroglottography may show resistance and performance of VHFO more accurately with the New Shaker device.

CONCLUSIONS

In conclusion, the VHFO and LaxVox techniques had similar effects on vocal and laryngeal symptoms, as a matter of fact, in terms of phonatory and acoustic measures. With regard to vocal symptoms, VHFO showed better immediate effects in men than in women. As a result, the hypothesis H0 is partially refuted.

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