CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Comparison of the immediate effect of voiced oral high-frequency oscillation and flow phonation with resonance tube in vocally-healthy elderly women

Comparação do impacto imediato das técnicas de oscilação oral de alta frequência sonorizada e sopro sonorizado com tubo de ressonância em idosas vocalmente saudáveis

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Keywords

Voice
Voice Training
Elderly
High-frequency Ventilation
Speech, Language and Hearing Sciences

ABSTRACT

Purpose: To verify and compare the immediate effects of the voiced oral high-frequency oscillation (VOHFO) technique and the phonation into a silicone resonance tube in the elderly self-perception of vocal and laryngeal symptoms and in their voice quality. **Methods:** 14 elderly women, over 60 years old, performed the VOHFO and phonation into a resonance tube technique (35cm in length and 9mm in diameter) with one-week interval between both to avoid carry-over effect. Initially, all participants answered questions regarding the frequency and intensity of their vocal/laryngeal symptoms. Recordings of the sustained vowel /a/ and counting numbers were performed for posterior perceptual and acoustic analyses of the voice quality. The maximum phonation time (MPT) for /a/, /s/, /z/ and counting numbers were also obtained. After that, a draw lot established which technique (VOHFO or resonance tube) would be initially applied for three minutes. After the exercise performance the same procedures were carried out and the elderly women answered a self-assessment questionnaire about the effect of the techniques in her voice, larynx, breathing and articulation. Comparison pre and post each technique were analyzed using ANOVA, Wilcoxon and Mann-Whitney tests. The sensations after the techniques were assessed using the Chi-square test ($p<0.05$). **Results:** The comparison of both techniques showed decrease in roughness and improvement in resonance for counting numbers after the resonance tube and same outcomes post VOHFO. There were no significant differences for the other analyzed variables between groups. **Conclusion:** The phonation into a resonance tube exercise improves the vocal quality of elderly women. In addition, both exercises are similar regarding self-perception of vocal / laryngeal symptoms and sensations post three minutes of the technique, suggesting that VOHFO can be safely applied in voice therapy for this population.

Descritores

Voz
Treinamento da Voz
Idoso
Ventilação de Alta Frequência
Fonoaudiologia

RESUMO

Objetivo: Verificar e comparar os efeitos imediatos da técnica de oscilação oral de alta frequência sonorizada (OOAFS) e sopro sonorizado com tubo de ressonância na autopercepção de sintomas vocais/laríngeos e na qualidade vocal de idosas. **Método:** Participaram 14 mulheres idosas que realizaram as técnicas OOAFS e sopro sonorizado com tubo de ressonância de silicone, com *wash-out* de uma semana. Todas responderam questões sobre frequência e intensidade dos sintomas vocais/laríngeos; foram submetidas à gravação da vogal sustentada /a/ e contagem de números, para análise perceptivo-auditiva e acústica vocal. Foram extraídos os tempos máximos de fonação (TMF). Em seguida, sorteou-se a técnica a ser realizada: OOAFS ou tubo de ressonância, por três minutos em tom habitual. Após exercício, os mesmos procedimentos da avaliação inicial foram repetidos e as idosas responderam a um questionário de autoavaliação sobre os efeitos das técnicas. Os dados foram comparados antes e após aplicação das técnicas por meio dos testes ANOVA, Wilcoxon e Mann-Whitney; para as sensações vocais após técnicas, aplicou-se teste Quiquadrado($p<0,05$). **Resultados:** Ao comparar as técnicas, verificou-se diminuição da rugosidade e melhora da ressonância na contagem dos números após tubo de ressonância e manutenção dos resultados após OOAFS. Não houve mais diferenças significantes para as demais variáveis estudadas entre os grupos. **Conclusão:** O sopro sonorizado com tubo de ressonância melhora a qualidade vocal de mulheres idosas. Além disso, ambos os exercícios apresentaram semelhanças na autopercepção dos sintomas vocais/laríngeos e sensações, sugerindo que a OOAFS é segura e pode ser empregada na terapia de voz nesta população.

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Received: March 14, 2019

Accepted: August 09, 2019

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Financial support: nothing to declare.

Conflict of interests: nothing to declare.

INTRODUCTION

The natural voice aging occurs progressively and parallel to other body functions; it is influenced by personal lifestyle throughout life, and to the person's anatomy and physiology[1].

The literature describes changes in the elderly voice quality characterized by increased breathiness, roughness and instability, more nasality, reduced rate of articulation, reduced respiratory efficiency and maximum phonation time, in addition to higher fundamental frequency for men and lower fundamental frequency for women[2].

The aging in the larynx structure and functionality causes calcification and ossification of the laryngeal cartilages, with reduced mobility, followed by possible atrophy and changes in vocal fold cover, which leads to the occurrence of spindle-shaped vocal fold closure pattern. In order to balance changes in the vocal fold, this population may also have supraglottic closure[3]. These vocal and laryngeal changes in the aging process may interfere with physical functioning, and there is a high tendency of avoiding social contacts[4] which will negatively impact the elderly's quality of life[5].

Thus, vocal exercises are necessary in order to minimize vocal alterations due to the aging effect and to guarantee a comfortable phonation, therefore improving oral communication and, consequently, the elderly quality of life. For elderly individuals, vocal exercises aim to improve glottal closure, increase subglottic pressure and vocal loudness, improve vocal coordination, as well as glottal competence and vocal tract expansion, stimulate resonance, and improve pneumophonoarticulatory coordination[6,7]. It is noteworthy the lack of studies that address to the vocal exercise effects in this population[7,8].

Hence, semi-occluded vocal tract exercises (SOVTEs) are being used to improve the vocal quality and the functionality of the larynx and the vocal folds during phonation[7-9]. When performing a SOVTE, the anterior region of the vocal tract becomes partially occluded. This increases the source-filter interaction, increases the glottic and supraglottic pressure and, therefore, decreases the collision between the vocal folds, producing a massage effect[10], which favors a more efficient and economical vocal production due to retroflex resonance[11]. A study with 33 healthy elderly, observed positive immediate effects on the vocal quality after one minute of the SOVTE with sounded blowing exercise added to no self-perceived vocal changes[7]. Similar was observed in another study with the elderly in which, after six vocal sessions using the Finnish tube, there was an improvement in almost all of the GRBASI scale parameters, except for breathiness and the vital capacity[8].

Many authors of the speech language pathology field have been seeking for new therapy techniques, thus the voiced oral high-frequency oscillation (VOHFO) was proposed[12,13]. This exercise is performed using a device called New Shaker®. The authors investigated the VOHFO effects on dysphonic and non-dysphonic individuals and observed that this technique improves the source-filter interaction and can be compared with the semi-occluded vocal tract exercises. Inside the New Shaker® there is a high-density stainless-steel ball supported by a circular cone[14], when the patient blows into the device, this steel ball vibrates at a frequency of approximately 15 to 30 Hz (Hertz) and this vibration generated more than 70 oscillatory movements per minute in the lung, according to the air flow and the inclination of the device, which will cause air flow and vibration variation through all respiratory system[15], including the larynx[12]. Therefore, exercises that use this device associated with phonation, can be considered similar to SOVTEs[12,13]. One of this study motivations and hypotheses was that, perhaps, the performance of VOHFO with New Shaker® could be easier for the elderly, considering the muscle conditions of the phonoarticulatory structures with the aging effect.

Only two studies of the voice field investigated the effects of the VOHFO. One of the studies was with dysphonic adults[14]; this study observed improvement in laryngeal symptoms in women and improvement in vocal symptoms in men three minutes post technique. The other study compared the effects of resonance tube and VOHFO in vocal-healthy individuals[15]; the outcomes showed that both techniques had similar effects, however, VOHFO had better effects for men than for women. It is noteworthy that, to the best of our knowledge, there are no studies that verified the immediate effects of VOHFO in the elderly population.

Taking this into account, the aim of the present study was to verify and compare the immediate effect of the voiced oral high-frequency oscillation (VOHFO) technique and the phonation into a silicone resonance tube in the elderly self-perception of vocal and laryngeal symptoms and in their voice quality.

METHODS

The present study was approved by the Committee for Ethics in Research under the protocol number 2.147.815 and all participants signed an informed consent form, after being informed of the study procedures.

Study design

This is a blind crossover study with one-week washout period.

Sample calculation

The sample size calculation was performed in a pilot study that had data from five elderly women and all variables were analyzed. The estimation method considered the highest standard deviation of the difference between the pre- and post-exercise moments of the fundamental frequency, which was 14.37Hz. The significance level was set at 5% and the test power at 80% to detect a minimum difference between both evaluation moments equal to a standard deviation; the required sample size was ten participants. Considering an estimated sample loss of 20%, the required sample size was set at 12 participants.

Sample

The study included 14 elderly women over 60 years old (average age of 70.12 years); they were invited to participate by the researchers and self-reported good general and vocal health. The study decided to include only women in its investigation of

the effects of vocal exercises, once elderly men usually do not collaborate in studies and women have longer life expectancy.

The exclusion criteria were: elderly women with vocal complaints, upper airway disorders, self-reported hearing loss, heart and lung problems, and elderly women who had previously undergone vocal therapy or laryngeal surgery. Also, the study did not include smokers and alcoholics.

The elderly answered a self-assessment questionnaire to evaluate possible laryngeal and vocal symptoms and their voice was recorded for further perceptual judgement and acoustic analysis of the voice quality.

The questionnaire was answered at the Speech Language Pathology Clinic (*Clínica de Fonoaudiologia*) of the institution and it addressed to questions regarding presence or absence of self-reported vocal complaints, vocal/laryngeal signs and symptoms, vocal and health habits and aspects related to general health. This data was considered to characterize the study sample.

Researchers team

The study data collection was carried out by three researchers: researcher 1 - was responsible for the voice recordings pre and post technique; researcher 2 - was responsible for the application of the questionnaire and researcher 3 - was responsible for performing the vocal techniques (VOHFO and resonance tube), this researcher was not present at the moment of the other evaluations.

Procedures

Vocal and laryngeal symptoms

The elderly answered to the Screening Index for Voice Disorder protocol - SIVD[16] that addressed to aspects related to frequency of vocal symptoms and laryngeal-pharyngeal sensations. They had to report the frequency of each symptoms considering the last 12 months using a four-point Likert scale (0 = never, 1 = sometimes, 2 = almost always and 3 = always). The aim of this evaluation was to characterize the study sample.

To investigate the intensity of vocal symptoms and laryngeal-pharyngeal sensations, an eleven-point numerical scale (0 to 10) was used, in which the elderly had to characterized their intensity sensation of each symptoms, where "0" referred to very low/no intensity and "10" to very high intensity[12,13]. The vocal symptoms and laryngeal-pharyngeal sensations were the same investigated in the SIVD protocol. This scale was applied to compare the intensity pre and post the vocal techniques.

Vocal evaluation

The voice recording took place at an acoustic treated room, the voice lab of the Speech Language Pathology Clinic (*Clínica de Fonoaudiologia*). The recordings were performed using Audacity professional audio editing software, the samples were digitized at 44.100 Hz rate and resolution of 16 bits, mono channel using Shure microphone, model SM58, coupled to the Maudio MA41 interface. The participants were asked to say, in a comfortable pitch, loudness and speed, the vowel /a/ as long as possible after a deep inspiration and to count the numbers one to ten.

Perceptual judgement of vocal quality

The voice sample of the pre and post VOHFO and resonance tube moments were randomly paired. The perceptual judgement of the voice quality was performed by one speech language pathologist voice specialist with experience in the voice field and blinded regarding the study procedures and the voice recording moment, pre or post technique. The voice specialist had to decide for the best of the two emissions or judge them to be similar considering: overall voice quality, roughness, breathiness, strain, instability, pitch and loudness for the vowel /a/ and the resonance for counting numbers. To analyze the intra-rater reliability, 20% of the sample was repeated.

Acoustic analysis

The acoustic voice analysis was performed using the Multi-Dimensional Voice Program – MDVP - Model 5105 by Kay Elemetrics (Kay Elemetrics Corporation, Lincoln Park, NJ). This analysis counted with the best 3s of the vowel /a/, eliminating the beginning and the end of the emission. The analyzed parameters were: fundamental frequency (f0), jitter (%), shimmer (%), harmonic-to-noise ratio (HNR), voice turbulence index (VTI), soft phonation index (SPI), fundamental frequency-tremor frequency (Fftr) and fundamental frequency-tremor intensity index (FTRI).

Aerodynamic

The aerodynamic analysis was performed considering the maximum phonation time (MPT) of the vowel /a/, the fricative sounds /s/ and /z/ and counting numbers. To perform this task the elderly had to say each one of these sounds after performing a deep inspiration, without expiratory reserve air. The MPT for each task was measured using the Audacity software.

Self-reported sensations post vocal techniques

After performing the techniques for three minutes, the elderly woman had to report if she felt any sensation regarding her voice, larynx, breathing and articulation. She had also to classify this sensation as "positive", "negative" or "no difference". If a positive or negative sensation was reported, it had to be described.

Performing the techniques

The sequence that each participant would perform the exercises, that is, first the VOHFO and then the phonation into a resonance tube or vice-versa, was randomly defined by draw lots. In other words, this draw lot established which technique would be performed in the first session and, consequently, which technique would be performed in the following session. Between the performance of both techniques, there was at least one week and at maximum two weeks washout period to avoid carry-over effect.

Voiced Oral High-Frequency Oscillation (VOHFO)

The VOHFO was performed using the New Shaker® device for three minutes[12,13]. The elderly woman performed the technique while sitting in a chair, with an upright posture, breathing normally and keeping neck and shoulders relaxed. The elderly was asked to hold the New Shaker® with one hand and to support the mouthpiece between the lips at a 90° angle in relation to the philtrum, making the /u/ vowel sound at a comfortable pitch and loudness. Before performing the exercise, the participants were guided and trained on how to handle the device, as well on how to perform the VOHFO.

Sounded blowing exercise into a resonance tube

The sound blowing technique was performed into a latex tube; the tube was 35cm long and had an internal diameter of 9mm. The technique was performed for three minutes. The elderly woman performed the technique while sitting in a chair, with an upright posture, breathing normally and keeping neck and shoulders relaxed. The elderly was asked to hold a bottle of water with the latex tube in it; her head could not bend down and they had to look to the horizon. A 510 mL plastic bottle was used, it was half filled up and the tube was submerged 2cm below the water surface[14].

The elderly women were instructed on how to correctly manipulate the instrument and, to inhale and then exhale through the mouth producing the vowel /u/ in a comfortable pitch and loudness. As in the VOHFO technique, the participants were guided and trained on how to handle the device.

Data analysis

The data were analyzed using Statistica® 17.0 software. "Acoustic analysis" and "maximum phonation time" are quantitative variables and "sensations" is a qualitative variable. For the quantitative variables, the Shapiro-Wilk test was used to test for normal distribution ($p < 0.05$). The two-way ANOVA parametric test was used to compare the exercises and the evaluation moments of these variables.

The Wilcoxon test was used to compare the intensity of vocal symptoms and laryngeal-pharyngeal sensations pre and post techniques (this variable did not present normal distribution); and the Mann-Whitney test was used to compare the exercises. The chi-square test was used to compare the exercises for the qualitative variable "sensations".

For all statistical analysis the level of significance was set at 95% ($p<0.05$).

RESULTS

Chart 1 shows the frequency of vocal symptoms and laryngeal-pharyngeal sensations reported by the elderly. Most of the elderly women reported not having such symptoms, however, it is noteworthy that 30% to 40% of the elderly women reported "phlegm", "dry cough" and "dry throat".

Table 1 shows the results regarding the intensity of vocal symptoms and laryngeal-pharyngeal sensations pre and post both techniques. No differences were observed after the exercises and there was no difference between both techniques.

Table 2 shows the results regarding the perceptual judgement of the voice quality for the sustained vowel /a/ and counting numbers. The groups were different regarding "roughness" ($p = 0.039$) and "resonance" ($p = 0.044$) in counting numbers. Considering the VOHFO, roughness and resonance were similar pre and post technique; considering the resonance tube, roughness and resonance were better post technique.

The Cohen's Kappa coefficient was used to analyze the intra-rater reliability that was 0.89 (89.29%) - almost perfect - for the vowel /a/ and 0.63 (64.29%) - substantial - for counting numbers[17].

Table 3 shows the results of the acoustic analysis. No significant differences were observed pre and post techniques, neither between VOHFO and resonance tube.

Table 4 shows the results of the maximum phonation time (MPT). No significant difference was observed between the techniques and between groups.

Table 5 shows the results of the self-reported sensations after performing the VOHFO and resonance tube techniques. No differences were observed between the sensations reported before and after both techniques. However, most elderly women reported positive or neutral sensations on their voice, larynx and breathing, after VOHFO and resonance tube techniques.

Chart 2 shows the main sensations reported by the elderly after performing the techniques. No negative sensation in the

Chart 1. Frequency, in percentage, of vocal symptoms and laryngeal-pharyngeal sensation reported by the elderly women

Symptom	Frequency			
	Never (0)	Sometimes (1)	Almost always (2)	Always (3)
Hoarseness	62.5% (10)	18.75% (3)	18.75% (3)	0% (0)
Voice loss	81.25% (13)	6.25% (1)	12.5% (2)	0% (0)
Breaking voice	87.5% (14)	0% (0)	12.5% (2)	0% (0)
Low-pitched voice	75% (12)	6.25% (1)	12.5% (2)	6.25% (1)
Phlegm	43.75% (7)	12.5% (2)	31.25% (5)	12.5% (2)
Dry cough	25% (4)	25% (4)	43.75% (7)	6.25% (1)
Cough with secretion	68.75% (11)	31.25% (5)	0% (0)	0% (0)
Pain when speaking	87.5% (14)	12.5% (2)	0% (0)	0% (0)
Pain when swallowing	68.75% (11)	25% (4)	6.25% (1)	0% (0)
Throat secretion	68.75% (11)	6.25% (1)	18.75% (3)	6.25% (1)
Dry throat	18.75% (2)	31.25% (5)	43.75% (7)	6.25% (1)
Fatigue when speaking	68.75% (11)	12.5% (2)	6.25% (1)	12.5% (2)

Table 1. Intensity of vocal symptoms and laryngeal-pharyngeal sensations pre and post both techniques

Symptoms	Groups	Pre-technique			Post-technique			p-value*	Difference among groups	
		Mean	SD	Median	Mean	SD	Median			p-value**
Hoarseness	VOHFO	1.21	2.26	0.00	0.79	2.39	0.00	0.336	-0.43	0.436
	Resonance tube	0.93	2.43	0.00	1.07	2.53	0.00	0.414	0.14	
Voice loss	VOHFO	0.00	0.00	0.00	0.07	0.27	0.00	0.317	0.07	0.317
	Resonance tube	0.00	0.00	0.00	0.00	0.00	0.00	1.000	0.00	
Breaking voice	VOHFO	0.07	0.27	0.00	0.21	0.58	0.00	0.157	0.14	0.549
	Resonance tube	0.07	0.27	0.00	0.14	0.53	0.00	0.317	0.07	
Low-pitched voice	VOHFO	1.14	2.35	0.00	1.29	2.52	0.00	1.000	0.14	0.507
	Resonance tube	1.00	2.22	0.00	1.57	2.65	0.00	0.496	0.57	
Phlegm	VOHFO	1.29	2.67	0.00	0.93	2.23	0.00	0.131	-0.36	0.898
	Resonance tube	1.00	2.48	0.00	0.14	0.53	0.00	0.180	-0.86	
Dry cough	VOHFO	0.00	0.00	0.00	0.21	0.58	0.00	0.180	0.21	0.521
	Resonance tube	0.00	0.00	0.00	0.07	0.27	0.00	0.317	0.07	
Cough with secretion	VOHFO	0.29	1.07	0.00	0.07	0.27	0.00	0.317	-0.21	0.959
	Resonance tube	0.21	0.80	0.00	0.07	0.27	0.00	0.317	-0.14	
Pain when speaking	VOHFO	0.14	0.53	0.00	0.29	0.83	0.00	0.157	0.14	0.087
	Resonance tube	0.21	0.80	0.00	0.14	0.53	0.00	0.317	-0.07	
Pain when swallowing	VOHFO	0.21	0.58	0.00	0.21	0.58	0.00	1.000	0.00	0.630
	Resonance tube	0.21	0.80	0.00	0.36	0.74	0.00	0.414	0.14	
Throat secretion	VOHFO	0.71	2.16	0.00	0.57	1.87	0.00	0.157	-0.14	0.585
	Resonance tube	0.50	0.94	0.00	0.21	0.58	0.00	0.157	-0.29	
Dry throat	VOHFO	0.86	1.66	0.00	0.43	0.76	0.00	0.285	-0.43	0.908
	Resonance tube	0.79	1.48	0.00	0.71	1.20	0.00	0.892	-0.07	
Fatigue when speaking	VOHFO	0.43	1.16	0.00	0.93	1.90	0.00	0.102	0.50	0.386
	Resonancetube	0.43	1.16	0.00	0.50	1.092	0.00	0.564	-0.07	

*Wilcoxon test; **Mann-Whitney test ($p<0.05$)
Caption: SD = Standard deviation

Table 2. Comparison of the voice quality parameters perceptually judged considering the sustained vowel /a/ and the counting numbers in the elderly post VOHFO and resonance tube techniques

Vocal parameters		Vowel /a/				Counting numbers			
		Worst	Better	Similar	p	Worst	Better	Similar	p-value*
Overall voice quality	VOHFO	0% (0)	28.6% (4)	71.4% (10)	0.267	14.3% (2)	7.1% (1)	78.6% (11)	0.088
	Resonance tube	14.3% (2)	35.7% (5)	50% (7)		0% (0)	35.7% (5)	64.3% (9)	
Roughness	VOHFO	28.6% (4)	35.7% (5)	35.7% (6)	0.746	21.4% (3)	7.1% (1)	71.4% (10)	**0.039***
	Resonance tube	21.4% (3)	28.6% (4)	50% (7)		7.1% (1)	50.0% (7)	42.9% (6)	
Breathiness	VOHFO	7.1% (1)	35.7% (7)	57.1% (8)	0.697	28.6% (4)	28.6% (4)	42.9% (6)	0.587
	Resonance tube	7.1% (1)	35.7% (5)	57.1% (8)		14.3% (2)	42.9% (6)	42.9% (6)	
Strain	VOHFO	14.3% (2)	21.4% (3)	64.3% (9)	0.449	21.4% (3)	50% (7)	28.6% (4)	0.186
	Resonance tube	14.3% (2)	42.9% (6)	42.9% (6)		0% (0)	64.3% (9)	35.7% (5)	
Instability	VOHFO	21.4% (3)	0% (0)	78.6% (11)	0.325	-	-	-	-
	Resonance tube	14.3% (2)	14.3% (2)	71.4% (10)		-	-	-	-
Resonance	VOHFO	-	-	-	-	21.4% (3)	35.7% (5)	42.9% (6)	**0.044***
	Resonance tube	-	-	-	-	0% (0)	78.6% (11)	21.4% (3)	
Pitch	VOHFO	0% (0)	14.3% (2)	100% (14)	0.142	0% (0)	0% (0)	100% (14)	0.309
	Resonance tube	0% (0)	0% (0)	87.5% (12)		7.1% (1)	0% (0)	92.9% (13)	
Loudness	VOHFO	0% (0)	28.6% (4)	71.4% (10)	0.139	14.3% (2)	28.6% (4)	57.1% (8)	0.641
	Resonance tube	0% (0)	7.1% (1)	92.5% (13)		14.3% (2)	14.3% (2)	71.4% (10)	

*$p<0.05$ Chi-square test
Caption: % = percentage of elderly women

Table 3. Comparison of the voice quality acoustic parameters pre and post VOHFO and resonance tube techniques in elderly women

Acoustic	Moment	Pre		Post		Effect	p-value*
		Mean	SD	Mean	SD		
f0	VOHFO	194.202	29.075	194.986	29.209	Exercise	0.776
	Resonance tube	195.371	34.693	191.049	27.035	Moment	0.827
						Exercise Vs Moment	0.943
Fftr	VOHFO	4.916	4.414	3.906	0.641	Exercise	0.900
						Moment	0.906
	Resonance tube	3.990	1.542	5.267	3.038	Exercise Vs Moment	0.332
Jitter	VOHFO	1.201	1.014	1.144	0.897	Exercise	0.623
						Moment	0.943
	Resonance tube	1.135	0.857	1.481	1.086	Exercise Vs Moment	0.117
Shimmer	VOHFO	4.240	2.468	4.454	3.086	Exercise	0.548
						Moment	0.406
	Resonance tube	3.338	1.804	3.343	1.629	Exercise Vs Moment	0.792
NHR	VOHFO	0.142	0.023	0.142	0.031	Exercise	0.829
						Moment	0.056
	Resonance tube	0.142	0.028	0.142	0.020	Exercise Vs Moment	0.784
VTI	VOHFO	0.052	0.021	0.052	0.012	Exercise	0.454
						Moment	0.586
	Resonance tube	0.048	0.021	0.043	0.014	Exercise Vs Moment	0.966
SPI	VOHFO	8.065	7.175	6.268	4.599	Exercise	0.383
						Moment	0.818
	Resonance tube	11.539	12.059	15.403	17.730	Exercise Vs Moment	0.358
FTRI	VOHFO	0.362	0.088	0.507	0.405	Exercise	0.134
						Moment	0.634
	Resonance tube	0.818	0.789	0.588	0.100	Exercise Vs Moment	0.300

*p<0.05 Two-way ANOVA parametric test and Tukey test
Caption: f0=fundamental frequency; SD = standard deviation; Fftr = frequency-tremor frequency; VTI = voice turbulence index; NHR=noise harmonic ratio; SPI = soft phonation index; FTRI = fundamental frequency-tremor intensity index

Table 4. Maximum phonation time (MPT) values pre and post VOHFO and resonance tube

MPT	Moment	Pre		Post		Effect	p-value*
		Mean	SD	Mean	SD		
/a/	VOHFO	13.06	3.99	13.29	4.31	Exercise	0.441
	Resonance tube	14.57	4.77	14.19	5.19	Moment	0.299
						Exercise Vs Moment	0.413
/s/	VOHFO	8.64	2.75	8.33	2.77	Exercise	0.952
	Resonance tube	8.59	2.38	9.44	3.46	Moment	0.183
						Exercise Vs Moment	0.094
/z/	VOHFO	9.77	2.96	10.27	2.98	Exercise	0.923
	Resonance tube	9.80	2.81	10.87	3.28	Moment	0.581
						Exercise Vs Moment	0.593
Numbers	VOHFO	14.21	4.59	15.47	5.23	Exercise	0.692
	Resonance tube	16.10	4.48	15.52	4.46	Moment	0.776
						Exercise Vs Moment	0.148

* p<0.05 Two-way ANOVA parametric test and Tukey test
Caption: SD = standard deviation; MPT = maximum phonation time

Table 5. Comparison of the self-reported sensations post VOHFO and resonance tube

Sensation	VOHFO			Resonance tube			p-value*
	Positive	Negative	No difference	Positive	Negative	No difference	
Voice	50% (7)	14.3% (2)	35.7% (5)	64.3% (9)	7.1% (1)	28.7% (4)	0.707
Larynx	64.3% (9)	14.3% (2)	21.4% (3)	57.1% (8)	21.4% (3)	21.4% (3)	0.879
Breathing	35.7% (5)	0% (0)	64.3% (9)	50% (7)	14.3% (2)	35.7% (5)	0.176
Articulation	14.3% (2)	0% (0)	85.7% (12)	50% (7)	0% (0)	50% (7)	0.103

* p<0.05 Chi-square test
Caption: % = percentage of elderly women

Chart 2. Main sensation reported by the elderly women post VOHFO and resonance tube techniques

Technique	POSITIVE SENSATIONS				NEGATIVE SENSATIONS		
VOHFO	**Voice = 7 (100%)**	**Larynx = 9 (100%)**	**Breathing = 5 (100%)**	**Articulation = 1 (100%)**	**Voice = 2 (100%)**	**Larynx = 2 (100%)**	**Breathing = 0 (100%)**
	Clearer 1 (14.28%)	Cleaner = 4 (44.45%)	More breath = 2 (40%)	Easier = 1 (50%)	Rougher = 1 (50%)	Sore = 1 (50%)	
	Cleaner = 3 (42.86%)	Lighter and relaxed = 2 (22.22%)	Easier = 1 (20%)	Clearer = 1 (50%)	More tired = 1 (50%)	Fatigue = 1 (50%)	
	Higher pitch = 1 (14.28%)	More opened = 2 (22.22%)	Lighter = 2 (40%)				
	Stronger = 2 (28.58%)	Stronger = 1 (11.11%)					
Resonance tube	**Voice = 9 (100%)**	**Larynx = 8 (100%)**	**Breathing = 7 (100%)**	**Articulation= 7 (100%)**	**Voice = 1 (100%)**	**Larynx = 3 (100%)**	**Breathing = 2 (100%)**
	Clearer = 1 (11.11%)	More opened = 1 (12.5%)	Easier = 3 (42.86%)	Easier to speak = 6 (85.72%)	More tired = 1 (100%)	Dry = 1 (33.3%)	Less breath = 1 (50%)
	Cleaner = 4 (44.45%)	Cleaner = 6 (75%)	Cleaner = 1 (14.28%)	"Softer" = 1 (14.28%)		Burning = 1 (33.3%)	More tired = 1 (50%)
	Easier and opened = 3 (33.33%)	More relaxed/ opened = 1 (12.5%)	More breath = 3 (42.86%)			Itching = 1 (33.3%)	
	Stronger = 1 (11.11%)						

articulation was reported after VOHFO and resonance tube techniques. It is noteworthy that the elderly women could report more than one sensation for each investigated aspect.

DISCUSSION

Aging is a natural process in humans that causes changes in the laryngeal structures, which can negatively impact the vocal quality. However, very few studies have analyzed the elderly population; thus, it is important to investigate the effects of vocal exercises and bring scientific evidence regarding the resources used in the clinical practice with the elderly and to verify the safety of these exercises.

The presence and frequency of vocal symptoms and laryngeal-pharyngeal sensations were investigated in order to characterize the population of the present study (Chart 1). Most of the elderly denied the presence of these symptoms. However, 30% to 40% of the elderly women reported "phlegm", "dry cough" and "dry throat". These symptoms may be related to reduced hydration and lubrication[18], as well as anatomo-physiological changes in the vocal fold mucosa (lamina propria)[19], respiratory and phonatory system[20].

Another aspect evaluated in this study was the intensity of vocal symptoms and laryngeal-pharyngeal sensations pre and post performing both techniques; no difference was observed (Table 1). Previous study with 42 elderly observed fewer vocal symptoms and vocal complaints in 90% of the sample after six speech language pathology sessions using the "Finnish" resonance tube[8].

To the best of our knowledge, there are no studies that investigated the effects of VOHFO and resonance tube in vocal and laryngeal symptoms in the elderly. However, a study compared the effects of VOHFO with silicone resonance tube in vocal-healthy individuals[14] and observed decrease in sore throat and softer vocal loudness in men and stronger vocal loudness in women post VOHFO. The authors believe that such effects may be related to the higher impedance created by the vocal techniques improving vocal fold vibration due to higher subglottic pressure.

Regarding the elderly women vocal quality, less roughness and stronger vocal loudness were observed after performing the sounded blowing exercise into a resonance tube (Table 2). Roughness is present in elderly women, probably due to postmenopausal metabolic syndrome and hormonal changes that make the vocal fold thicker[21], which may lead to changes in the mucosal wave vibration. After three minutes of performing sounded blowing exercise, there might occur an improvement in the mucosal wave vibration justified by the physiology of this exercise, that is considered to be a SOVTE[11,12]. When blowing a silicone tube submerged 2cm below the water surface in a bottle of water, the vocal tract expands and serves as a filter for the sound produced in the vocal fold[22]. In addition, it is assumed that the resistance offered by this exercise when blowing the tube, generates a retroflex resonance, decreases the vocal tract strain, once it expands and improves respiratory ventilation, which will also decrease the vocal roughness and improve the vocal loudness. Such effects were also observed in previous study with individuals that had muscle tension dysphonia and performed humming exercise, also considered an SOVTE[23].

Regarding the exercise effects in the elderly population, Siracusa et al.[7] observed the immediate effect of sounded blowing exercise in the elderly and reported no differences in the perceptual judgement of the voice quality after one minute of its performance. It is noteworthy that the present study and Siracusa et al.[7] paper, did not verify if the participants had presbyphonia and presbylarynx, since no laryngeal examination was performed, as this was not the studies' objectives. Perhaps

further studies could investigate the effects of phonation into a resonance tube and VOHFO with New Shaker® in elderly with presbyphonia and investigate more deeply aspects related to the duration of the vocal exercises in this population.

No differences were observed after performing the VOHFO with the New Shaker® device (Table 2). This might have occurred due to the short duration - three minutes - of the exercises, thus, not enough to promote vocal changes. Therefore, further studies should analyze this technique with different durations in the elderly population. However, it is noteworthy that the voice quality did not get worse but maintained its characteristics, which can be considered positive, since this study also analyzed the safety of this new technique.

Regarding the acoustic parameters, no changes were observed post both techniques (Table 3). Perhaps the performance for only three minutes is insufficient to modify acoustic parameters when it comes to the elderly population. This result does not corroborate with previous studies that investigated the effects of VOHFO with New Shaker® in adults with and without vocal alteration[12,13]. These authors reported significant increase in the fundamental frequency in women[12,13] and in men without vocal complaints and in the voice turbulence index (VTI) in vocally healthy women[12]. Moreover, women without vocal complaint had a decrease in the soft phonation index (SPI) while women with vocal complaint had an increase in the SPI.

Similarly, another study with 23 singers analyzed the immediate effect of SOVTEs with LaxVox® tube after three minutes[9] and observed increase in the fundamental frequency for women and reduction in the Glottal to Noise Excitation Ratio (GNE), however, this study performed the exercise including frequency variations. No studies that investigated the acoustic assessment changes in the elderly population immediately after performing a vocal exercise were found. The closer to this was a brief communication about cognitive therapy in three elderly individuals[24] who performed six vocal therapy sessions including different vocal exercises; the outcomes showed improvement in jitter and HNR.

Regarding the maximum phonation time (MPT), no significant changes were observed after VOHFO and resonance tube (Table 4), which is in accordance to Saters et al.[12], study that also did not observe changes in sustained emissions after VOHFO. Another study with nine elderly[25] performed the Vocal Function Exercise (VFE) in a six-week therapy program (six sessions with 60 minutes); the authors found no significant changes in the acoustic parameters, MPT and visual-perceptual evaluations of laryngeal images after the program. On the other hand, a study with vocally healthy adults, observed longer MPT in the fricatives /s/, /z/ and in counting numbers post VOHFO, with no significant differences post SOVTEs with LaxVox®[13] tube. The present study hypothesis was that the techniques would increase the MPT, once the aim of the New Shaker® device is to improve pulmonary functionality and that phonation into the resonant tube stimulates the airflow[26] improving glottic closure. Perhaps the duration of the techniques was insufficient to improve respiratory support and provide balance of aerodynamic and myoelastic forces in elderly women. Thus, further studies may improve this scientific evidence by testing these techniques performance for longer duration in the elderly, hence, establish the optimal duration of these techniques in the vocal clinic for this specific population.

It is noteworthy that some elderly women had difficulties to maintain the techniques in MPT and reported tiredness. During the data collection when this happened, the elderly was instructed to stop performing the exercise and inhale through her nose and then begin the exercise again. Also, during the technique performance it was observed that handling the New Shaker® device was easier than handling the bottle of water with the resonance tube.

The literature shows scientific evidence regarding the principles of exercise physiology applied to voice[27], therefore, considering the reports of tiredness during the exercise, it is possible that the MPT improves when there are intervals during the performance of the exercise. The PhoRTE[28] program has been applied in the elderly population; it consists of vocal exercises produced with a loud, energized voice in a sustained phonation adding glides; the program increases voice-related quality of life and decrease phonatory effort. Similarly, Lee Silverman® method is also used to treat presbyphonia. This method is performed in sixteen 60-minute treatment sessions for a period of four weeks; it uses loud and effortful phonatory tasks based on increased phonatory effort to provide better vocal fold closure. Authors have verified the efficacy of Lee Silverman® to treat elderly with presbyphonia; they observed improvement in the glottal competence, in the acoustic parameters and in the perceptual judgement of the vocal quality[29].

Regarding self-reported sensations (Chart 2), it was observed that both techniques did not promote significant changes (Table 5). However, when analyzing the percentages, there are more reports of positive sensations in the voice and larynx (45% to 65%) for both techniques and more reports of "no difference" for breathing and articulation (35% to 85%). Regarding VOHFO, the positive self-reported sensations after the voice technique were: cleaner, stronger, easier and opened. Regarding the larynx sensations, 50% of the elderly reported: cleaner, without secretion, lighter and relaxed, seems clearer and more opened. However, they also reported negative sensation, such as: more tired, rougher, lots of effort. Regarding breathing, 35% of the elderly reported the sensation of more breath, better to breathe, it became lighter. Finally, regarding the articulation, they mentioned the sensations of clearer, easier to speak, softer. It is noteworthy that the elderly did not report negative sensation for breathing and articulation. These data are in accordance with recent studies[12,13] that performed VOHFO in dysphonic and non-dysphonic individuals; the authors did not observe significant changes after the technique. However, the sensations reported by the participant were not assessed.

Considering the outcome with the use of the resonance tube (Chart 2), almost 65% of the elderly reported a positive effect on the voice after the exercise, such as: clearer, cleaner and stronger. Regarding the larynx sensations, 57% of the elderly women reported the sensation of more opened, cleaner and more relaxed. Regarding breathing, 50% of the elderly women reported positive feelings after the exercise, such as more breath, it was easier to breathe. No negative sensations were reported

for articulation. These results may be related to better vocal folds vibration, improvement of the glottal source, providing more harmonics and lower phonation pressure[30]. Hence, the effects of vocal source could be the result of the lower phonation pressure due to the changes in the air column inertance of the vocal tract during the exercise[26]. The reported sensations of the present study are in accordance with another study that analyzed the immediate effects of two SOVTEs (finger kazoo and straw phonation) in 23 women without vocal complaints[12]. After the exercise the participants reported sensation of clearer voice, easier to speak and stronger. The authors suggested that the sensations were due to changes in the vocal fold vibration pattern, lowering of the first formant and of the subglottal pressure required for phonation.

The present study also observed negative reports such as: more tired, dry throat, sore throat, itchy throat, more tired breathing and less breath. These sensations reinforce that not all exercises are good for everyone and that therapeutic tests are necessary to provide a better vocal rehabilitation and/or training.

It is noteworthy that vocal and laryngeal changes are different between men and women and the impact of these alterations in their quality of life also differ. Therefore, one of the limitations of this paper was not to include elderly men. In addition, although this was not the present study objective, further research should verify the effects of vocal exercise in the elderly population with laryngeal diagnosis of presbylarynx both in men and women, separately, also considering the impact in the long-term.

Overall, the results of the present study show that both techniques have similar effects when performed for three minutes in elderly women. Thus, as reported by previous studies[12,13], it is believed that VOHFO with the New Shaker® device can be considered an SOVTEs and can be safely performed by elderly women. However, further studies are needed to verify the effects of these techniques on the larynx, to compare the duration of each techniques performance in order to find the optimal duration for each population and type of vocal alteration. Also, further studies should include other types of evaluation such as spirometric measurements, since the elderly may have an alteration in the pulmonary function due to aging, another limitation of this study.

CONCLUSION

In the conditions that the present study was carried out, the outcomes show that the sounded blowing exercise into a resonance tube improves the vocal quality (less roughness and more vocal projection) in elderly women. In addition, both techniques have similar effects in the self-perception of vocal and laryngeal symptoms and in the vocal quality of elderly women, which suggests that the VOHFO can be safely applied in voice therapy for this population.

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Author contributions

PCP - study design, data collection, analysis and interpretation data, writing the manuscript, approval of final version to be published; KCAS - analysis and interpretation data, paper review, approval of final version to be published; APDL - paper review and approval of final version to be published; DH, LF, KS and YB - collection and analysis data, writing the manuscript, approval of final version to be published study review; LTDS - study design, analysis data, writing and review the manuscript, approval of final version to be published.