PHONATION INTO A GLASS TUBE IMMERSE IN WATER: ANALYSIS PERCEPTIVEAUDITORY VOCAL AND VIDEOLARYNGOSTROBOSCOPY IN WOMEN WITHOUT LARYNGEAL DISORDERS, COMPLAINTS OR VOCAL ALTERATIONS

Fonação em tubo de vidro imerso em água: análise vocal perceptivoauditiva e videolaringoestroboscópica de mulheres sem afecções laríngeas, queixas ou alterações vocais

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ABSTRACT

Purpose: to check and correlate measures of vocal acoustic of the glottal source and laryngeal characteristics of women without laryngeal disorders and without vocal complaints, after the phonation in a glass tube immersed in water. **Methods:** twenty-four women, between 18 and 40 years, were available and allocated equitably in the study group and in the control group. Were performed collect the vowel /a:/ and videolaryngostroboscopy before and after the execution of technique, in the study group, and before and after a period of silence in the control. Was performed an analysis vocal acoustics and hearing perceptual and statistical analysis with *Wilcoxon,* Chi-square and *Spearman* (p<0,05). **Results:** SG: improvement of the smoothed *pitch* perturbation quotient, voice turbulence index, *Shimmer* percentage and *Shimmer* in dB; improvement of breathiness in the perceptual evaluation; in the videolaryngostroboscopy, the laryngeal vestibule constriction did not change significantly. **Conclusion:** the technique phonation in a glass tube immersed in water reduced of vibration glottal aperiodicity and the noise, with increased energy harmonic and consequent improvement of the glottal signal. In videolaryngostroboscopy, the laryngeal vestibule constriction did not change significantly, this suggests that the technique does not cause laryngeal hypertension.

KEYWORDS: Voice; Rehabilitation; Phonation; Speech Acoustics; Voice Quality

INTRODUCTION

The Semi-occluded vocal tract exercises (SOVTE) present semi-occlusion of lips during execution, which promotes retroflex resonance toward the vocal folds, favoring vocal spare and efficiency, besides increased loudness[1-9]. The SOVTE group encompasses sonorous vibration of tongue and lips, fricatives (/ v /, / z /, / ž /, / β /), glottal firmness (vowels / v / or / u / with soft occlusion of the mouth with the palm of the hand), finger kazoo (sound of vowels / o / or / u / over the index finger, similar to the silence sign), prolonged / b / (extension of the sound of the consonant / b /), humming (issuance of the nasal / m / sound), y-buzz (soft emission directed to the upper alveoli with rounded lips), lip constriction (soft issue as in / v /, directed to rounded lips), rounded vowels (/ o / or / u /) and tube phonation[1-3,7-11].

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Resonance tube phonation in water (RTPW) was first studied in the 1960s by the Finnish professor Antii Sovijärvi, from the University of Helsinque[10]. From Sovijärvi's work, other authors examined the vocal changes produced by that technique using tube made by different materials, with different lengths, diameters, task and execution times, but without being immersed in water[1,2,4,5,10,12,13].

Studies have shown that tube phonation improves the activity of larynx intrinsic muscles[3]; causes changes in the vocal tract[4,12]; results in positive vocal self-perceptions[1,10,13,14]; increases the amount of harmonics; decreases hyperfunctional laryngeal standard, viewed on Transnasal Endoscopy (TNE)[8]; and improves the *Cepstrum* and *Jitter* parameters (frequency perturbation measures) and harmonics-to-noise ratio (HNR)[14]. Regarding the fundamental frequency (f0), the effects are less evident, and a study showed decreased f0[1], whereas another study found no changes after the application of the technique[4].

However, the literature brings no publications on RTPW. In this sense, there is a lack of research using multidimensional evaluations correlating the findings. Little that is known about some of the technical details was mentioned in a literature review that used congress presentation papers from the 1960s, thus its effects have not yet been proved[15].

This present research included women with no laryngeal disorders (LD) and no voice constrains, in order to observe changes in a balanced system, due to the increased demand for vocal enhancement and to the fact that women seek more often for health assistance, using various acoustic measures of the same parameter for a broader analysis. The research hypothesis addresses the improvement of vocal acoustic measures and laryngeal aspects analyzed after RTPW.

This paper aimed at checking and relating glottal source acoustic voice measures and laryngeal characteristics of adult women with no LD nor voice constrains after RTPW.

METHODS

Characterization of research and ethical aspects

Analytical and quantitative observational cross-sectional study approved by the Ethics Committee in Research of the Federal University of Santa Maria. (23081.016945/2010-76). The target population received clarification regarding the procedures and was asked to read and sign the Statement of Informed Consent Form (ICF) (CONEP / 1996).

Research subjects

The survey was distributed and explained in lectures, workshops and graduate courses of two institutions of higher education, and women interested signed a list and provided their contact information. The time and date were scheduled for the evaluation and implementation of data collection.

The inclusion criteria were: signing the ICF; female, due to the greater number of studies in the literature involving this gender; aged 18 to 40 years to exclude hormonal dysfunctions and structural changes of aging, which can occur especially after 40.

Exclusion criteria were: report of endocrine, neurological, psychiatric, gastric, respiratory and systemic diseases previously diagnosed[13]; existing respiratory infections and allergies on the date of evaluations; vocal complaints; presence of LD; report of laryngeal surgery and / or any surgical procedure in the head and neck; hormonal dysfunction resulting from pregnancy or premenstrual or menstrual period on the date of assessments; a smoker and / or drinker; having underdone speech therapy and / or previous ENT; singers; having auditory dysfunction; disorders of the stomatognathic system, which could interfere with the execution of the technique or with the assessment of voice; and intolerance to videolaryngoestroboscopy (VLE), requiring the use of anesthesia[15].

At first, volunteers answered a questionnaire and underwent an assessments of otolaryngology, stomatognathic system and audiometric screening for the application of the criteria for inclusion and exclusion.

Women who did not meet the criteria were excluded from the study and referred for appropriate evaluations. A total of 31 volunteers participated and three were excluded for requiring anesthesia in VLE; two for having LD; one for being in the pre-menstrual period and another for being a smoker. Thus, the sample consisted of 24 women, aged between 18 and 40 years (mean of 23.04 years of age) with no vocal complaints nor LD, and each was distributed randomly and systematically into two groups (SG = study group and CG = control group, with 12 volunteers each).

Data collection

All volunteers issued the vowel / a: / and were further submitted to VLE evaluation before and immediately after the execution of RTPW (SG) and before and immediately after a period of absolute silence (CG).

VLEs were performed with the videolaryngostroboscopy Atmos system (Lenzkirch, Germany) with Storz of 70° (Tuttlingen, Germany) by the same otolaryngologist. The volunteers remained seated, with their head tilted slightly forward and upward. The sustained issuance of vowels / e / and / i / was requested, as well as around two issues of reverse phonation, without topical anesthesia.

The collection of two voice samples of vowel / a: / were held in an environment with noise level below 50dB, verified by the sound pressure meter Instrutherm Dec-480[9,11] performing / a: / in regular pitch and loudness[9]. After deep inspiration, they issued the vowel in maximum phonation time (MPT), without making use of expiratory reserve[9,16].

We used professional a *Zoom* digital recorder, model H4n (stereo microphone, unidirectional, 96KHz, 16bit, 50% of the recording level of the input signal), set on pedestal and positioned at an angle of 90 ° and four centimeters in front of subjects mouth[9,14].

In both moments planned, the shortest time among all subjects in the SG and CG was taken as basis for the set of standard time (standard time for the research), where the vocal attack and the end of issue were already eliminated, due to the natural periods of instability, resulting in vocal sample time for the analysis of 3.5s[1,9,17].

Implementation of technical RTPW

A glass tube was used with 27 cm in length, 1mm thick and 0.9mm in diameter[2,7,12] and a water container that was 12cm wide, 12cm deep, 15cm long, with water up to nine cm, in order to prevent the improper posture of the cervical spine during the execution of the technique. A bracket was adjusted to place the tube on the container, in a way that the angle between the tube and the jaw could be the same for all subjects; and so that its distal end remained submerged to 2cm from the surface (as previously marked on the tube)[10] (Figure 1).

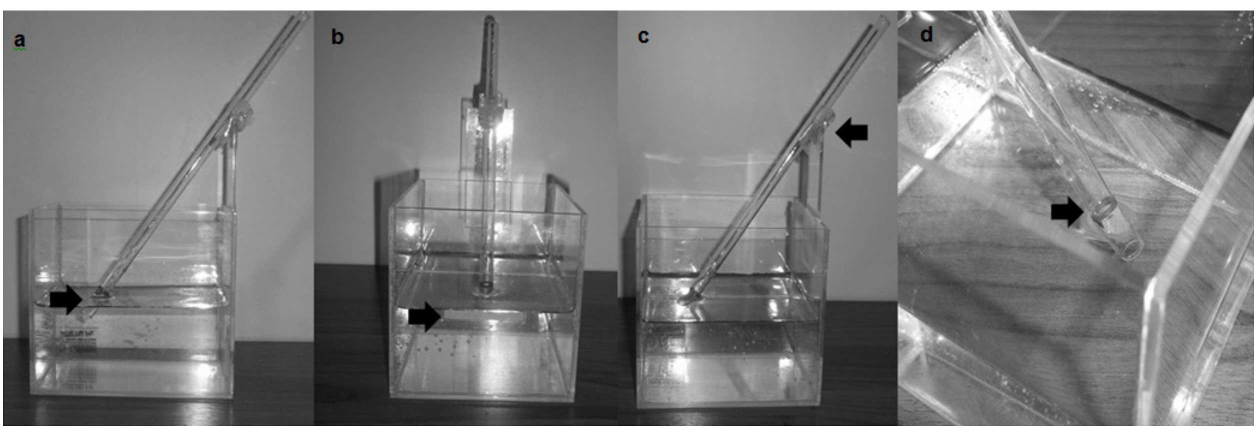

Figure 1 – a) tube mark in water level, immersed at 2cm from the surface; b) water level mark on the recipient (9cm); c) Tube support; d) Tube mark for immersion at 2 cm

After collecting / a: / in the pre-technique phase, the volunteers of the SG were taught to perform RTPW through the technical guidance and demonstration of a speech therapist. They were instructed to remain seated comfortably, keeping their back straight, feet flat on the floor and placing the proximal end of the tube between lips before issuing the phoneme / u: /[2,7,12] with no muscle effort of the shoulder girdle and the supra-hiodea, in usual pitch and loudness (Figure 2). The issue of the phoneme / u: / occurred in a full expiration (in MPT) and each support was considered equivalent to a repetition, three sets of 15 repetitions were performed[9,18,19]. Posture, muscle effort and the correct execution of the technique were monitored visually by the speech therapist[9].

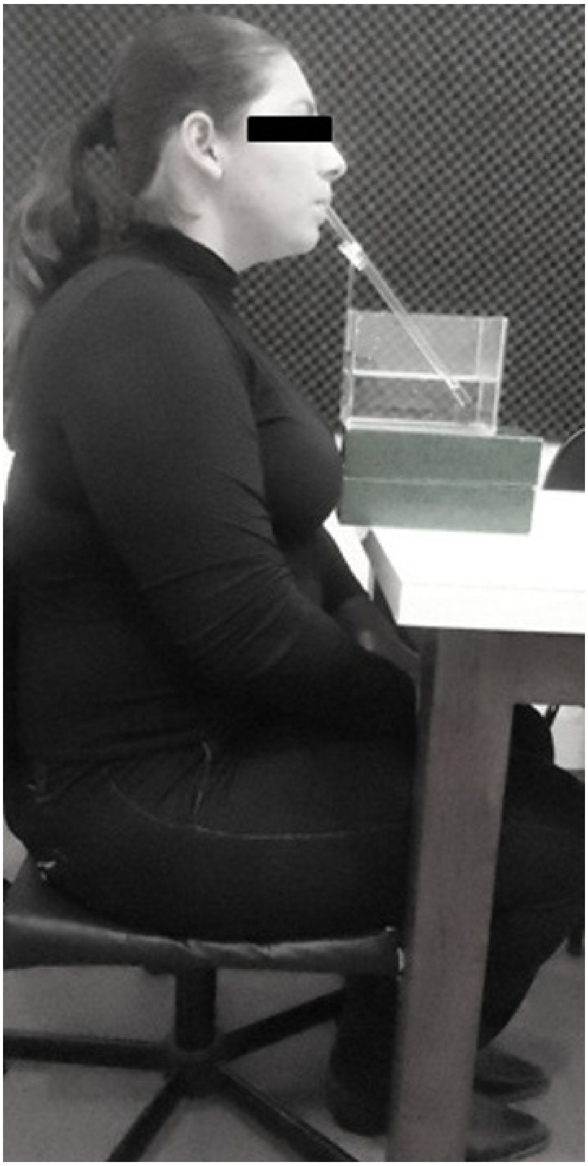

Figure 2 – Proper posture for the RTPW technique

After each series, the volunteers had a 30 second rest (absolute silence) [9,18,19], when they could ingest up to 250ml of water[9]. Water intake was allowed because the hydration occurs systemically, taking a few hours to get to the larynx[9,11].

CG volunteers, after collecting / a: /, instead of performing the technique, they remained absolutely silent during the corresponding time when their respective pairs from the SG took to perform it. The average runtime of the technique and, consequently, the CG silent period, was 11 seconds.

Perceptual voice assessment

Perceptual voice assessment was conducted individually by four speech therapists with expertize in voice. The specialists received a DVD in which the voices were recorded in pairs, referring to the pre-technique or pre-silence and to the post-technique time or post-silence, separated by a silent interval and were asked to analyze emissions with use of headphones, listening to the voices as many times as necessary, in a silent environment[3].

The RASATI scale was used, which aims to evaluate the parameters of hoarseness (R), roughness (A), breathiness (S), asthenia (A), tension (T) and (I) instability. The following are assigned for each of the items on the scale: 0 = normal, when no vocal deviation is perceived by the listener; 1 = mild deviation or when in doubt whether the deviation exists or not; 2 = moderate, when the deviation is obvious, and 3 = extreme vocal deviations extremos[9,11,20-24].

Analysis of the videolaryngostroboscopic evaluation

The analysis of the VLE for the two moments of the research was performed individually by two otolaryngologists with expertise in laryngology. Each physician received a DVD with the videos of the tests and evaluated pairs of VLE images taken at pre-technique or pre-silence and post-technique or post-silence of a particular subject, by comparing the laryngeal images, and they filled a specific protocol[23,24]. The specialists were given pairs of VLE appearing simultaneously (without audio) on the screen, as well as one after another, consecutively (with audio), in order to ease their analysis. The aspects evaluated were: glottal closure, amplitude of vibration, laryngeal vestibule constriction, symmetry of vibration and mucus wave[25].

None of the audiologists or physicians was involved in the research as a subject or author, and all were unaware of the purpose of this research, the researched technique, of pre and post-technique phases, of what the sample codes meant, and of their replication[9,16], they were only aware of subjects' gender and age[9].

Acoustic voice analysis

The voices were also acoustically analyzed by the Multi Dimension Voice Program Advanced (MDVPA), from KayPentax®, based on the vowel / a: / edited on the standard time of 3.5s, with a sampling rate of 44KHz and 16bits. Since the acoustic analysis still does not allow the establishment of direct relationship between a specific characteristic of vocal physiology and a particular acoustic measure, different acoustic measures of the same phenomenon were used, interpreted altogether. We determined the **frequency measures:** f0, f0 high (fhi), f0 low (flo), Standard deviation of f0 (STD);

the **frequency perturbation measures:** Absolute jitter (Jita), percentage or relative jitter (Jitt), relative average of pitch perturbation (RAP), pitch perturbation or frequency quotient (PPQ), Smoothed pitch pitch perturbation or frequency quotient (sPPQ), Variation of f0 (vf0); the **amplitude perturbation measures**: Absolute shimmer or in dB (SHDB), percentage or relative shimmer (Shim), Amplitude perturbation quotient (APQ), Smoothed Amplitude perturbation quotient (sAPQ), Variation of amplitude (vAm); **noise measures:** Noise-harmonic ratio (NHR), voice turbulence index (VTI), soft phonation index (SPI); **voice break measures:** Degree of voice breaks (DVB), number of voice breaks (NVB); **measures of deaf or unvoiced segments:** Number of unvoiced segments (NUV), Degree of unvoiced segments (DUV); **measures of sub-harmonic segments:** Degree of sub-harmonic components (DSH), number of sub-harmonic segments (NSH). Thus, we were able to analyze the levels of aperiodicity / noise; harmonic energy, stability and frequency of the vocal signal. For the measure of f0, reference values of 150 to 250Hz were used, based on the literature for women[11,26].

Statistical Analysis

RASATI and VLE samples were replicated at 25%, so that the intra-rater reliability could be verified. Thus, 24 pairs of samples (12 from the CG and 12 from the SG) and six replicates were assessed, totaling 30 pairs for each assessor. From the calculation of the Kappa coefficient, in the analysis of the RASATI judges, the values found were 0.72 for judge 1; 0.56 for judge 2; 0.46 for 3; 0.38 for judge 4. In the VLE analysis, the values founds were 0.50 for judge 1, and 0.29 for judge[9,19,26]. The inter-assessor reliability of the three judges of RASATI was 0.31 and for the judges of the VLE, it was 0.2. The values 0.8 to 1 for reliability are considered almost perfect; 0.6 to 0.79, good; 0.4 to 0.59, moderate; 0.2 to 0.39, regular; zero to 0.19, poor; zero to -1, none[9,22]. The evaluation of the three most reliable judges in RASATI and of the two judges of the VLE evaluations were considered altogether to determine the prevailing judgment in each parameter[9,23].

To compare the measures of the MDVPA, the Wilcoxon test was used. For VLE and RASATI data comparison, the Chi-square test was used. And the Spearman correlation coefficient was used to correlate the assessment results. The classification of correlation values was: very weak correlation (0 to 0.19); weak correlation (0.20 to 0.39); moderate correlation (0.40 to 0.69); strong correlation (0.70 to 0.89); very strong correlation (0.90 to 1.00). The level of significance was 5% ($p < 0.05$).

RESULTS

The Wilcoxon test ($p < 0.005$) was used to compare the vocal acoustic measures of glottal source of the MDVPA, between the pre and post-technique moments or silence. At the SG, significant improvement was found for the sPPQ (0.0498), ShdB (0.0229), Shim (0.0229) and VTI (0.0229) measures. In the CG, there was improvement for sAPQ (0.0186) (Table 1).

The chi-square test ($p < 0.005$) was used for comparing the results of perceptual voice analysis (RASATI scale), pre and post-technique in the SG and pre and post-silence in the CG. A significant improvement was noted for breathiness in the SG (0.0130) (Table 2).

Table 3 shows the comparison of videolaryngostroboscopic modifications, pre and post-technique in the SG and pre and post-silence in the CG, for which the chi-square test ($p < 0.005$) was used. Significant change was found in the non-alteration of laryngeal vestibule constriction for the SG (0.0039).

Tables 4 and 5 show the results of the MDVPA and RASATI correlations after the technique and the moment of silence, respectively. No significant results were found for the SG. For the CG, a significant positive correlation was found between instability and ShdB (0.0077), Shim (0.0077), APQ (0.0032) and NHR (0.0108).

Table 1 – Comparison of vocal acoustic measures of glottal source from the Multi Dimension Voice Program Advanced between pre and post-technique in the study group and pre-and post-silence in the control group

	SG					CG				
	Pre-technique		Post-technique		p-value	Pre-silence		Post-silence		p-value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
f0 (Hz)	198,14	23,59	200,93	28,19	0,6378	214,93	20,49	215,40	16,80	0,4327
fhi (Hz)	218,75	34,51	215,21	32,94	0,6378	226,17	23,17	225,09	18,19	0,5829
flo (Hz)	184,10	19,38	191,06	28,88	0,1579	205,59	20,15	206,66	17,41	0,3881
STD f0 (Hz)	3,81	2,70	2,54	0,93	0,0916	2,86	0,98	2,63	0,74	0,3669
***Jita* (us)**	58,26	32,15	46,78	23,44	0,1360	60,14	30,77	55,56	32,59	0,5829
***Jitt* (%)**	1,16	0,69	0,90	0,38	0,1579	1,29	0,67	1,17	0,63	0,5302
RAP (%)	0,70	0,42	0,54	0,23	0,1360	0,78	0,41	0,70	0,38	0,5302
PPQ (%)	0,68	0,40	0,54	0,24	0,1467	0,75	0,38	0,68	0,36	0,4801
sPPQ (%)	0,95	0,61	0,65	0,21	0,0498*	0,84	0,370	0,76	0,32	0,4801
vf0 (%)	1,94	1,47	1,28	0,49	0,0597	1,32	0,42	1,23	0,36	0,4327
ShdB (dB)	0,33	0,09	0,29	0,09	0,0229*	0,27	0,06	0,26	0,04	0,3465
***Shim* (%)**	3,76	1,04	3,42	1,10	0,0229*	3,17	0,74	2,98	0,52	0,3465
APQ (%)	2,80	0,71	2,53	0,74	0,3123	2,31	0,52	2,23	0,42	0,6948
sAPQ (%)	5,16	1,48	4,39	0,91	0,0994	4,51	1,02	3,80	0,80	0,0186*
vAm (%)	14,06	5,34	11,86	3,22	0,3881	11,57	2,19	10,23	3,55	0,6378
NHR	0,14	0,02	0,13	0,02	0,1166	0,12	0,02	0,12	0,02	0,5049
VTI	0,05	0,01	0,04	0,02	0,0229*	0,04	0,01	0,04	0,01	0,8445
SPI	12,73	7,69	10,61	7,19	0,1166	8,64	4,88	9,32	5,55	0,9374
DVB (%)	0,08	0,29	0,00	0,00	-	0,00	0,00	0,00	0,00	-
DSH (%)	0,64	1,16	0,35	0,57	0,4630	0,21	0,39	0,14	0,49	0,5929
DUV (%)	0,46	1,18	0,00	0,00	-	0,00	0,00	0,00	0,00	-
NVB (%)	0,08	0,28	0,00	0,00	-	0,00	0,00	0,00	0,00	-
NSH (%)	0,75	1,35	0,41	0,66	0,8626	0,25	0,45	0,16	0,57	0,5929
NUV (%)	0,58	1,50	0,00	0,00	-	0,00	0,00	0,00	0,00	-

Wilcoxon test
* statistically significant values (p<0.05)
SD: standard deviation
SG: study group
CG: control group

Table 2 – Result comparison of perceptual voice analysis between pre and port-technique in the study group and pre and post-silence in the control group

	SG									CG								
	Pre-technique (%)				Post-technique n (%)				p-value	Pre-silence n (%)				Post-silence n (%)				p-value
	0	1	2	3	0	1	2	3		0	1	2	3	0	1	2	3	
R	6 (50,00)	5 (41,67)	1 (8,33)	-	9 (75,00)	3 (25,00)	-	-	0,3499	8 (66,67)	4 (33,33)	-	-	8 (66,67)	4 (33,33)	-	-	1,0000
A	12 (100,00)	-	-	-	12 (100,00)	-	-	-		12 (100,00)	-	-	-	12 (100,00)	-	-	-	-
S	2 (16,67)	10 (83,33)	-	-	8 (66,67)	4 (33,33)	-	-	0,0130*	9 (75,00)	3 (23,00)	-	-	4 (33,33)	7 (58,33)	1 (8,33)	-	0,4984
A	12 (100,00)	-	-	-	12 (100,00)	-	-	-	-	12 (100,00)	-	-	-	12 (100,00)	-	-	-	-
T	11 (91,67)	1 (8,33)	-	-	11 (91,67)	1 (8,33)	-	-	1,0000	12 (100,00)	-	-	-	12 (100,00)	-	-	-	-
I	6 (50,00)	5 (41,67)	1 (8,33)	-	8 (66,67)	4 (33,33)			0,2482	6 (50,00)	6 (50,00)	-	-	6 (50,00)	6 (50,00)	-	-	1,0000

Chi-square Test
* statistically significant values (p<0.05)
R= hoarseness A=roughness S= breathiness A= asthenia T= tension I= instability SG= study group CG= control group

Table 3 – Comparison of videolaryngostroboscopic modifications between pre and post-technique in the study group and pre and post-silence in the control group

	SG				CG			
	Improvement n (%)	Decline n (%)	No alteration n (%)	p-value	Improvement n (%)	Decline n (%)	No alteration n (%)	p-value
Glottal closure	4 (33,33)	2 (16,67)	6 (50,00)	0,3679	2 (16,67)	2 (16,67)	8 (66,67)	0,0498*
Vibration amplitude	6 (50,00)	6 (50,00)	-	1,0000	7 (58,33)	2 (16,67)	3 (25,00)	0,1738
Laryngeal vestibule constriction	1 (8,33)	-	11 (91,67)	0,0039*	-	-	12 (100,00)	-
Symmetry of vibration	-	-	12 (100,00)	-	2 (16,67)	2 (16,67)	8 (66,67)	0,0498*
Mucus wave	8 (66,67)	4 (33,33)	-	0,2482	6 (50,00)	2 (16,67)	4 (33,33)	0,3679

Chi-square
* statistically significant values (p<0.05)
SG: study group CG: control group

Table 4 – Correlation of results from the *Multi Dimension Voice Program Advanced* and the post-technique perceptual voice analysis in the study group

	R		A		S		A		T		I	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
f0 (Hz)	-0,0278	0,9314	-	-	0,1536	0,6335	-	-	-0,3930	0,2062	0,1024	0,7514
fhi (Hz)	-0,0278	0,9314	-	-	0,0000	1,0000	-	-	-0,2183	0,4953	0,0000	1,0000
flo (Hz)	-0,0836	0,7961	-	-	0,1536	0,6335	-	-	-0,3930	0,2062	0,1024	0,7514
STD (Hz)	-0,4181	0,1761	-	-	0,0512	0,8744	-	-	0,0436	0,8928	-0,1536	0,6335
***Jita* (us)**	0,0278	0,9314	-	-	-0,3072	0,3313	-	-	0,2183	0,4953	-0,1024	0,7514
***Jitt* (%)**	0,0836	0,7961	-	-	-0,4608	0,1315	-	-	0,1310	0,6848	-0,0512	0,8744
RAP (%)	0,0836	0,7961	-	-	-0,4608	0,1315	-	-	0,1310	0,6848	-0,0512	0,8744
PPQ (%)	0,0836	0,7961	-	-	-0,4096	0,1859	-	-	0,1310	0,6848	-0,1024	0,7514
sPPQ (%)	-0,1393	0,6657	-	-	-0,1536	0,6335	-	-	0,2183	0,4953	-0,0512	0,8744
vf0 (%)	-0,3066	0,3323	-	-	0,0512	0,8744	-	-	0,1310	0,6848	-0,1536	0,6335
ShdB (dB)	-0,4738	0,1196	-	-	0,0000	1,0000	-	-	-0,2183	0,4953	-0,5633	0,0565
Shim (%)	-0,4738	0,1196	-	-	0,0000	1,0000	-	-	-0,1310	0,6848	-0,5120	0,0887
APQ (%)	-0,4738	0,1196	-	-	0,0000	1,0000	-	-	-0,1310	0,6848	-0,5120	0,0887
sAPQ (%)	-0,5296	0,0765	-	-	-0,1024	0,7514	-	-	-0,3930	0,2062	-0,3584	0,2525
vAm (%)	0,1024	0,7514	-	-	0,3056	0,3338	-	-	0,2560	0,4218	-0,5305	0,0759
NHR	-0,1282	0,6912	-	-	-0,3062	0,3330	-	-	-0,1795	0,5765	-0,2792	0,3794
VTI	0,1282	0,6912	-	-	0,3062	0,3330	-	-	0,1282	0,6912	0,2508	0,4315
SPI	-0,5120	0,0887	-	-	0,1310	0,6848	-	-	-0,3072	0,3313	-0,0997	0,7577
DVB (%)	-0,4886	0,1069	-	-	0,2604	0,4135	-	-	-0,2137	0,5046	-0,0335	0,9176
NVB (%)	-0,4923	0,1039	-	-	0,3674	0,2400	-	-	-0,1538	0,6330	-0.0452	0,1314
DUV (%)	-	-	-	-	-	-	-	-	-	-	-	-
NUV	-	-	-	-	-	-	-	-	-	-	-	-
DSH (%)	-	-	-	-	-	-	-	-	-	-	-	-
NSH	-	-	-	-	-	-	-	-	-	-	-	-

Spearman Correlation Test
* statistically significant values ($p<0.05$)
r: value of the correlation coefficient
p: statistical significance

Table 5 – Correlation of results from the *Multi Dimension Voice Program Advanced* and from the post-silence perceptual voice analysis in the control group

	R		A		S		A		T		I	
	r	p	r	p	r	p	r	p	r	p	r	p
f0 (Hz)	0,0512	0,8744	-	-	-0,4026	0,1943	-	-	-	-	0,0965	0,7652
fhi (Hz)	-0,1024	0,7514	-	-	-0,5342	0,0735	-	-	-	-	0,0000	1,0000
flo (Hz)	0,1024	0,7514	-	-	-0,3587	0,2520	-	-	-	-	0,0965	0,7652
STD (Hz)	-0,1024	0,7514	-	-	-0,0318	0,9216	-	-	-	-	-0,2896	0,3610
***Jita* (us)**	-0,0512	0,8744	-	-	0,0797	0,8054	-	-	-	-	-0,0965	0,7652
***Jitt* (%)**	-0,0512	0,8744	-	-	0,0358	0,9118	-	-	-	-	-0,0965	0,7652
RAP (%)	-0,0512	0,8744	-	-	0,0358	0,9118	-	-	-	-	-0,0965	0,7652
PPQ (%)	-0,0512	0,8744	-	-	0,0358	0,9118	-	-	-	-	-0,0965	0,7652
sPPQ (%)	0,0000	1,0000	-	-	0,0358	0,9118	-	-	-	-	-0,0482	0,8815
vf0 (%)	0,0000	1,0000	-	-	0,0358	0,9118	-	-	-	-	-0,1448	0,6533
ShdB (dB)	-0,1024	0,7514	-	-	0,0318	0,9216	-	-	-	-	0,7242	0,0077*
Shim (%)	-0,1024	0,7514	-	-	0,0318	0,9216	-	-	-	-	0,7242	0,0077*
APQ (%)	-0,3072	0,3313	-	-	-0,1873	0,5598	-	-	-	-	0,7724	0,0032*
sAPQ (%)	0,0000	1,0000	-	-	-0,0438	0,8923	-	-	-	-	0,3379	0,2826
vAm (%)	0,2048	0,5230	-	-	0,1953	0,5429	-	-	-	-	0,3379	0,2826
NHR	-0,4881	0,1073	-	-	-0,3420	0,2764	-	-	-	-	0,7025	0,0108*
VTI	-0,5120	0,0887	-	-	-0,5501	0,0638	-	-	-	-	0,5310	0,0756
SPI	0,2048	0,5230	-	-	0,4185	0,1756	-	-	-	-	-0,3862	0,2149
DVB (%)	-0,2132	0,5058	-	-	-0,3983	0,1996	-	-	-	-	-0,3015	0,3408
NVB (%)	-0,2132	0,5058	-	-	-0,3983	0,1996	-	-	-	-	-0,3015	0,3408
DUV (%)	-	-	-	-	-	-	-	-	-	-	-	-
NUV	-	-	-	-	-	-	-	-	-	-	-	-
DSH (%)	-	-	-	-	-	-	-	-	-	-	-	-
NSH	-	-	-	-	-	-	-	-	-	-	-	-

Spearman Correlation Test
* statistically significant values ($p<0.05$)
r: value of the correlation coefficient
p: statistical significance

DISCUSSION

Currently, in clinical practice, there is great interest on SOVTE, with the intent to obtain benefits through retroflex resonance[9,10]. More recent studies on SOVTE phonation into tubes were conducted with various methodologies and materials, showing positive results on both the source and the vocal filter[1,2,12-14].

In this research, we attempted to obtain data from different types of assessments, such as the vocal acoustic analysis, perceptual and VLE to check the changes generated by RTPW in different dimensions of vocal production. On acoustic voice analysis, there was significant improvement in values for sPPQ, VTI, SHDB and Shim of SG (Table 1).

The Jitter and Shimmer measures related to the vibrational aperiodicity and sign instability, highlighting how much a cycle of vibration differs from another during emission, showing the disturbance of frequency (jitter) and amplitude (shimmer)[17,27]. VTI shows the noise level at high frequencies and is related to turbulence noise caused by the lack of coaptation of vocal folds[17].

Based on the findings of the SG, it is suggested that the RTPW has reduced vibration mucus aperiodicity in the vocal folds, the noise level of turbulence at high frequencies and sign instability, providing improved glottal signal with increased harmonic energy and reduced noise. Moreover, the respiratory level may have influenced the improvement of such measures due to increased air flow and greater control of the respiratory muscles, which consequently influence the subglottic pressure, vibration and coaptation of vocal folds[2,13,14].

The SOVTE increase intraoral pressure, increasing mucosal contact of the vocal folds with less effort, enhance the activity of the intrinsic muscles of the larynx, mucus-wave motion and the timing of vibration through retroflex resonance[2,8,13,14], which explain the above findings.

To strengthen such findings, a research that include women without LD and without voice complaints that have executed SOVTE finger kazoo, has found a significant decrease in measures of MDVPA of NHR and DSH after the technique[11]. Two other studies conducted with SOVTE of sonorous tongue vibration, have also found significant reduction in noise[16].

A survey with dysphonic teachers who performed sequence of tube phonation associated with ascending and descending glissandi, with increased pitch and loudness, found significant reduction of jitter and shimmer and increased PHR and amplitude of Cepstrum and Shimmer[18], agreeing with the results of this study.

A research on tube phonation with subjects with and without LD, there were improvements in measures of frequency disturbance, such as Jita, Jitt, RAP, PPQ and vf0 and in the noise measure NHR, but with no significant statistical difference significativa[13]. Irrelevant improvements were also found in this study (Table 1) in relation to all measures of jitter, shimmer and measures of DVB, DSH, DUV, NVB, NSH, NHR and NUV that altogether suggest greater stability and higher harmonic energy with decreasing noise[2,4,8,13,14].

In the present study, no significant changes in f0 after the completion of RTPW (Table 1), the same result of a survey conducted with tubes 15cm long and 5mm in diameter[4] and another with plastic tube of 8.7 cm in length and 1.5mm in diameter[13]. However, a work on plastic tube of 8.7 cm in length and 1.5mm in diameter has indicated significant reduction of f0[1].

The results of the aforementioned studies differ from research findings with SOVTE finger kazoo[11] and tongue sonorous vibration[16,26], which indicated significant increase of f0. Thus, it appears that there is no evidence in the literature regarding changes in f0 and also other parameters of acoustic and perceptual analysis of voice, more studies are needed with SOVTE.

In perceptual analysis, there was significant improvement of breathiness (S) after the execution of the technique (Table 2), agreeing with the improvements obtained in the acoustic assessment, as reduced vibration aperiodicity resulting in improved glottal signal, as well as increased airflow, which influences the subglottic pressure, likely associated with reduction in voice breathiness[1,8,13,14]. This result is also consistent with the literature that points, in SOVTE, phonation with greater vocal efficiency and spare due to less friction in coaptation, with improved mobility of the mucosa, which helps reduce air leakage during phonation[1,4,8,13,14].

There are rare studies that have used tubes with this assessment, but there are some with SOVTE which used and found different results for each technique[6,28].

A research on fricative sound / ž / has evaluated perceptual hearing changes after the technique, showing improvement[28]. Another study has investigated the immediate effects of breathing exercise and acute sound and also found improvement in voice quality after the technique[6].

After three minutes of vibration technique sonorous language of women without dysphonia improved their voice in the perceptual hearing evaluation[15]. Still, after five minutes with a vibration technique sonorous language in women with vocal nodules, a perceptual voice analysis showed an improvement in overall vocal classification and reduction of roughness and breathiness[28].

However, research on the technique finger kazoo, conducted with women without LD and no complaints[9] and study on subjects with and without LD with tube having 8.7 cm long and 1.5 mm diameter with subjects of both genders[13] that made use of perceptual voice analysis, found no changes after vocal technique.

Considering that the VLE is an examiner-dependent evaluation (subjective) in which laryngeal aspects are visually analyzed and presented many subtleties in this research after RTPW , just do not change the laryngeal vestibule constriction was significant (Table 3) . With this finding, it is clear that the technique does not promote hypertension of the vocal apparatus, which is consistent with indications from the literature of improved efficiency and vocal economy, reducing the level of phonation pressure and less effort vocal[1-3,5-9].

With similar results, research on phonation into tubes in subjects with and without AL also found no relevant statistically laryngoscopic improvements[13]. However, a recent study with nasolaringofibroscopia found that after following SOVTE phonation into tubes and bilabial / β fricative: / associated with ascending and descending glissandos, six subjects with musculoskeletal stress syndrome, three had reduced the degree of tension and three eliminated it[8].

In this research, we could identify significant vocal changes provided by RTPW but sparingly which is in agreement with the results of most studies conducted with other variations of the technique[1,2,4,12-14].

Importantly, no studies were found in literature on RTPW, plus a review of literature[10], because research conducted in Finland with the technique not available in scientific journals. There are only studies with phonation in plastic tubes and glass not immersed in water have not used all the criteria, assessments and parameters applied in this research, and multidimensional assessments are recommended and make the most reliable research. Furthermore, this study was concerned to keep under control the largest possible all the procedures involved in performing the technique since the posture of voluntary in relation to the container and the tube, the determination of the measures of the container and the water depth and tube angulation of the bracket, and the number of repetitions performed the task of speech.

While not all post-RTPW improvements have been significant, it is important to note that in all tests applied, there was percentage improvement. This data is relevant and could be interpreted in the context of vocal and laryngeal normal subjects the SG of this work, ie, it is possible that subjects with functional or structural changes of base could present more significant results after the technique, which launches the hypothesis that RTPW can show clearer results in dysphonic subjects.

Given the results, it is suggested that further research should be conducted with RTPW to clarify its benefits in individuals with and without dysphonia or LD and enriching research in the area and offering greater scientific allowance for its use in clinical speech therapy.

CONCLUSION

The RTPW technique has decreased the values of sPPQ, VTI, Shim, ShdB and breathiness, suggesting reduction of aperiodicity of glottal vibration and noise, with increased harmonic energy and consequent improvement of the glottal signal.

In VLE, the laryngeal vestibule constriction was not significantly changed, suggesting that the technique does not cause laryngeal hypertension.

RESUMO

Objetivo: verificar e correlacionar medidas vocais acústicas de fonte glótica e características laríngeas em mulheres sem afecções laríngeas e sem queixas vocais após a fonação em tubo de vidro imerso em água. **Métodos:** vinte e quatro mulheres, entre 18 e 40 anos de idade, foram avaliadas e distribuídas de forma igualitária no grupo de estudo e no grupo de controle. Realizaram-se coleta da vogal /a:/ e videolaringoestroboscopia antes e após a execução da técnica, no grupo estudo, e antes e após um período de silêncio no controle. Realizou-se análise vocal acústica e perceptivoauditiva e análise estatística com *Wilcoxon,* Qui-quadrado e *Spearman* (p<0,05). **Resultados:** grupo estudo: melhora do quociente de perturbação do *pitch* suavizado, índice de turbulência vocal, *Shimmer* percentual e *Shimmer* em dB; melhora da soprosidade na avaliação perceptivoauditiva; na videolaringoestroboscopia, a constrição do vestíbulo laríngeo não se alterou significantemente. **Conclusão:** a técnica de fonação em tubo de vidro imerso em água reduziu a aperiodicidade da vibração glótica e do ruído, com aumento da energia harmônica e consequente melhora do sinal glótico. Na videolaringoestroboscopia, a constrição do vestíbulo laríngeo não se alterou significantemente, o que sugere que a técnica não provoca hipertensão laríngea.

DESCRITORES: Voz; Reabilitação; Fonação; Acústica da Fala; Qualidade da Voz

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