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Original articles

Vocal range profile of chorists after the tongue-trill technique associated with scales

Perfil de extensão vocal em coristas após técnica de vibração de língua associada a escalas

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ABSTRACT

Purpose: to identify the immediate effect of the sonorous tongue-trill technique associated with tonal variation on the vocal range profile of chorists, analyzing time spent on choral singing, voice types and exercises.

Methods: quantitative cross-sectional study, with 13 singers, eight women and five men, mean age of 39± 20.11 years, with different voice types. The vocal range profile was obtained using Vocalgrama software (CTS Informática). Samples were collected at three different times: before, after one minute and after two minutes of applying the sonorous tongue-trill technique associated with tonal variation.

Results: six chorists (46.2%) showed an increase in vocal range profile after two minutes of the technique. Sopranos and tenors obtained higher mean vocal range profile at any of the three times considered.

Conclusion: the sonorous tongue-trill technique associated with tonal variation had no effect on the vocal range profile of the chorists under study. However, time spent on exercises and voice types seemed to have an influence on the results.

Keywords: Singing; Evaluation; Acoustics; Voice Training; Treatment Outcome

RESUMO

Objetivo: identificar o efeito imediato da técnica de vibração sonorizada de língua associada à variação tonal sobre o perfil de extensão vocal de coristas, analisando o tempo de prática de canto, naipe e tempo de execução do exercício.

Métodos: estudo transversal quantitativo, com 13 cantores, sendo oito mulheres e cinco homens, com média de idade de 39±20,11 anos, pertencentes a diferentes naipes. O perfil de extensão vocal foi obtido a partir da análise pelo software Vocalgrama da CTS Informática. As amostras foram coletadas em três momentos: antes, após um minuto e após dois minutos de aplicação da técnica de vibração sonorizada de língua associada à variação tonal.

Resultados: seis coristas (46,2%) aumentaram o valor do perfil de extensão vocal, após dois minutos de execução da técnica. Os naipes sopranos e tenores apresentaram valores médios maiores do perfil de extensão vocal após dois minutos de exercício. Em relação ao tempo de prática de canto, não houve diferença entre os grupos no valor do perfil de extensão vocal em nenhum dos três momentos considerados.

Conclusão: a técnica de vibração sonorizada de língua associada à variação tonal não interferiu no perfil de extensão vocal dos coristas estudados. Entretanto, o tempo de execução do exercício parece influenciar nos resultados.

DECRITORES: Canto; Avaliação; Acústica; Treinamento da Voz; Resultado do Tratamento

INTRODUCTION

The voice of choristers is characterized by rich details in resonance, sound amplification and vocal range, such that the voice is emitted in a refined and harmonious manner, since this singing style does not allow a change from the original sound of the music [1,2].

In addition to exhibiting a heterogeneous dynamic that involves different age ranges, as well as amateur and professional singers, choristers are classified into voice types according to their specific vocal qualities. Moreover, they perform different adjustments to their larynx and vocal tract to reach the goal determined by the music and the conductor, in terms of quality, expression, vocal range and dynamic range[1,3,4].

However, before singing it is essential to warm up the vocal cords, since this allows the preparation and association between the respiratory, laryngeal and resonant systems, in addition to favoring longevity and vocal health, enhancing quality and increasing voice frequency and intensity[5-7].

One of the exercises performed in vocal warm up is the Voiced Tongue-Trill Technique (VTTT), which involves the production of a prolonged vibrating /r/ associated with the laryngeal sound. The technique has been proven in clinical practice and in studies showing positive results in quality voice emission and adjustment[3,8-10]. It may be associated with tonal variation in the form of vocal warm up exercises, using ascending scales that promote greater vocal cord flexibility and, consequently, increased vocal range[4,6].

Vocal range can be assessed by instrumental software such as Phonetogram or Vocalgram, which measure and analyze vocal range profile (VRP) via the minimum and maximum fundamental frequency, expressed in Hertz (Hz) and semitones (st), as well as the minimum and maximum intensity, expressed in decibels (dB). Therefore, VRP is a combination of measures that allow assessment of maximum phonational frequency range as a function of dynamic voice range, illustrated on a graph (phonetogram or vocalgram) whose area can be measured in cm^2 or percentages[11-14].

Thus, it is important to underscore that the value of the vocal range profile area represents not only the variation in frequencies and semitones that an individual manages to emit (phonational range), but also maximum and minimum intensities that can be reached (dynamic range) during this variation in phonational range. Thus, a higher-quality and better performing voice in terms of controlling frequency and vocal intensity is often related to a graph with a large area[14].

Tongue-trill exercises are known to benefit vocal quality[3,8,9,15,16] and tonal variation training is used for vocal warm ups in rehearsals in order to increase tessitura. In this respect, associating the tonal variations of vocal warm up exercises, which optimizes vocal flexibility, with the tongue-trill technique, which improves balance in voice emission, may influence the vocal range profile (VRP).

It is important to emphasize that the concepts of tessitura and vocal range differ, the former including the deepest bass to the highest treble tones that a person can produce, while maintaining vocal quality and comfort[2,17,18], whereas range encompasses the limit of emitted sounds in addition to natural sounds, that is, total frequencies, from the highest to the lowest that an individual is capable of producing, irrespective of quality[11,19].

Vocal range is influenced by factors such as age, sex, profession, pathologies and laryngeal surgeries[19-21], and vocal training can maximize tessitura[20,21].

Therefore, considering that one of the principles of science is verifying the effect of a treatment[22], and that instrumental resources must be carefully used as a complement to clinical diagnosis[22-25], it is important to confirm the effect of these associated exercises via instrumental measures in specific populations, as in the present study.

Despite knowing that vocal range represents the physiological limits of the subject and that tessitura is the most susceptible to improvement with vocal training, it is important to highlight that the measure obtained in VRP is not restricted to vocal range, but rather to the association between measures of vocal range and vocal intensity[26].

Thus, the aim of this study was to identify the immediate effect of the voiced tongue-trill technique on the change in vocal range profile in choristers, after one and two minutes of the technique, considering voice type, singing experience and time spent on exercises.

METHODS

The study was approved by the Research Ethics Committee of the Center for Health Sciences of the Federal University of Pernambuco, under CAAE number 02751412.0.0000.5208, protocol 76929. All the participants gave their informed consent before data collection.

This is a cross-sectional quantitative study where fundamental frequency (in Hz) and intensity (in dB) were measured at the same time in two situations: before (pre-technique) and after (post-technique) application of the voiced tongue-trill technique associated with tonal variation in ascending and descending glissandos.

The sample was composed of 13 choristers with no vocal complaints, mean age of 39 (±20.11) years, five men and eight women, belonging to the university choir.

Included in the sample were all the members of the choir of the Center for Arts and Communication at the university where the study was developed and who agreed to take part in the intervention study.

The following exclusion criteria were considered: exhibiting any vocal complaint during the examination or unable to perform the voiced tongue-trill technique associated with scales at the moment of recording.

Since this is a matched pair analysis, that is, individuals were their own controls, in order to determine the effect of exercise irrespective of the performance of each individual before execution of the technique, the age factor was not considered as exclusion criterion.

Recordings were made using an HP PC laptop computer, with a Karsect HT-2 headset microphone, Andrea Pure Audio USB-AS adaptor™, and noise reduction technology. Vocal recordings were made in a clinic waiting room and all precautions were taken to ensure that the environment was free of external noise during the recordings. The microphone was kept at a distance of approximately four centimeters from the subject's mouth, at an angle of 45º.

The subjects remained seated during data collection in a comfortable chair, legs bent at a 90º angle, with feet on the floor, in an air conditioned room. Collection was divided into six moments, performed by each subject on the same day for around thirty minutes, as follows.

1) Subjects were asked to emit the vowel /ɛ/ in ascendant glissando up to the maximum pitch and descendant to the minimum that they were able to reach, at the weakest intensity possible; next, the same emission, at the strongest intensity possible. Both were recorded on the vocal range profile (VPR) graph of Vocalgrama software, on weak and strong intensity curves, respectively, according to the instructions of the program itself[13].
2) Application of the vocal technique using tongue -trill exercises associated with the descending glissando from the subjects' mean comfortable pitch to the lowest they can produce, within their tessitura, in thirty seconds. Next, the same exercise was conducted for the same length of time, but in ascending glissando, from the mean to the highest possible pitch, for a total of one minute.
3) Recording of a new vowel /ɛ/ emission in ascending and descending glissando as described in the first step.
4) Vocal rest for five minutes to neutralize the effects of the technique.
5) Reapplication of the technique described in step 2, but with a one –minute duration in both descending and ascending glissando exercises, for a total of two minutes.
6) Recording of new vowel /ɛ/ emission in ascending and descending glissando, as described in the first step.

First, the singers performed the vibration technique in descending tonal variation as standard criterion by researcher consensus. All the recordings were made in the analysis program itself.

The VPR value at pre and post application of the technique, calculated by the percentage of the area occupied in Vocalgrama, was via software analysis. The result considered is the value presented in "total summary" (illustrated in the table of values obtained from the program), which represents the calculation of phonational range (corresponding to the maximum and minimum frequencies and semitones) multiplied by the dynamic range (corresponding to maximum and minimum intensities) on the weak and strong intensity curves (according to the method used to obtain VPR measures).

After the vowel /ɛ/ was recorded in ascending and descending glissando, the graph showed the points corresponding to emission, in relation to frequency (on the x-axis) and intensity (on the y-axis), on two curves: weak and strong-intensity emissions.

The Shapiro-Wilk test was used to determine whether the VPR values exhibited normal distribution, at a significance level of $p<0.05$.

The Wilcoxon nonparametric test for related samples was used to compare values before and after application of the technique, for one and two minutes (pre and post 1; pre and post 2, respectively); the Mann-Whitney nonparametric tests for two independent

samples and the Kruskal-Wallis test for independent k samples were applied for intergroup comparison (time spent singing and between voice types, respectively). Statistical significance was considered when $p<0.05$.

RESULTS

Table 1 shows the characterization of the sample according to voice types and time the choristers spent singing. Most of the participants in the present study were sopranos.

The mean ages of the choristers, distributed by voice type were: 44.67 (±20.72) years, 39.5 (±24.75), 23 (±4.24) and 39 (±20.11) years, respectively for sopranos, contraltos, tenors and bass.

Table 2 contains the individual values (%) of the vocal range profile (VRP) pre and post-application of the technique for one or two minutes of the exercise, as well as the difference between the values obtained pre and post-technique. Of the 13 choristers, only three (23.08%) exhibited an increase in VRP after one minute of the technique and the remainder showed a decrease in value.

After two minutes, six choristers (46.16%) exhibited a rise in VRP. However, the difference between pre and post-technique was not significant.

Table 1. Distribution of singers according to voice types and singing experience, n=13

Voice type	10 years or more		Less than 10 years		Total	
	n	(%)	n	(%)	n	(%)
Soprano	5	38.4	1	7.7	6	46.1
Contralto	-	-	2	15.4	2	15.4
Tenor	1	7.7	1	7.7	2	15.4
Bass	1	7.7	2	15.4	3	23.1
Total	7	53.8	6	46.2	13	100.0

n=number of subjects

Table 2. Distribution of individual values of vocal range profile, at pre-technique (pre) and after one (post 1) and two minutes (post 2) of the voice tongue variation technique

Voice type	Pre VRP (%)	Post 1 PRV (%)	*Pre X post difference*	Post 2 VRP (%)	*Pre X post difference*
Soprano	9.12	8.98	- 0.14	7.11	- 2.01
	9.82	8.97	- 0.85	8.72	- 1.10
	9.76	10.87	+ 1.11	13.17	+ 3.41
	10.65	8.57	- 2.08	11.16	+ 0.51
	9.26	10.49	+ 1.23	9.10	- 0.16
	8.92	6.62	- 2.30	13.17	+ 4.25
Contralto	12.53	12.28	- 0.25	11.43	- 1.10
	11.10	10.21	- 0.89	8.75	- 2.35
Tenor	10.12	10.29	+ 0.17	14.25	+ 4.13
	11.42	6.89	- 4.53	7.87	- 3.55
Bass	8.92	7.41	- 1.51	9.04	+ 0.12
	8.97	8.87	- 0.10	11.24	+ 2.27
	15.44	11.06	- 4.38	10.50	- 4.94
Total mean	10.46	9.35	- 1.11*	10.42	- 0.04**
sd	1.86	1.71	1.82	2.21	2.90

Wilcoxon test – significance level of p<0.05
***p=0.055 **p=0.861*
sd = standard deviation
VRP = Vocal range profile

Table 3 depicts the mean values (%) of the VRP areas of the singers, pre and post-technique, for one and two minutes, respectively, distributed according to the voice types of the choir. After one minute of the technique, the mean differences in VRP values were negative, indicating a decrease in area in all the groups. However, after two minutes, there were positive mean differences in sopranos and tenors, indicating a rise in area values for these two voice types.

Table 3. Distribution of mean vocal range profile values, after one (post 1) and two minutes (post 2) of the voiced tongue -trill technique, according to voice type.

Voice type	Pre VRP (%)	Post 1 VRP (%)	*Pre X post 1 difference*	Post 2 VRP (%)	*Pre X post 2 difference*
Soprano	9.59	9.08	- 0.51	10.41	+ 0.82
Contralto	11.82	11.25	- 0.57	10.09	- 1.73
Tenor	10.77	8.59	- 2.18	11.06	+ 0.29
Bass	11.11	9.11	- 2.00	10.26	- 0.85

VRP = Vocal range profile

The low number of contraltos, tenors and bass precluded intragroup comparisons. Thus, voice types were compared, considering VRP values at the three moments: pre, post 1 and post 2. The results showed no significant difference in VRP between voice types (p=0.433).

The mean VRP values, according to singing experience, at pre and post-moments for one and two minutes were 9.91%, 9.44% and 10.39% respectively in the group with up to 10 years of singing experience and 10.90%, 9.08% and 10.82%, in the group with more than 10 years. There was no intergroup difference in VRP values at any of the three moments (p=0.617, 0.688 and1.000, respectively).

DISCUSSION

Studies have shown the benefits of tongue-trill technique for vocal quality[3,9,15,27], but did not directly determine the effect of the voiced tongue-trill technique (VTTT) associated with tonal variation in scales, as was done in the present study. Given that this association is common practice in vocal warm up exercises, studies are needed to measure the effects of associated techniques on choristers.

This investigation aims at establishing a better framework for vocal coaches, singing teachers and conductors, thereby contributing to speech therapy in the area.

Moreover, it underscores the importance of testing the association with techniques, considering the physiological effect and applicability of each variation according to the specific need of the target population[27].

Given that one of the purposes of vocal warm up exercises is to prepare vocal cords for the tasks to follow and that the characteristics of the individuals and the task to perform must be considered, exercises that favor muscle conditioning exercises are used to prevent injuries and vocal fatigue and improve vocal flexibility. Therefore, ascending and descending melodic exercises are included with variations in pitch and intensity[28-30].

Thus, ascending and descending exercises were considered in the present study, given that the subjects were in the lower (contralto and bass) and higher (soprano and tenor) ranges. Furthermore, in choral singing, it is important to have good vocal endurance in order to preserve vocal quality for the frequency range established for each voice type[31].

With respect to method, it is important to underscore that none of the subjects warmed up before the first recording so that it would not influence pre-technique performance. This option considered the effect of vocal warm up on vocal intensity and pitch[5-7], given that the study was on the immediate effect of the exercise applied.

In relation to the study sample, since this is the first study that aimed to measure the instrumental effect of an association of vocal techniques on vocal range profile, the age of the choristers was not an exclusion factor, despite the recognized interference of age on pitch and intensity and the fact that maximum vocal

efficiency is considered to be between the ages of 25 and 45 years[2,19-21,32,33].

Thus, this study exhibited high variability in terms of chorister ages, in all voice types, except for tenors (table 1). This demonstrates the characteristic of the choir under study, which belongs to a public university and therefore contains individuals from different age groups.

It is important to underscore the use of computerized equipment for acoustic voice analysis, such as that used to analyze VRP, owing to its usefulness in documenting and following the progress of singers and singing students[20], in addition to being useful in measuring the results of vocal warm up exercises, commonly assessed in a subjective manner[34].

With respect to the results obtained, it can be inferred that the age factor interferes in the performance of singers and that future studies that consider the variables discussed in this research should seek to homogenize the sample in terms of this criterion. However, this study did not consider age, in principle to show the effect of vocal technique and not vocal quality prior to application of the exercise.

The results of the effect of the VRP technique shows that there was no difference in either of the two moments the exercise was applied (Table 2). However, a number of observations should be made regarding the following aspects: vocal range, intensity and application of the technique.

In relation to vocal range (which is related to the maximum and minimum limits of voice frequency), it is known that it is determined by factors not susceptible to vocal training[19-21,29]. However, tessitura is susceptible to change[20,29]; thus, since VRP is a measure that associates intensity and frequency, it is expected that the technique could increase the values found before and after its application.

However, since individual analysis showed that PRV declined in 53.8% of the subjects, it can be inferred that VTTT, associated with tonal variation, favors vocal comfort and quality[7,21] and may promote a phonational adjustment that causes a decrease in vocal intensity, or limits vocal range to a comfort level (decline in vocal frequency). It is important to underscore that since VRP is analyzed according to the percentage of the area on the graph, it may exhibit low range and/or intensity values, irrespective of its displacement in frequency range. In this study the fact that VTTT was associated with descending glissandos may have contributed to lower adjustment of the individual's vocal potential, which may also have contributed to the decreased percentage on the graph.

To test these hypotheses, it is suggested that future studies separately assess frequency and intensity and determine their maximum and minimum limits, as well as total VRP. Moreover, perception-auditory analysis of vocal quality at the three moments is essential to establish the influence of exercise compared to tessitura and vocal range, primarily because vocal warm up exercises (tonal variation) and VTTT aim at widening tessitura[20,29].

Sample size should be considered, mainly when dividing the group into voice types.

In relation to voice types, despite the fact that the results did not show significant differences, the increase in the VRP of sopranos and tenors (Table 3) observed after two minutes of the technique suggest that, since they have the highest pitched voices in the choir (females and males, respectively), how the technique was applied may have had an influence, given that tonal variations in descending glissandos were applied first followed by descending glissandos, which may have favored the more high-pitched voice ranges. This reinforces the idea that vocal range exercises for choristers should respect the vocal range and quality of each voice type.

However, it is important to underscore that in order to confirm whether the effect of the technique favored the higher vocal ranges, maximum and minimum range values (in frequency and semitones) must be compared, given that VRP values are presented in percentage of the graph filled.

The apparent increase in VRP in most of the voice types after two minutes of the technique compared to one minute suggests that the longer exercise time seems to generally benefit the voice types. The rise in VRP after two minutes of exercise compared to the pre-technique in nearly half the sample seems to reinforce this hypothesis, corroborating the findings of another study[15]. Therefore, it is suggested that for an increase in VRP, VTTT associated with tonal variations should be applied for at least two minutes.

The decrease in contraltos at the two moments may be explained by the small sample size of this voice type (Table 1).

With respect to intergroup comparison of singing experience, even though no significant difference was found between the means, there was an increase in VRP after two minutes of the technique in the group with less than ten years. It is suggested that a study with a

larger sample size be conducted to test the hypothesis that this specific exercise promotes greater gains in beginners than in subjects with more experience, considering that it increases vocal range[2,20].

Individual assessment of choristers, with respect to duration of the technique, showed a decrease in VRP in most choristers, after one minute. This result seems to corroborate the hypothesis that exercise promotes initial phonational adjustment, allowing greater control of vocal frequency and intensity in a more comfortable emission[9]. This is because there is probably only one accommodation adjustment for emission after only one minute of exercise, meaning frequency and intensity decline initially due to a possible improvement in vocal quality[35].

Given that the pre-technique moment was conducted with no vocal warm up or body preparation, it can be suggested that even though VRP was higher at this moment, emission may have been less controlled and after the adjustment caused by the technique, VRP was lower due to the possible vocal control provided to the singers.

This may corroborate the hypothesis that vocal training hinders control of intensity related to frequency[20,35,36].

Thus, in addition to investigating a specific population of choristers, this study may contribute by having compared the effect of VTTT in a population with no vocal alterations and tested the duration of vocal exercises[9].

It is suggested that future studies control the limitations contained in the present study, such as increasing the number of subjects per voice type, separating the forms of executing the technique (in ascending and descending glissandos executed separately) and controlling the age range of individuals.

CONCLUSION

The results of this study demonstrated that VTTT associated with tonal variation caused an increase in VRP values in 46.2% of choristers and a decrease in 53.8% after two minutes of the technique. However, the difference between pre and post-exercise moments was not significant.

The VRP values did not differ between groups according to voice types and singing experience.

Thus, it is suggested that complementary studies be carried out to determine the effect of the technique on vocal range, in addition to comparing the results with perception-auditory analysis of vocal quality.

Furthermore, other studies are needed, varying the exercise application methodology, according to the voice type of the choral.

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