The Effects of Phonation Into Glass, Plastic, and LaxVox Tubes in Singers: A Systematic Review

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Summary: The present study aimed to perform a systematic literature review to assess the effects of phonation therapy on voice quality and function in singers. The systematic search was performed in February and updated in October 2017. No restriction of year, language, or publication status was applied. The primary electronic databases searched were LILACS, SciELO, PubMed, and Cochrane. Kappa coefficient was used to assess the agreement between examiners in judging article eligibility. The eligible articles were analyzed based on their risk of bias using the tools proposed by the Joanna Briggs Institute. *Mendeley Desktop 1.13.3* software package (Mendeley Ltd, London, UK) was used to standardize the references of identified articles. The general sample consisted of 1965 articles screened out of the electronic databases. Two examiners analyzed the sample in the search for eligible articles. The agreement between examiners reached excellent outcomes (kappa coefficient = 0.88). After the selection, phase 6 articles remained eligible. Together, the eligible studies accounted 141 subjects (65 men and 76 women) aged between 18 and 72 years old. Electroglottography was considered as the most common method (83.33%) of assessment of the effects of phonation therapy in singers. The most prevalent exercises within the therapies were phonation into straws and phonation into glass tubes. The phonation into glass tubes immersed in water, straws, and LaxVox tubes promoted positive effects on the voice quality in singers, such as more comfortable phonation, better voice projection, and economy in voice emission.
Key Words: Phonation–Singing–Voice–Voice training–Semioccluded vocal tract exercises.

INTRODUCTION

Individuals who use their voice as work instruments, such as singers, represent a population with intense voice performance. Variations in voice projection and adjustments between breathing, articulation, and resonance are common in these individuals.[1,2] Additionally, the frequency, intensity, timing, and duration of the phonation may be higher in singers than in other professionals who use their voice for working.[2,3] From a physiological point of view, the increase in voice frequency and intensity expands the amplitude of vibration in the vocal folds, decreases the amplitude of surface wave in the mucosa, increases the phonation threshold pressure, and consequently leads to the lack of energy due to the increase of friction.[4]

Work-related voice disorders are defined as any phonetic alteration caused by voice misuse during labor activities that hamper professional communication.[5] Usually, these disorders are observed more often in singers who use their voice intensely and improperly.[6,7] High prevalence rates of self-reported voice disorders are observed among singers of classical and popular music, as well as voice coaches, during their career (46.09%). These rates become even more evident considering music students.[3] In this context, preventive approaches play an important part in the prevention of voice disorders.[3]

Semioccluded vocal tract exercises (SOVTEs) are broadly explored in the clinical routine to promote better glottal coaptation and less activation of the laryngeal vestibule.[8] Phonation into tubes emerges as an exercise to improve the proprioception of the larynx and to enhance the relation between source and filter.[9–11] Consequently, an improved phonation is achieved with economic vibration of the vocal folds and efficient emission of voice.[4,10,12] In this context, SOVTEs are valuable to support singers with intense and energetic performances.[13]

Phonation into tubes may be performed using plastic straws,[14] Sovijärv's glass tubes,[15] and LaxVox tubes.[16,17] The immersion of tubes in water may be set with different depths according to vocal and laryngeal characteristics specific for each individual. This exercise is founded on the relation between water pressure and depth—the deeper the tube, the higher the resistance to voice resonance.[18]

Knowing the effects of voice exercises is essential to support their application in practice. Based on that, optimal exercises could lead to optimal therapeutic outcomes, performances, and longevity for singers and their voices.[19] Considering the scarce scientific lines of evidence that explore voice exercises, the present study aimed to perform a systematic literature review to assess the effects of resonance in tubes in the voice quality, glottal function, and vocal tract of singers.

METHODS

Research protocol and registration

The present systematic review was performed following PRISMA (Preferred Reporting Items for Systematic Reviews and

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This research was performed in the Postgraduation Program in Applied Health Sciences, Universidade Federal de Sergipe (UFS), Lagarto, Sergipe, Brazil.

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Meta-Analyses)[20] and Cochrane.[21] The systematic review was registered in the PROSPERO database under the protocol CRD42017078823. (https://www.crd.york.ac.uk/PROSPERO/)

Study design and eligibility criteria

The present research aimed to answer the following question: what are the effects of phonation into tubes on the voice quality, glottal function, and vocal tract of singers?

The research question was based in the PVO strategy for exploratory systematic reviews, in which "P" stands for population, context, or problem-based situation, "V" stands for variables, and "O" stands for the expected or unexpected outcomes.

The adopted inclusion criteria consisted of observational studies and/or clinical trials with male and female singers - professionals or singing students aged above 18 years. These studies addressed voice exercises using phonation into glass tubes, plastic straws, and LaxVox tubes. The inherent outcomes should report the effects of voice exercises on the voice quality, the glottal function, and the vocal tract of singers. No restriction was applied to the year of publication, language, and publication status. Studies not related to the research topic were excluded, as well as those that did not sample singer and individuals aged >18 years. Case reports, case series, experimental models, dissertations, theses, literature reviews, books, book chapters, letters to the editor, and editorials were also excluded.

Databases and data sources

The identification of studies was performed in the following electronic databases: Cochrane, LILACS, PubMed, and SciELO. The articles were searched in these databases using MeSH (Medical Subject Headings—https://www.ncbi.nlm.nih.gov/mesh) and DeCS (Health Science Terms—http://decs.bvs.br/) terms. Boolean operators "AND" and "OR" were used to build combinations and to support the search strategy (Table 1). The search was performed in February 2017 and updated in October 2017. To standardize the identified articles and to exclude duplicates, *Mendeley Desktop 1.13.3* (Mendeley Ltd, London, UK) software package was used.

Study selection

The selection of studies was performed by two independent examiners (ALFM and AMGDA) in two phases. In the first phase, the titles and abstracts were read and analyzed by the examiners, which were not blinded concerning the names of the authors and journals. The studies not related to the topic or not using phonation into tubes and addressing individuals aged >18 years were excluded, as well the case reports, experimental models, dissertations, theses, literature reviews, books, book chapters, letters to the editor, and editorials.

The second phase consisted of the preliminary analysis of full texts of the eligible articles. This procedure was performed to verify if the articles initially eligible fulfilled the inclusion and exclusion criteria. The articles excluded at this phase were registered separately with their respective reasons for exclusion clearly stressed. Disagreement between examiners was managed with a third examiner. The agreement between examiners was quantified with kappa coefficient.

Data collection and extraction

The data extraction was performed standardly by two speech therapists (ALFM and AMGDA). The information extracted and registered in data collection sheets consisted of the authorship, year of publication, country of publication, objective, type of study design, sample size and age, musical genre and experience with singing, type of tube (material, diameter and length, and immersed in water or not), phonation task, methods of evaluation, and outcomes of the exercise. Disagreements at this phase were managed with a third examiner. The authors of each article were contacted by e-mail if the data were unclear for extraction.

Risk of bias across studies

The risk of bias across studies was assessed with tools recommended by the JBI Critical Appraisal Checklist for Randomized Controlled Trials,[22] which are specific cross-section and case-control studies. Two independent examiners (ALFM and AMGDA) performed the analysis. The concordance between the examiners was assessed with kappa coefficient. The following questions were used to assess the risk of bias in **cross-sectional studies**: (1) Were the criteria for inclusion in the sample clearly defined? (2) Were the study subjects and the setting described in detail? (3) Was the exposure measured in a valid and reliable way? (4) Were objective, standard criteria used for the measurement of the condition? (5) Were confounding factors identified? (6) Were strategies to deal with confounding factors stated? (7) Were the outcomes measured in a valid and reliable way? (8) Was appropriate statistical analysis used? In **case-control studies**, the following questions were used: (1) Were the groups comparable other than the presence of disease in cases or the absence of disease in controls? (2) Were cases and controls matched appropriately? (3) Were the same criteria used for the identification of cases and controls? (4) Was exposure measured in a standard, valid, and reliable way? (5) Was exposure measured in the same way for cases and controls? (6) Were confounding factors identified? (7) Were strategies to deal with confounding factors stated? (8) Were outcomes assessed in a standard, valid, and reliable way for cases and controls? (9) Was the exposure period of interest long enough to be meaningful? (10) Was appropriate statistical analysis used? Based on these questions, the risk of bias in the articles was classified as **low** (articles that scored >70%), **moderate** (articles that scored between 50% and 69%), and **high** (articles that scored <49%).

RESULTS

Study selection

The initial sample selection in the four electronic databases resulted in 1965 articles. After excluding duplicates, 1080 remained for title and abstract readings. Next, 960 articles were excluded. Full-text reading was performed in 120 articles and resulted in 114 exclusions. The reasons behind the exclusions were (1) studies that did not use phonation into tubes as a method of intervention (85 articles), (2) reports of case studies (2 articles), (3) reports of case series (2 articles), (4) studies using experimental models (3 articles), (5) studies using phonation into tubes within a population other than singers (21 articles), and

TABLE 1.
Search Strategies Used in the Electronic Databases

Databases	Search Strategies (October 2017)	n
LILACS	Therapy AND voice AND phonation AND voice disorders	66
http://lilacs.bvsalud.org/	Therapy AND voice AND phonation AND dysphonia	41
	Voice training AND phonation AND voice disorders	29
	Voice training AND phonation AND dysphonia	13
	Voice training AND phonation AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	02
	Singing AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	01
SciELO	Therapy AND voice AND phonation AND voice disorders	11
http://www.scielo.org/	Therapy AND voice AND phonation AND dysphonia	06
	Voice training AND phonation AND voice disorders	10
	Voice training AND phonation AND dysphonia	03
	Voice training AND phonation AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	01
	Singing AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	00
Cochrane	Therapy AND voice AND phonation AND voice disorders	33
www.cochranelibrary.com/	Therapy AND voice AND phonation AND dysphonia	22
	Voice training AND phonation AND voice disorders	28
	Voice training AND phonation AND dysphonia	11
	Voice training AND phonation AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	02
	Singing AND semioccluded vocal tract exercises OR semioccluded vocal tract exercises	01
PubMed http://www.ncbi.nlm.nih.gov/pubmed	("therapy" [subheading] OR "therapy" [all fields] OR "therapeutics" [MeSH terms] OR "therapeutics" [all fields]) AND ("voice" [MeSH terms] OR "voice" [all fields]) AND ("phonation" [MeSH terms] OR "phonation" [all fields]) AND ("voice disorders" [MeSH terms] OR ("voice" [all fields] AND "disorders" [all fields]) OR "voice disorders" [all fields])	913
	("therapy" [subheading] OR "therapy" [all fields] OR "therapeutics" [MeSH terms] OR "therapeutics" [all fields]) AND ("voice" [MeSH terms] OR "voice" [all fields]) AND ("phonation" [MeSH terms] OR "phonation" [all fields]) AND ("dysphonia" [MeSH terms] OR "dysphonia" [all fields])	363
	("voice training" [MeSH terms] OR ("voice" [all fields] AND "training" [all fields]) OR "voice training" [all fields]) AND ("phonation" [MeSH terms] OR "phonation" [all fields]) AND ("voice disorders" [MeSH terms] OR ("voice" [all fields] AND "disorders" [all fields]) OR "voice disorders" [all fields])	281
	("voice training" [MeSH terms] OR ("voice" [all fields] AND "training" [all fields]) OR "voice training" [all fields]) AND ("phonation" [MeSH terms] OR "phonation" [all fields]) AND ("dysphonia" [MeSH terms] OR "dysphonia" [all fields])	95
	("voice training" [MeSH terms] OR ("voice" [all fields] AND "training" [all fields]) OR "voice training" [all fields]) AND ("phonation" [MeSH terms] OR "phonation" [all fields]) AND (semioccluded [all fields] AND vocal [all fields] AND tract [all fields] AND ("exercise" [MeSH terms] OR "exercise" [all fields] OR "exercises" [all fields] OR "exercise therapy" [MeSH terms] OR ("exercise" [all fields] AND "therapy" [all fields]) OR "exercise therapy" [all fields])) OR (semioccluded [all fields] AND vocal [all fields] AND tract [all fields] AND ("exercise" [MeSH terms] OR "exercise" [all fields] OR "exercises" [all fields] OR "exercise therapy" [MeSH terms] OR ("exercise" [all fields] AND "therapy" [all fields]) OR "exercise therapy" [all fields]))	20
	("singing" [MeSH terms] OR "singing" [all fields]) AND (semi-occluded [all fields] AND vocal [all fields] AND tract [all fields] AND ("exercise" [MeSH terms] OR "exercise" [all fields] OR "exercises" [all fields] OR "exercise therapy" [MeSH terms] OR ("exercise" [all fields] AND "therapy" [all fields]) OR "exercise therapy" [all fields])) OR (semioccluded [all fields] AND vocal [all fields] AND tract [all fields] AND ("exercise" [MeSH terms] OR "exercise" [all fields] OR "exercises" [all fields] OR "exercise therapy" [MeSH terms] OR ("exercise" [all fields] AND "therapy" [all fields]) OR "exercise therapy" [all fields]))	13
Total		1965

Abbreviation: n, number of articles detected.

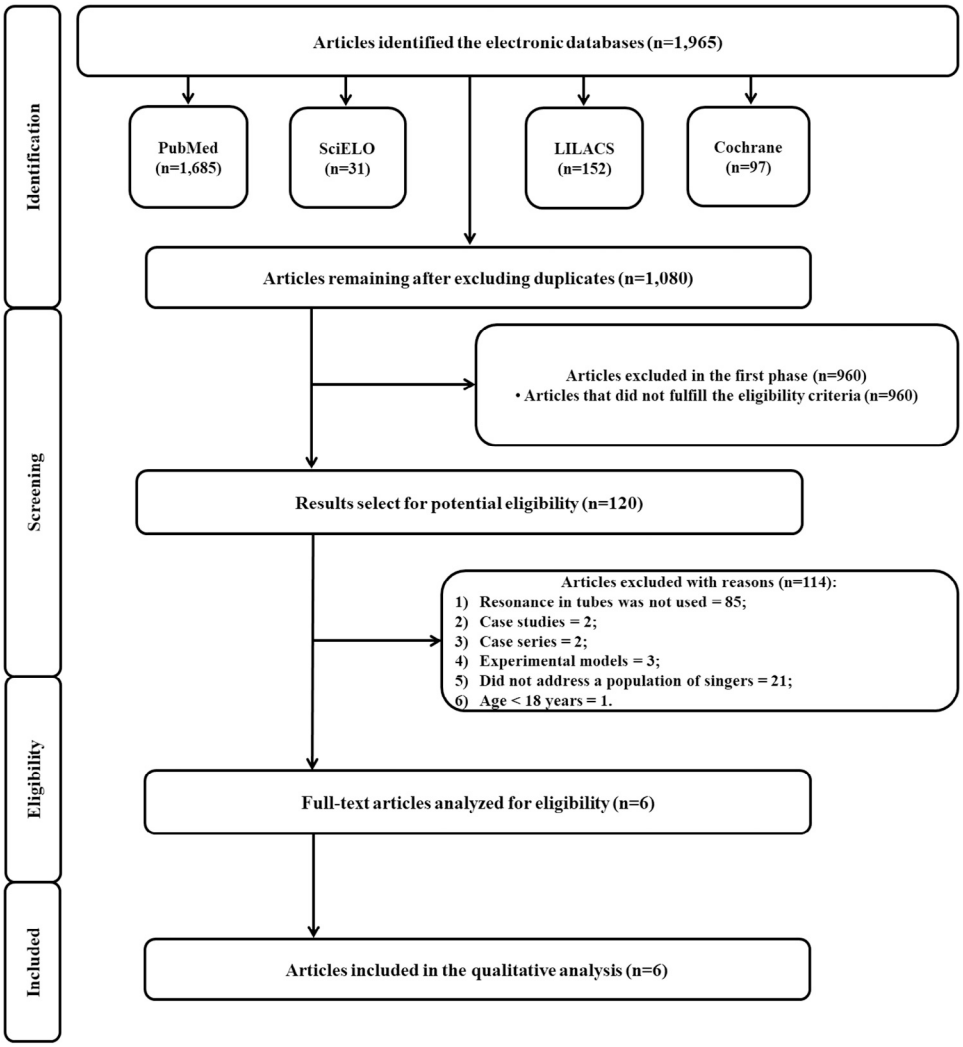

FIGURE 1. Flowchart adapted from PRISMA describing the identification, inclusion, and exclusion of articles in the present study.

(6) studies that sampled individuals aged <18 years old (1 article). After search, selection, inclusion, and exclusion phases, six articles remained in the present systematic literature review (Figure 1).

Study characteristics

The characteristics of the eligible studies are found in Table 2. The studies were published between 2012 and 2017 and were conducted in the United States,[23,26] Chile,[25,27] Sweden,[24] and Brazil.[16] The total sample of individuals addressed in these studies was 141 (65 men and 76 women). These individuals were aged between 18 and 72 years old. One study was designed as case-control,[23] whereas five studies were cross-sectional.[16,24–27]

Risk of individual bias

The agreement between examiners to assess the risk of individual bias was excellent (kappa coefficient = 0.88). Five articles[16,23,25–27] presented a low risk of bias, whereas one article[24] presented a moderate risk. Questions answered with "uncertain (U)" indicated that the articles did not describe clearly the eligibility criteria and the strategy taken to avoid confusing factors in each study. Uncertain data were verified in two articles.[23,25] Table 3 shows the analysis of the risk of bias expressed for each study.

Individual outcomes

The time of experience with singing ranged from 1 to 35 years. Classical music was the most prevalent music genre.[23–25] Three articles used plastic straws,[25–27] two articles used glass tubes,[23,24] and one article used flexible silicone tubes (LaxVox)[16] (Table 4).

The methods of evaluation used in the articles consisted of self-evaluation,[16,27] measurements of the intraoral pressure,[26,27] quantification of the collision threshold pressure,[24] perceptive-auditory analysis,[16,24,27] acoustic analysis,[16,23,27] and electroglottography.[23–27] The last method was the most prevalent among the articles. An increase in contact quotient was observed in one study,[23] whereas a decrease was observed in another.[25] All the articles[16,23–27] expressed positive effects of the phonation into tubes.

TABLE 2.
Compilation of the Main Characteristics of the Eligible Articles

Authors and Year	Country	Objective	Study Design	Sample Size	Sample Age (y)
Gaskill and Quinney, 2012[23]	United States	To compare the effects of resonance in tubes in the glottal contact quotient with and without task instructions in trained and in nontrained voices	Case-control	20 ♂	19–43
Enflo et al, 2013[24]	Sweden	To verify the effects of resonance in tubes immersed in water in the threshold pressure for collision	Cross-sectional	12 ♀	26–40
Guzman et al, 2013[25]	Chile	To determine the influence of resonance tubes and the phonation with vibrato on the quotient of glottal occlusion	Cross-sectional	13 ♂ and 23 ♀	19–62
Maxfield et al, 2014[26]	United States	To quantify the intraoral pressure promoted by 13 movements usually considered semiocclusions	Cross-sectional	10 ♂ and 10 ♀	20–72
Fadel et al, 2016[16]	Brazil	To analyze the immediate effects of exercises with resonance in LaxVox tubes on the semiocclusion of the vocal tract	Cross-sectional	10 ♂ and 13 ♀	18–47
Portillo et al, 2017[27]	Chile	To verify if the physiological and the traditional voice warm-ups affect differently the aerodynamic, electroglottographic, acoustic, and self-perceptive voice parameters in contemporary music singers	Cross-sectional	12 ♂ and 18 ♀	24–39

Notes: ♂ indicates men and ♀ indicates women.

DISCUSSION

Voice disorders impact the quality of life and may lead to social problems, especially for those who use their voices for working. Specifically, these disorders may hamper labor performances by limiting basic functions related to the transmission of verbal and emotional messages.[28,29] The present study assessed the effects of phonation into tubes on voice quality, glottal function, and the vocal tract of singers through a systematic literature review. According to the extracted data, positive effects were observed in voice quality mainly concerning phonation comfort and voice projection after the phonation into plastic, LaxVox, and glass tubes immersed in water or not.

Phonation into tubes is a topic of interest in the scientific literature.[30] This approach has shown benefits to the laryngeal

TABLE 3.
Individual Risk of Bias Specific for Each Type of Study According to the Checklist of the Joanna Briggs Institute[22]

Authors and Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Risk (%)	Risk of Bias
Enflo et al, 2013[24]	U	✓	✓	✓	—	U	✓	✓	62.5	++ (moderate)
Guzman et al, 2013[25]	✓	✓	✓	✓	✓	✓	✓	✓	100	+ (low)
Maxfield et al, 2014[26]	✓	✓	✓	✓	✓	✓	✓	—	87.5	+ (low)
Fadel et al, 2016[16]	✓	✓	✓	✓	✓	✓	✓	✓	100	+ (low)
Portillo et al, 2017[27]	✓	✓	✓	✓	✓	✓	✓	✓	100	+ (low)

Authors and Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Risk (%)	Risk of Bias
Gaskill and Quinney, 2012[23]	✓	✓	U	✓	✓	—	U	✓	✓	✓	70	**+ (low)**

Notes: Cross-sectional studies: Q1: Were the inclusion criteria for sampling described clearly? Q2: Was the study topic described clearly? Q3: Was the experiment addressed in a valid and reliable way? Q4: Did the research include objective criteria and standards to assess the condition? Q5: Were the confounding factors identified? Q6: Did the research include strategies to manage the confounding factors? Q7: Were the outcomes quantified in a valid and reliable way? Q8: Were the statistical analyses appropriate? Case-control study: Q1: Were the groups comparable beyond the disease in the case group or lack of disease in the control group? Q2: Were the case and control subjects concordant? Q3: Did the research use the same criteria to identify case and control subjects? Q4: Was the experiment addressed in a standard, valid and reliable way? Q5: Was the experiment measured the same way for case and control subjects? Q6: Were the confounding factors identified? Q7: Did the research include strategies to manage the confounding factors? Q8: Were the outcomes quantified in a standard, valid and reliable way? Q9: Was the experiment long enough to be significant? Q10: Were the statistical analyses appropriate? ✓ indicates yes; — indicates no; U indicates uncertain; ++ indicates moderate; and + indicates low.

TABLE 4.
Compilation of the Main Outcomes of the Eligible Articles

Authors and Year	Musical Genre/ Experience	Type of Tube	Phonation Task	Evaluation Method	Clinical Effects
Gaskill and Quinney, 2012[23]	Undergraduate and graduate students, with and without vocal training in classical music with at least 5 y of experience	Glass tubes with diameter and length measuring 8 mm and 50 cm, respectively	Resonance of 12× for at least 5 s five each within a total task time of 1 min	Electroglottography and acoustic analysis	The CQ altered considerably for all the participants after the exercises. A small correlation was found between the alterations and the level of education and instruction of the subjects. However, better outcomes were observed in subjects with higher training.
Enflo et al, 2013[24]	Subjects with at least 3 y of experience with classical music and subjects with no formal training	Glass tubes measuring 27 cm in length, immersed 1–2 cm in water	Resonance of the letter "u" for 2 min	Perceptive-auditory analysis, electroglottography, and quantification of the threshold pressure for collision	A significant increase was observed in the threshold pressure for collision after the exercises. A trend for improving the quality of the voice perceived was detected. Better outcomes were observed in professionals who practiced singing on a daily basis.
Guzman et al, 2013[25]	Subjects with at least 5 y of experience in classical music	Plastic straws with diameter and length measuring 5 mm and 33.8 cm, respectively	Four tasks: resonance of letter "a" without vibrato, constant resonance in the tube without vibrato, resonance of letter "a" with vibrato, and constant resonance in the tube with vibratoThe total task protocol was accomplished in nearly 15 min	Electroglottography	There was a lack of statistically significant effects in the CQ. However, the evaluation method revealed a decrease in the CQ during the exercise
Maxfield et al, 2014[26]	Music genre not described Vocal experience between 1 and 35 y	A thin straw, a straw 6 mm in diameter and 19.5 cm in length, and a long and curved straw immersed 7 cm in water	Four tasks: three frequencies similar to a siren, constant resonance during 3–5 s, constant resonance during 3–5 s with comfortable and soft frequency, and constant resonance during 3–5 s with comfortable and loud frequency	Electroglottography and quantification of the intraoral pressure	Resonance in straws with smaller diameters promoted a resistance compatible or even stronger than the glottal function.
Fadel et al, 2016[16]	Music students Years of experience not described	A silicone tube (LaxVox) immersed 2 cm in a bottle (500 mL) of water	First minute: resonance of the letter "u" in habitual frequency, second minute: ascending and descending resonances, and third minute: ascending and descending resonances in scales	Self-evaluation, perceptive-auditory analysis, and acoustic analysis	Most of the singers referred better voice after the exercises. Statistical analyses showed no significant difference among the variables through the perceptive-auditory analysis; the acoustic analysis reported an increase in F_0 and a decrease in the GEN after the exercise.
Portillo et al, 2017[27]	Contemporary music singers he mean experience training time in case and control groups was 4.8 and 5.2 y, respectively.	Straws 5 mm in diameter and 25.8 cm in length	Sustained phonation of a vowel (u:) using habitual voice frequency and intensity, ascending and descending glissandos in a comfortable vocal range (including falsetto), and pitch and loudness (rapid changes in pitch and loudness)	Self-evaluation, acoustic analysis, and perceptive-auditory, aerodynamic, and electroglottography measurements	Statistically significant differences were not observed between the two warm-up methods. Both methods resulted in better self-reported voice quality.

Abbreviations: CQ, contact quotient; GEN, glottal excitation to noise.

muscles[31] and the vocal tract.[32] In practice, this approach is used by singers to increase voice potential and quality.[19] To confirm these benefits with scientific evidence, a systematic review was performed in studies testing the phonation into tubes in populations of singers. However, it is important to note that voice is multidimensional. For this reason, the articles considered eligible should have a correlation in the vocal parameters under analysis.[33] The studies analyzed these parameters subjectively,[16,23–27] such as through self-evaluation and perceptive-auditory evaluation (considered the gold standard for the analysis of vocal quality). These evaluations are essential for the diagnosis of voice disorders and may be useful for planning therapeutic approaches.[34]

In this context, Portillo et al[27] examined 30 singers randomly distributed in two groups of voice physiological warm-up. Voice warm-up was performed traditionally using plastic straws measuring 5 mm × 25.8 mm (based on the open vowel [a:]). The authors observed a better self-reported voice quality after both warm-up methods. Fadel et al[16] analyzed the vocal quality of 23 singers after exercises with LaxVox tubes. Most of the singers reported improvement in voice quality for speaking and singing. The benefits reported were related to voice stability and less tension for speaking. Other positive effects included voice projection and phonation for singing.[16] Enflo et al[24] presented similar results using glass tubes immersed from 1 to 2 cm in water. These outcomes may result from the decrease in the efforts for singing promoted by the voice impedance exercised with the phonation into tubes.[4,16] Additionally, this exercise also protects the glottis, increasing the pressure in the supraglottal region and decreasing it in the transglottal region.[35,36]

The retroflex phonation caused by the semiocclusion in the vocal tract is fundamental to the voice because it modifies the vibration pattern of the vocal folds and enables a more efficient and economic phonation (considering tissue collision).[4,12,32,37,38] Consequently, the risk of developing vocal symptoms, such as hoarseness, vocal fatigue and throat itching, irritation, and dryness, is reduced.[39] Functional alterations that considerably impact career and quality of life may also be prevented in singers.[40]

As an alternative to subjective analysis, acoustic analysis is also used to assess the effects of phonation into tubes. This approach quantifies the vocal signal and enables the differentiation between a voice with a normal quality and a pathologic condition. In practice, the acoustic analysis may aid in differential diagnoses and treatment plans.[41] Manternach et al,[42] in a study with phonation into straws with school choir singers and students in music education, observed through acoustic analysis a statistically significant increase in the voice spectrum. Positive long-term outcomes were observed on sound pressure levels of 0–10 kHz and 2–4 kHz. The authors concluded that SOVTEs are useful for an efficient and economic singing performance, especially for vocal warm-up. In the acoustic analysis, the parameters considered are the fundamental frequency (F_0), the frequency perturbation (jitter), the amplitude perturbation (shimmer), noise measurements (*harmonics-to-noise ratio*), and formant frequencies (F_1, F_2, F_3, and F_4), which are produced by articulatory mechanisms and modified by specific adjustments in the vocal tract.[43,44]

Using the acoustic analysis in 20 singers, Gaskill and Quinney[23] observed aspects related to the vocal tract of singers after phonation into tubes not immersed in water. Small differences were observed between F_1 and F_0. The authors suggested that voice training may improve the conditioning of the vocal tract and may induce the same pattern of glottal occlusion independent of the phonation task applied. Additionally, a reduction in F_1 was observed. This finding indicates that the extension of the vocal tract and the frequency promoted an increase in the contact quotient independent of the voice training and instructions before the exercise.[23] Yet, concerning F_0, Fadel et al[16] used LaxVox tubes to report a projection of F_0 toward high notes within phonation tasks that include scales.[16] During these exercises, the cricothyroid muscle is activated,[19] which may lead to an increase in voice amplitude.

To evaluate the effects of phonation into tubes on the glottal function, the studies addressed in the present research used electroglottography. Electroglottography is a noninvasive method designed to monitor the movement of the vocal folds during phonation using electrodes positioned laterally to the cricoid cartilage.[23,45,46] Gaskill and Quinney[23] detected an increase in the contact quotient through phonation into tubes not immersed in water. Oppositely, Guzman et al[25] observed a decrease in the contact quotient in 36 individuals using phonation into plastic straws. This finding must be interpreted carefully once it may have a positive influence in vocal economy and a high therapeutic value in the treatment of singers with hyperkinetic dysphonia, which is characterized by an excessive tension of the intrinsic and extrinsic muscles of the larynx.[47,48] An increase in the signal of electroglottography was observed in one study with singers.[24] This increase suggests a larger contact surface in the vocal folds potentially caused by the increase in blood flow in this region. Additionally,[24] the same study reported a significant increase in the threshold pressure for collision after the exercises. The authors justify that this finding may related to the oral pressure caused by the phonation into tubes immersed in water. This exercise could promote effects similar to a massage in the vocal tract and folds, which could have influenced the biomechanic properties of the voice.

In a study with 20 subjects,[26] plastic straws measuring 3.5 mm in diameter were used for phonation exercises. The authors observed consistent pressure intensity between men and women. In this study by Maxfield et al, the authors explain that the small diameter of the straw provided more accuracy toward the semiocclusion of the vocal tract. In contrast, the glottal resistance observed in larger tubes is satisfactory only in men. This finding is justified on the anatomic and physiological traits of the vocal folds in men. In practice, this finding suggests that tubes larger than 3.5 mm could not enable satisfactory intraoral pressure for an effective voice therapy.[26]

Despite the scarce scientific literature, research involving phonation into tubes expanded considerably over the last years. On the other hand, the present study highlighted the lack of randomized clinical trials as a limitation of the investigations in the

field. In the present systematic literature review, only observational studies were analyzed. Controlled randomized clinical trials on the effects of phonation into tubes in singers are encouraged for stronger evidence-based practices.

CONCLUSION

The outcomes of the articles considered eligible in the present study revealed the positive effects of voice therapy using phonation into tubes on the voice quality of singers. Specifically, these effects promoted comfortable phonation, voice projection, voice economy, and an increase in the limit for collision during the phonation into glass tubes immersed in water, straws, and LaxVox. Additionally, an enlargement of the vocal tract and a reduction in F_1 were also observed. The vocal effects observed a few minutes after the voice therapy with phonation into tubes may support optimal voice warm-up and may prevent voice disorders in singers.

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