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Immediate effects of semi-occluded vocal tract exercises in low and high voices: a self-perception study

Efeitos imediatos de exercícios de trato vocal semiocluído em vozes graves e agudas: estudo sobre a autopercepção

Keywords

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ABSTRACT

Purpose: To investigate the self-perception by individuals on the immediate effects of three semi-occluded vocal tract exercises (SOVTE), that is, phonation into a latex tube, finger kazoo and phonation into a high-resistance straw, and to compare the self-perception results between the high and low voice groups. **Method:** The study participants consisted of 26 choristers (seven sopranos, seven altos, six tenors, and six basses) subdivided into high and low voices with ages ranging from 18 to 58 years. Voice samples of each subject were recorded before and after performing the exercises randomly for three subsequent weeks. A self-assessment questionnaire was applied. **Results:** All exercises had a statistically significant improvement, according to the participants' self-perception. Latex tube phonation was the preferred technique for 11 (84.62%) participants in the low voice group; while the high-resistance straw was reported as the less beneficial exercise by 10 (79.92%) participants in the same group. On the other hand, the high-resistance straw (9; 69.2%) was the preferred exercise for the high voice group; while finger kazoo (6; 46.15%) and latex tube (5; 38.4%) were the least beneficial exercises. **Conclusion:** The study showed that the effects of these exercises are different and should be suited for each type of voice, such as the latex tube, which was the most preferred by low voice participants and also rated as less beneficial by high voice participants, and the high-resistance straw, which was the most preferred by the high voice participants and also rated as less beneficial by low voice participants.

RESUMO

Objetivo: Observar, pela autopercepção dos sujeitos, os efeitos imediatos de três exercícios de trato vocal semiocluído: a fonação em tubo flexível de látex, *finger kazoo* e fonação com canudo de alta resistência. Comparar os resultados da autopercepção entre os grupos com vozes agudas e graves. **Método:** Participaram do estudo 26 coristas, divididos em dois grupos: vozes graves (seis baixos e sete contraltos) e vozes agudas (seis tenores e sete sopranos) com faixa etária de 18 a 58 anos. Houve gravação pré e pós-realização dos exercícios, que foram executados pelos sujeitos em três semanas diferentes. Foi aplicado questionário de autoavaliação vocal antes e após a execução de cada técnica. **Resultados:** A autopercepção evidenciou que todos os exercícios apresentaram efeitos benéficos nas vozes dos participantes. A fonação em tubo de látex foi a técnica preferida por 11 (84,62%) dos sujeitos graves e 10 (79,92%) desses sujeitos escolheram o canudo de alta resistência como exercício menos benéfico. Para as vozes agudas, o exercício preferido foi o canudo de alta resistência, 9 (69,2%), e os menos benéficos, segundo os sujeitos, foram o *finger kazoo*, 6 (46,15%), e o tubo de látex, 5 (38,4%). **Conclusão:** O estudo demonstrou que esses exercícios podem ser mais bem adequados às vozes graves e agudas. O tubo de látex foi preferido pelos participantes com vozes graves e classificado como menos benéfico pelos com vozes agudas. O canudo de alta resistência foi preferido pelos participantes com vozes agudas e classificado como menos benéfico pelos com vozes graves.

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INTRODUCTION

Young and adult choirs are often polyphonic, thus requiring its members to be divided into parts according to their respective vocal tessituras⁽¹⁻²⁾. Although most singers sing or have sung in a choir, most scientific research on singing voice is focused on solo singing. Choral singing features decreased intensity, less intense singer's formant and more intense low partials⁽³⁾. Choir singers may also use different resonance strategies, or adjust their singing based on their ability to listen to their own voice in relation to others⁽⁴⁾.

A vocal conditioning program, including warm-up and cool-down exercises, is a great strategy for problem prevention and vocal quality maintenance⁽²⁾. Semi-occluded vocal tract exercises (SOVTE) favor the interaction between glottis and supraglottis, promoting a more economical and efficient vocal production and, thus, are highly recommended for subjects with intense vocal use⁽⁴⁻⁷⁾. There are several techniques and programs for speech-language pathology practice in singing voice.

Some examples of SOVTE include techniques such as vibrating sounds (lips and tongue), fricative sounds, prolonged /b/, humming, glottic closure, lip constriction, finger kazoo and tube phonation ET, as they are all performed with some type of occlusion of the vocal tract⁽⁸⁾. These exercises are classified into two groups: regular (glottic closure, humming and high-resistance straw) and fluctuation exercises (vibrating sounds and latex tube)⁽⁶⁾.

Regular exercises show greater stability of contact quotient and fundamental frequency (f_0), promoting an easier phonation. While fluctuation exercises show the contact quotient and f_0 variables, and also use a secondary vibratory source, thus obtaining a "massage effect" on the vocal tract and greater proprioceptive feedback. It is possible to combine both types of exercise into a single vocal conditioning program so that these effects can add up⁽⁹⁾.

The phonation into a flexible latex tube is performed with one tube end in water, for example. The bubbling of water during phonation causes the oscillation of oral pressure that leads to the massage effect on the vocal tract⁽⁷⁾. Tube phonation favors the achievement of therapeutic goals such as pharyngeal enlargement and larynx lowering without the need for biomechanical instructions to the patient, as this type of exercise promotes improved biofeedback⁽¹⁰⁻¹³⁾.

Phonation into a high-resistance straw is one of the exercises that most highlights short-term effects^(5, 14, 15). Exercise leads to an increase in the total volume of the vocal tract, mainly due to the increase of cross-sectional areas in the pharyngeal region. This change is most prominent when the straw provides more airflow resistance⁽¹⁰⁾. This exercise promotes an immediate improvement in vocal quality in choristers, which can be proven by vocal self-assessment and computer analysis⁽⁴⁾.

Finger kazoo is another very common SOVTE, as it has good effects without the need for any instrument to help perform phonation. Acoustic and auditory-perceptual measurements of the glottic source after this exercise show an increase in the fundamental frequency within the normal range and also a reduction in measures related to noise and instability⁽¹⁶⁾. The

technique performed by the Brief and Intensive Therapy program shows significant improvement in glottal coaptation, breathing and resonance at the end of treatment⁽¹⁷⁾.

SOVTE are widely used in speech-language pathology practice routine, either in the conditioning process or in the rehabilitation and prevention of different dysphonias⁽⁶⁾. When comparing the conventional vocal warm-up in singers, which is based on the open vowel [a] with the physiological vocal warm-up, which performed with SOVTE, it can be noticed that both warm-up procedures produce favorable sensations; however, some changes after conventional warm-up may be an early stage of vocal fatigue⁽¹⁸⁾, reinforcing the vocal economy concept promoted by SOVTE.

This study aimed to investigate the self-perception by amateur choristers on the immediate effects of three semi-occluded vocal tract exercises (SOVTE): Phonation into a latex tube, finger kazoo and phonation into a high-resistance straw. In addition, the secondary objective was to compare the subjects' self-perception according to their voice groups, high and low voices, in order to check if there are any particular effects in a specific group.

METHOD

This is a quantitative and interventional study that was submitted and approved by the Research Ethics Committee of the State University of Campinas - Unicamp, under the CAAE no. 57782916.8.0000.5404 and opinion no. 1.649.152. Data collection was performed between August 2016 and March 2017. All participants signed the Free Prior Informed consent. Vocal quality was assessed by the subjects before and after the exercises, through a vocal self-perception questionnaire⁽¹⁹⁾.

Study participants

Twenty-six choristers (13 men and 13 women) from *Ziperna Boca* choir participated in the research, of which seven were sopranos, seven altos, six tenors and six basses. The sample consisted of adults aged 18 to 58 years (mean age: 31.4; standard deviation: 13.9). More than half of the subjects (14; 53.8%) had already taken or were still taking singing lessons at the time of their participation in the research, regardless of the vocal technique lessons of the choir. Choir time ranged from eight months to five years, with only three (11%) subjects being in the choir for less than one year, 14 (54%) from one to three years, seven (27%) from three to five years and two (8%) had been in the choir for over five years.

As for how long the participants sang, three subjects (12%) had one to three years of practice, five had three to five years and most subjects (18; 69.2%) had been singing for over five years.

The division of the parts in this choir is directed by a prior hearing with the conductor and the vocal coach, in order to indicate the tessitura and the vocal classification of the choristers. The conductor and founder of the choir, has a doctorate's degree in music, master's degree in arts and a bachelor's degree in conducting at the Unicamp, while the vocal coach has a bachelor's degree in folk singing and also in popular and classical singing at the Unicamp. The choir performs with classical and popular songs,

but has a mostly popular repertoire that is changed annually. In the year of data collection, the repertoire was composed of songs by Chico Buarque, and the choir also participated in the staging of the opera called *L'elisir d'amore*. In addition to singing, the choir includes performing arts in their performances.

Exclusion criteria for participation in the study were as follows: presence of health problems that could affect vocal quality; continuous-use medication that could affect vocal production and smoking or alcohol consumption. In addition, participants should not have vocal complaint, have sung, or done vocal warm-up on the day of the survey.

Inclusion criteria were to attend the amateur choir for at least five months, longer than the adaptation period; and aged between 18 and 59 years. Aspects such as the previous speech-language pathology therapy or the profession of the subjects were not included as inclusion criteria of the subjects.

Procedures

Participants were separated into two groups of 13 subjects each: High Voices (Group H), which consisted of sopranos and tenors and Low Voices (Group L), which consisted of altos and basses. This study decided not to include a control group, thus choosing to compare only the possible differences between the exercises chosen. The amount of data sample was decided based on the study design (three weeks of exercises per subject); thus 156 data samples were analyzed.

The following semi-occluded vocal tract exercises were applied to conduct the study, all previously demonstrated by the researchers. The exercise was carried out in two sets of one minute with a 5-minute interval⁽¹⁹⁾. Exercises are shown in Figure 1.



Figure 1. Exercises performed

- **Phonation into a latex tube:** the participant should make a sound blow into a 35 cm long and 9 mm diameter latex tube with one tube end in a 500ml container with 330ml of water and the other end coupled between the teeth. The tube was dipped 3cm below the water level⁽⁸⁾.
- **Finger kazoo:** the participant should make a sound blow with habitual frequency and intensity, without inflating the cheeks and with the index finger placed in front of the lips⁽¹⁹⁾.
- **Phonation into a high-resistance straw:** an 8.7 cm long and 9 mm diameter rigid plastic straw. Production of a prolonged sound similar to “vu”, repeatedly, in average frequency and intensity, holding the straw between the

teeth and closing the lips so that the expiratory airflow comes out through the straw, continuously⁽²¹⁾.

Data collection was conducted in three stages, as participants performed a separate exercise every week, for three weeks, so that the effect of an exercise would not be added to the subsequent one. The weeks with a participation in the study were not necessarily consecutive, since when the subject had a health problem such as flu or cold, the application was rescheduled to ensure that the inclusion and exclusion criteria were met at all stages.

The voice samples were recorded using a SM58 Shure microphone (unidirectional, with frequency response from 50Hz to 16kHz and sensitivity of -51.5 dB/2.6mV/Pa), positioned at 10cm from the subject's mouth, coupled to a DR-40 Tascam® Digital Recorder immediately before and immediately after the exercise. In addition, the exercise order was randomly defined for the subjects by a sequence generator of the random.org/sequences website, in which each week the subject performed a different technique, so as to avoid an impact in the participant's response due to the order of the exercises performed.

The voice sampling protocol included connected speech (number counting, phonetically balanced text (Appendix 1), excerpt from the song “Happy Birthday”, CAPE-V⁽²²⁾ sentences, and sustained vowel production (three vowels [a]).

The answers to the vocal self-assessment questions were collected after recording the vocal samples. The procedure was based on the participant's sensations and perceptions regarding the tasks performed in the recording, so that, according to the methodological design of the study, the subjects did not listen to their recordings to answer the self-perception questionnaire. The questionnaire was applied immediately after recording and had three multiple choice questions with previously stipulated alternatives, such as: specific changes in voice (clearer, dirtier, stronger, weaker, etc.); sensations (easy singing or speaking, steady voice, dry mouth or throat, etc.); and general assessment of the exercise effect (improvement, worsening or no effect). The sensations were evaluated before and after the techniques, while voice changes and the general evaluation of the exercise were completed only after the technique. This questionnaire has already been applied in another study and has the most common positive and negative sensations after performing SOVTE⁽¹⁹⁾.

After the self-assessment stage, the participants should perform the requested vocal technique and then the entire vocal sample recording procedure was performed again and the vocal self-assessment questionnaire was also applied again. In addition, on the last day of collection, participants were asked to rate the exercises with the most or least beneficial effects on their voice.

In order to analyze the results, the subjects self-evaluated their vocal quality before and after the exercises, both in the spoken and singing voice, through vocal self-assessment questions⁽¹⁹⁾.

A Chi-Squared Test was performed for the statistical analysis of the results to verify differences between the proportions of responses, using the R v.3.4.0 software, which is available at r-project.org, and a significance level of 5% ($p < 0.05$).

RESULTS

The results shown include the data related to the vocal self-assessment of the study participants.

Table 1 shows the answers of the 26 subjects regarding the changes and sensations in the voice after each exercise. It should be noted that most subjects (88.5%) noticed improvement in their vocal quality after performing the three exercises.

Table 1. Results after exercises

		Exercise/ Number of responses		
		Latex tube N %	Finger Kazoo N %	High-resistance straw N %
CHANGES ON VOICE	Stronger	17 (65.4%)	17 (65.4%)	18 (69.2%)
	Clearer	23 (88.5%)	25 (96.2%)	21 (80.8%)
	Easier	23 (88.5%)	20 (76.9%)	20 (76.9%)
	Weaker	2 (7.7%)	1 (3.8%)	1 (3.8%)
	Dirtier	2 (7.7%)	0 (0%)	1 (3.8%)
	Harder	1 (3.8%)	3 (11.5%)	2 (7.7%)
	P-value	0.006*	0.059	0.1476
SENSATIONS AFTER EXERCISE	Easier singing or speaking	23 (88.5%)	24 (92.3%)	21 (80.8%)
	Looser muscles	18 (69.2%)	23 (88.5%)	19 (73.1%)
	More stable voice	24 (92.3%)	22 (84.6%)	19 (73.1%)
	Dry mouth or throat	6 (23.1%)	11 (42.3%)	11 (42.3%)
	Tiredness	4 (15.4%)	4 (15.4%)	6 (23.1%)
	Noise in voice	6 (23.1%)	4 (15.4%)	4 (15.4%)
P-value	0.0002*	0.0015*	0.0161*	
GENERAL EVALUATION	Improvement	24 (92.3%)	23 (88.5%)	23 (88.5%)
	Worse	1 (3.8%)	0 (0%)	2 (7.7%)
	No effect	1 (3.8%)	3 (11.5%)	1 (3.8%)
	P-value	0.3048	0.09	0.2801

Captions: Chi-Squared Test with significance level of 5% (p-value<0.05)

With respect to the voice changes, the latex flexible tube (p-value=0.006) was the exercise reported by the subjects as the one with the most positive changes, followed by the finger kazoo indicating a trend (p-value=0.059) and, finally, the high-resistance straw (p-value=0.1476).

Most of the sensations reported by the subjects after the exercises were positive, with statistically significant values for all techniques (p-value<0.05). The overall evaluation of the exercises showed beneficial effects reported by most subjects.

Figure 2 shows the association of all responses of the 26 participants, between the sensations before and after the phonation into a latex tube exercise. There was an increase in the positive sensations in voice (p-value=0.0002) and most of the negative sensations decreased or disappeared after the exercise. In addition, 24 (92.3%) of the 26 subjects reported that there was an improvement in vocal quality after the exercise and only one (3.8%) reported worsening and one (3.8%) reported that there was no effect. The perception of this exercise by the subjects

suggests a more expressive increase of positive sensations for the low voice group.

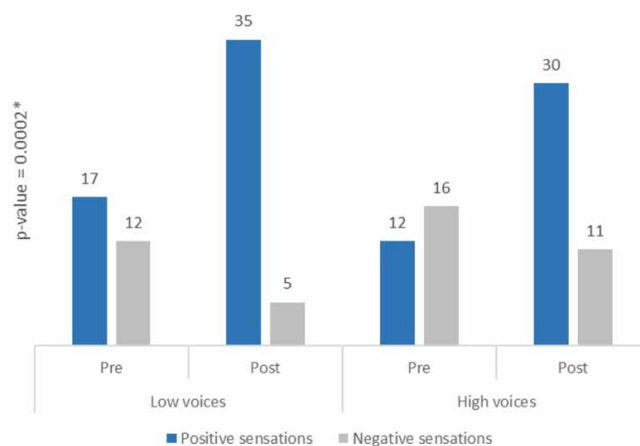


Figure 2. Sensations after and before exercise: látex tube

Captions: Chi-Squared Test with significance level of 5% (p-value<0.05)

Figure 3 summarizes the responses of the participants on the sensations before and after the finger kazoo exercise. There was a significant increase in the positive sensations in voice (p-value=0.015); while negative sensations decreased or disappeared, especially in relation to voice noise. In addition, 23 (92.3%) subjects reported that there was an improvement in vocal quality after the exercise and only three (11.5%) reported that there was no effect. The perception of this exercise by the subjects shows similar results in positive and negative sensations in both groups.

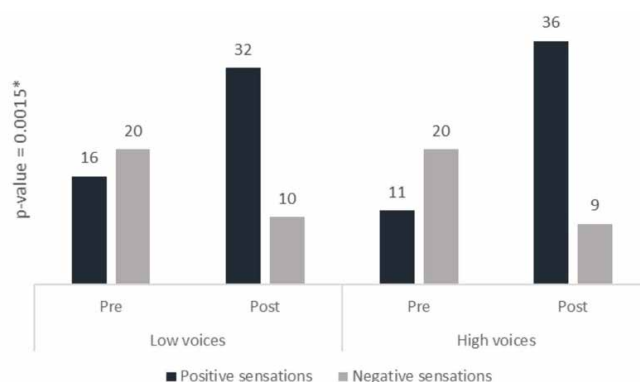


Figure 3. Sensations after and before exercise: finger kazoo

Captions: Chi-Squared Test with significance level of 5% (p-value<0.05)

Figure 4 shows the responses of the participants on the sensations before and after the phonation into a high-resistance straw exercise. Similar to the other exercises, there was a significant increase in the positive sensations in voice (p-value=0.0161); while negative sensations decreased or disappeared. In addition, 23 (92.3%) subjects reported that there was an improvement in vocal quality, two (7.7%) reported worsening and one (3.8%) reported that there was no effect after the exercise. The perception of this exercise by the subjects suggests a more expressive increase of positive sensations for the high voice group.

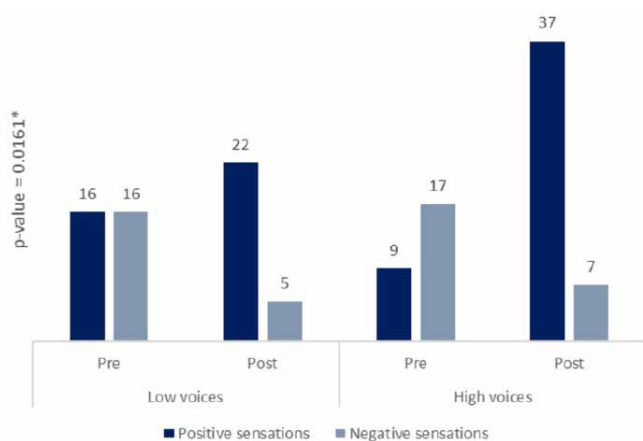


Figure 4. Sensations after and before exercise: high-resistance straw

Captions: Chi-Squared Test with significance level of 5% (p-value<0.05)

The preference of exercises was also evaluated according to each group. The number of subjects who considered phonation into a high-resistance straw in group H as the most beneficial (n=9; 69.2%) was higher than in group L (n=1; 7.7%), and this was also the worst evaluation among the techniques by participants in group L. On the other hand, the phonation into a latex tube was classified as the most beneficial by group L (n=11; 84.6%), whereas it was considered the least beneficial (n=5; 38.4%) in group H, along with finger kazoo (n=6; 46.2%). It should be noted that the finger kazoo had a slight preference for both groups, being considered as most beneficial by only 2 subjects (15.4%) in group H and 1 (7.7%) in group L.

DISCUSSION

Vocal quality of the subject can be assessed acoustically, using a software, and through auditory-perceptual assessment using different scales and should always consider the self-perception of the subjects on their voices. This study focused on studying the self-assessment of the subjects, since it is a powerful tool for clinical practice and should also be included in the speech-language pathology clinic^(2, 4, 8, 9).

It could be noted a preference on the part of high voice participants for the phonation into a high-resistance straw, and this group listed more positive changes in voice compared to low voices, as well as a greater decrease in negative sensations after this exercise. The high-resistance straw causes an increase in the subglottic pressure due to the new constriction point that was created by the exercise, promoting an increase of the fundamental frequency, since the increased subglottic pressure causes greater tension in vocal folds⁽⁶⁾, which justifies the preference of high voices for this technique.

Group L participants rated the high-resistance straw as the least beneficial technique and preferred the phonation into a latex tube. This group listed more positive changes and reduction in negative sensations compared to high voices. Phonation into a latex tube, together with the finger kazoo, was classified as less effective by the high voice participants. The research reports that the phonation into a latex tube promotes vocal tract stretching

that is directly associated with decreased pitch⁽⁸⁾, which may justify the preference of low voices for this exercise.

Choristers are known to develop the ability to listen to their own sound in relation to others, contributing to vocal self-assessment⁽⁴⁾, which could suggest that the proprioception of exercises accurately judged by study participants in their voices. Although the length of participation in the choir varied among study participants, it is known that their experiences in choirs also contribute significantly to vocal self-perception⁽²⁰⁾. Most participants have been singing for more than five years.

In addition, literature shows that SOVTE improves subjects' self-perception^(11,12) associated to their own voices. Thus, the study analyzes considered the group as a whole, even if the sample was a slight heterogeneity bias with regard to age and length of participation in the choir.

Despite being based on a previous study⁽¹⁹⁾, the vocal self-assessment questionnaire applied has not yet been validated, which may also characterize a limitation of this study. Nevertheless, the researchers understood that the evaluation procedure was adequate for the study objectives. In addition to the sensations mentioned in the questionnaire, other sensations or voice changes could be added. SOVTE provide vocal economy, that is, they aid in normal vocal production with less effort^(12, 23). However, it can be noted that the use of the instrument did not allow quantifying sensations that may have been important for participants to choose the best technique, such as the change in pitch perception as a consequence of the tract stretching caused by this class of exercises^(4, 6, 8, 9, 11) and, the lack of a scale that would allow quantifying the sensations could have provided a more detailed comparison between techniques, since perception of noise was often perceived in different techniques, but with different intensities.

Another factor that was noticed only after collection was related to the execution time of each exercise. Although based on previous studies^(19, 23), the five-minute interval between the two sets of one-minute exercise may nullify the effects of the first minute of the previous exercise, thus, the total exercise time in practice was one minute. Studies show positive effects of SOVTE soon after the first minute of execution^(8, 14, 24). In addition, some studies favor shorter exercises for professional voice use, suggesting that this would help the professional to develop the skill in a disciplined manner⁽¹²⁻²⁰⁾.

The improvement in the participants' sensation due to the exercises shows the importance of these techniques as vocal warm-up and conditioning procedures, especially considering the preference for a specific technique for each type of voice. It is recommended to use SOVTE exercises for vocal warm-up and conditioning since these exercises are directly related to vocal efficiency, promoting greater vocal economy during phonation^(9,25). A study comparing conventional vocal warm-up with warm-up exercises using SOVTE reported that conventional warm-up also produces favorable sensations very similar to those of SOVTE, such as easier phonation, cleaner voice, and noise reduction. However, some changes after conventional vocal warm-up (decreased sound pressure level, increased glottal airflow and decreased aerodynamic efficiency) may be correlated with the early stage of vocal fatigue⁽²⁶⁾.

It could be questioned whether the proprioceptive recollection of the last exercise performed by each participant could influence the selection of the best or worst exercise in their self-assessment. However, an analysis of each participant's choice was made, considering the order of the exercises (first, second or third), and the results were variable, indicating that there was no such influence.

No vocal assessment was performed prior to the study, since this study focused on knowing and comparing the sensations of three variations of a class of exercises. The researchers assume that a previous vocal assessment would not change the subjects' perception of the results significantly.

Although no sample calculation was performed regarding the number of participants in the sample, a survey of recent studies with a similar design was made^(12, 27, 28, 29). Given the difficulties of Brazilian researchers in constituting larger samples, this type of previous survey to constitute a sample is advocated by authors⁽³⁰⁾. Also according to the authors, the evidence and homogeneity of the results make a smaller sample accepted.

The research highlighted the importance of further studies to analyze the individual effect of each exercise comparing participants' self-perception of their own voices and the varying effects that different techniques may cause on the subjects. Thus, this study focused on gathering more evidence to fit the choice of techniques in the clinical practice of the speech-language pathologist, since there are no studies showing the effects of SOVTE according to the type of voice or the size of the vocal tract, the latter being one of the correlates for a lower or higher voice. The first findings, shown in this study, may guide the therapist in choosing the most appropriate technique for their patients or customers, and thus, also considering self-perception of the chosen technique, increase self-confidence and singing performance.

Further researches with acoustic and auditory-perceptual analysis are needed to complement these data. The recording protocol used with the subjects was created in order to contemplate future analyzes. All the procedures conducted with the participants were described to the Ethics and Research Committee. In addition, the study highlights the need for further research in the area, including a larger number of subjects and other singing styles.

CONCLUSION

Through self-perception, the subjects indicated the latex tube as more beneficial to low voices, and less beneficial to high voices; while the high-resistance straw was perceived as more positive to high voices and less positive to low voices. All exercises had positive effects on most subjects.

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Appendix 1. Phonetically balanced text⁽³¹⁾.

O dia amanheceu bonito na fazenda. A viagem da noite anterior havia sido muito cansativa. O problema na direção do carro demorou a ser resolvido e por isso chegamos tarde e fomos logo dormir.

Naquela manhã o vaqueiro apareceu cedo trazendo o leite e uma cesta com biscoitos. Tínhamos um dia cheio pela frente, no entanto bem diferente do que estávamos acostumados na capital. Tivemos sorte de poder participar de um rodeio divertido, onde o peão deveria montar zebras, girafas e elefantes no lugar de tradicionais cavalos e touros. Que ideia absurda!

Tiago, zelador do sítio onde ocorreria o rodeio, resolveu exibir com orgulho o prêmio que ganhou naquela brincadeira. Já o último colocado, que era um homem húngaro, acabou machucando o joelho.

Antes do encerramento ocorreu outro incidente: uma égua invadiu o estádio, assustando toda a plateia. O dia foi ótimo e compensou o cansaço de ontem!

Captions: The phonetically balanced text needed to be use in portuguese for further analysis.

Authors' contributions

DHCM participated in the idealization of the study, data collection, and article writing; ACC was the responsible for the guiding during the entire period of research, project design and writing of the article. A research was developed in the Speech and Language Therapy course at UNICAMP.