Effectiveness of Voice Therapy Associated With Electromyographic Biofeedback in Women With Behavioral Dysphonia: Randomized Placebo-Controlled Double-Blind Clinical Trial

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Summary: Objective. To analyze the effectiveness of vocal therapy associated with electromyographic biofeedback in women with behavioral dysphonia.

Materials and methods. This is a randomized placebo-controlled double-blind clinical trial. Twenty-two adult women with behavioral dysphonia were randomly divided into two groups: Experimental Group—11 women participated in vocal therapy associated with the application of electromyographic biofeedback; Placebo Group—11 women participated in vocal therapy associated with the application of placebo electromyographic biofeedback. Both groups performed eight therapy sessions, twice a week, lasting 30 minutes. The vocal therapy of both groups was composed of semioccluded vocal tract exercises (trill, humming, and fricative). The evaluations were performed at four time points—before, after, one, and three months after the vocal therapy—and will consist of the following assessments: auditory-perceptual evaluation of voice, acoustic evaluation of voice, and surface electromyographic. The data were analyzed statistically comparing the groups and the time of evaluation ($P < 0.05$).

Results. The proposed vocal therapy promoted positive results in vocal quality and muscular electrical activity during rest in women with behavioral dysphonia for both groups. Electromyographic biofeedback promoted additional positive results in muscle electrical activity during phonatory tasks in women with behavioral dysphonia.

Conclusion. In this study, the vocal therapy associated with electromyographic biofeedback had equivalent efficacy to traditional therapy in the voice. The biofeedback was more effective than traditional therapy on muscular electrical activity and had effects that remained for a longer time in women with behavioral dysphonia.

Key Words: Dysphonia–Electromyography–Biofeedback–Voice therapy–Voice.

INTRODUCTION

Although there is no standard classification for dysphonia, a current international suggestion is to divide dysphonia into behavioral and organic.[1] Behavioral dysphonia is a voice disorder whose etiology is directly related to the use of voice and may be due to inappropriate vocal behavior, voice misuse or abuse, lack of technique, or muscle tension.[1] Thus, it includes dysphonia with various denominations such as functional dysphonia, muscle or musculoskeletal dysphonia, hyperfunctional dysphonia, hyperkinetic dysphonia, and isometric laryngeal dysphonia, among others.

The clinical characteristics of behavioral dysphonia can manifest in four levels: respiratory, glottic, resonant, or articulatory.[1] At the respiratory level, the main manifestation is a short, compressed upper breathing.[2,3] At the glottic level, the main features are the presence of constriction, glottic cleft, and the presence of benign lesions in the vocal folds.[1,3,4] At the resonant and articulatory levels, there may be incorrect use of resonance boxes and imbalances in articulation.[5] The voice quality changes in these individuals are characterized by the presence of roughness, breathiness, and strain, as well as deviations in pitch and loudness.[1,3,6,7]

Behavioral dysphonia can also have musculoskeletal and postural effects, leading to excessive tension in the laryngeal, cervical, and scapular girdle musculatures, elevated larynx in the neck with decreased thyrohyoid space, high shoulders, and anteriorly overextended head.[1,6,8]

Although the literature shows the effectiveness of several methods and programs of vocal rehabilitation,[3,7,9,10] few studies explore body self-perception and the participation of the cervical and scapular girdle musculatures in the clinical manifestation of dysphonia. One must remember that inadequate body adjustments, combined with decreased body and vocal perception during phonation, may prolong dysphonia as well as increase the chances of recurrence after treatment.[6] Thus, it is essential to transfer the vocal and muscle adjustments, achieved with the vocal techniques and exercises, to the conversation, as well as the generalization of the new vocal behavior.[11,12]

In order to improve the perception and neuromuscular behavior during voice production by individuals with behavioral dysphonia, electromyographic biofeedback has been proposed.[13] Through electromyographic biofeedback, individuals view, in a computer screen, a data trace representing muscle electrical activity, allowing simultaneous observation of the behavior of their musculature during a given action. In this way, the visual feedback from the electrical signals in the musculature can be used to improve the perception and the control of the muscle

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recruitment exerted during voice production, helping achieve a balanced execution of the function.[13,14] The method is based on the principle that neuroplasticity allows the individual to adapt to a new demand, in this case vocal and corporal. Thus, electromyographic biofeedback, through the repetition of tasks with isolated exercises or with exercises associated with vocal function, can generate a neurofunctional (re)organization that increases the chance of the individual automating the new vocal and corporal neuromuscular behavior during phonation,[13,14] improving the overall clinical presentation of the individual with behavioral dysphonia.

Therapeutic programs that applied biofeedback to the voice field showed reduction of muscle electrical activity[13,15–17] and improvement in voice quality,[18] sustained for up to 18 months[19] after rehabilitation. However, the designs of these studies had low levels of evidence and discrepancy in temporal variables, besides failing to describe the activities performed or how muscle activity was controlled, hindering their reproduction. Therefore, a clinical trial is necessary to analyze the effectiveness, in behavioral dysphonia, of voice therapy associated with electromyographic biofeedback, comparing it with traditional voice therapy, to support decision making by professionals in the field.

The present study sought to analyze the effectiveness of vocal therapy associated with electromyographic biofeedback in women with behavioral dysphonia.

The null hypothesis (H0) of the present study was as follows: there is no difference between vocal therapy associated with electromyographic biofeedback and vocal therapy associated with placebo electromyographic biofeedback regarding the effectiveness on voice quality and muscle electrical activity in women with behavioral dysphonia.

MATERIALS AND METHODS

Type of study

This is a randomized placebo-controlled double-blind clinical trial.

Ethical considerations

This clinical trial followed the recommendations of CONSORT,[20] was approved by the institutional Research Ethics Committee (no. 1.235.463), and was registered in the Registry of Clinical Trials (no. RBR-9C73CM).

Professionals

The present study was conducted by a team of five professionals in order to ensure blinding. The roles and the form of masking of the professionals were as follows:

- Professional 1: Voice Therapist. In charge of the randomization and allocation of participants. Blinded to the stages of sample selection and evaluation of the outcomes.
- Professional 2: Otorhinolaryngologist. Responsible for laryngological exams. Blinded to the selection, randomization, and allocation of participants, and to the other stages of outcome evaluation.
- Professional 3: Voice Therapist. In charge of the selection of the sample, evaluation of the outcome variables, and collection of materials sent to evaluation by outside judges (who were not part of the study). Blinded to the randomization and allocation of participants.
- Professional 4: Voice Therapist. In charge of therapy for the two intervention groups. Blinded to sample selection and to the stages of evaluation of the outcomes.
- Professional 5: Voice Therapist. In charge of editing the materials sent for evaluation by outside judges and of data tabulation. Blinded to sample selection, randomization, and the allocation of participants, and the stages of evaluation of outcomes.

Participants

Sample calculation used a previous study[17] on the effect of biofeedback on electrical activity and the voice of singers as an estimate of the variability of this method. In that study, the highest standard deviation of the difference in electrical activity of the muscles analyzed (trapezius and sternocleidomastoid [SCM]) between preintervention and postintervention times was 1.07 μV for the group that performed biofeedback. With a 5% level of significance and 80% test power to detect a minimum difference between groups equal to one standard deviation, considering an estimated loss of 20% of the sample, the estimated size of the sample was 11 participants per group.

The sample included dysphonic women, aged 18–45 years, with diagnosis of behavioral dysphonia, who signed the Informed Consent Form. Exclusions comprised participants who reported clinical history of neurological or syndromic diseases, hearing dysfunction, laryngeal and/or pulmonary surgery, vocal and/or otorhinolaryngological treatment for dysphonia in the last 6 months, and smoking, and participants who failed to complete the on-site sessions of the proposed interventions.

For the selection process, all the participants answered a sample questionnaire and underwent a vocal screening and an otorhinolaryngological evaluation. The sample questionnaire, developed by the researchers, addressed the following topics: identification, occupation, habits, complaints, and history of vocal and general health. Vocal screening was performed through an auditory-perceptual evaluation consisting of a binary classification of the voice, as normal or altered. A laryngological examination consisted of telelaryngoscopy, laryngeal stroboscopy, and nasolaryngoscopy. Participants classified as having behavioral dysphonia had complaints and histories of habits and vocal health pointing to an etiology related predominantly to voice use, and presented with altered voices in vocal screening and benign lesions in the larynx evidenced in otorhinolaryngological evaluation, such as bilateral vocal fold edema, vocal cyst with contralateral reaction, or bilateral vocal nodules.

This study employed block randomization. Three blocks were randomized, each including eight participants. For this, the numbers from one to 24 were arranged in a *Microsoft Office Excel 2010* (Microsoft Corporation) spreadsheet in ascending order, separated in three columns, with eight participants from each block. Then, the eight numbers in each column were rearranged with the RANDBETWEEN function. The top half

of the numbers in each column were assigned to the Experimental Group (EG) and the bottom half to the Placebo Group (PG). The numbers corresponding to each block of participants were arranged in sealed individual envelopes: block one (one to eight), block two (nine to 16), and block three (17–24). Participants would draw an envelope at the selection stage, and the envelope number designated their intervention group.

Thus, the participants were allocated blindly and randomly in two groups: EG—participants receiving voice therapy associated with the application of electromyographic biofeedback; and PG—participants receiving voice therapy associated with the application of placebo electromyographic biofeedback. The study participants were blinded to the existence of two intervention groups.

Losses were counted as the number of participants who abandoned the survey before its completion, and for each one the reasons and the time of the intervention were recorded. Losses that occurred after the end of the in-site intervention were called follow-up losses.

Evaluation of outcome variables

This study had three primary outcomes: auditory-perceptual evaluation of voice quality; acoustic evaluation of voice quality, and electromyographic surface evaluation.

The outcome variables were evaluated in four times: before the execution of the intervention (time 1 = T1), immediately after the intervention (time 2 = T2), 1 month after the intervention (time 3 = T3), and 3 months after the intervention (time 4 = T4). All four evaluations followed the same procedures.

Voice quality assessment

Vocal evaluation comprised the auditory-perceptual and acoustic evaluation of the voice quality, from a voice recording performed in an environment with acoustic treatment and ambient noise lower than 50 dB SPL. To record the voice, the participants were placed in an orthostatic position in an acoustically treated room and were instructed to perform the following tasks: sustained vowel /a:/, isolated and after deep inspiration, in their usual pitch and loudness; and number counting from one to 10 in their usual speed, articulation, pitch, and loudness. Productions were captured through an AKG professional microphone, model C-444PP (AKG Acoustics GmbH, Vienna, Austria), positioned at a 45-degree angle from the participant's mouth and 4 cm away from the labial commissure, and were recorded directly into a computerized system consisting of an Intel Pentium 4 computer with 2,040 GHz CPU and 256 MB RAM, LG Flatron E7015 17" monitor and Creative Sound Blaster Audigy II (Creative Technology Ltd, Singapore) sound card. The recordings were made with *Sound Forge 10.0* software (Sony, New York) at a sample rate of 44,100 Hz, mono channel, at 16 bits. The recording time was not controlled; the participants were free to perform their recordings to their best ability.

For the auditory-perceptual evaluation of voice quality, the voices were randomized with replication of 20% of the sample. Subsequently, they were referred to three speech therapists, voice specialists who were not part of the study. The parameters analyzed included grade, roughness, breathiness, and strain. For the analysis of the sustained vowel production, the instability parameter was added. For each parameter evaluated, a 100-mm analogue visual scale was used. The judges were instructed to mark an "X" by crossing the line at the point that characterized their opinion on the oral productions of the sample, with 0 mm (extreme left) equal to no deviation and 100 mm (extreme right) equal to the strongest deviation. The judges were blinded to which group each of the participants belonged to, to the timing of the evaluations, and to the replication of the samples. The judges received prior auditory training with the use of anchor voices of balanced voice quality and with deviations of all degrees of parameters: roughness, breathiness, and strain. After the training and after explaining each step regarding auditory-perceptual evaluation, the judges received the material for analysis. The judges' analyses were conducted in a quiet environment using AKG K-44 headphones microphone (AKG Acoustics GmbH), and the computers were set to display 44,100 Hz, a 16-bit sample rate audio format, using the same equipment and settings used in the training. The judges were instructed to listen again to the balanced voice quality anchor voice after every 10 voices analyzed and to rest for 5 minutes for every 20 voices analyzed. Then, the distance from the beginning of the scale to the marking of each item was measured with a ruler to ascertain the corresponding score. For each parameter, the average of the evaluations of the three judges was considered. The intrajudge and interjudge concordance values were also calculated.

The acoustic analysis used the recording of the sustained production of the vowel /a:/. The instructions and equipment used for recording were the same as those described in the auditory-perceptual evaluation. The acoustic analysis was performed with the *Multi-Dimensional Voice Program*, model 5105 (Kay Elemetrics, Lincoln Park, NJ), with a sample rate of 44 kHz and 16 bits. The measures analyzed were fundamental frequency (F0), fundamental frequency variation, jitter percent, shimmer percent, amplitude variation, noise-harmonic ratio, voice turbulence index, and soft phonation index (SPI).

Surface electromyography evaluation

The electromyographic evaluation was performed with the NM800F—New Miotool Face USB surface electromyograph (Miotec, Porto Alegre, Rio Grande do Sul, Brazil), with eight channels and a reference electrode (ground) individually connected to active sensors SDS500 through alligator connectors. An Inspiron 15 5000 Series Special Edition notebook (Dell Inc., Eldorado do Sul, Rio Grande do Sul, Brazil) with a Dual-Core Inside i7 processor and a *Windows 8.1* operating system (Microsoft Corporation) was attached to the electromyograph. The *New Miotool* software (Miotec)[21,22] was used to record the electrical potentials. The surface electrodes were the single adult Solidor model consisting of a silver/silver chloride pad, immersed in conductive gel, co-sided in pairs with interelectrode distance of 1 cm.[22] In order to decrease the impedance and increase the electrical signal pickup, the skin was sanitized with 70° GL ethanol.

For the stabilization of the signal, a reference electrode (ground) was used, adapted in the olecranon of the ulna of the right arm of the participants.[21] Muscles analyzed were the right-sided and

the left-sided descending fibers of the trapezius muscle, right sternocleidomastoid (RSCM) and left sternocleidomastoid (LSCM) muscles, left infrahyoid (LIH) and right infrahyoid (RIH) muscles, and suprahyoid (SH) muscles.

For the trapezius muscles, a pair of electrodes was attached 8 cm from the seventh cervical vertebra, bilaterally toward the acromion.[23] For the SCM muscles, a pair of electrodes was attached 4 cm below the mastoid process, to the center of each muscle belly, longitudinally with respect to its fibers, with the detection site perpendicular to the fibers, bilaterally.[23] For the IH muscle group, two pairs of electrodes were adapted bilaterally to the larynx, 1 cm from the thyroid notch in the craniocaudal direction, bilaterally.[21,22] For the SH muscles a pair of electrodes was placed in the submandibular region, longitudinally to their fibers.[23]

The electrical signals were captured during the following vocal tasks: at rest (30 seconds), sustained vowel /a:/ production (7 seconds), and maximal voluntary contraction (MVC) (5 seconds).[23] Each activity was collected three times at 1-minute intervals.

At all times the phonatory task was captured in the habitual manner—after deep inspiration, in the participant's usual pitch, loudness, and rhythm. From T2 the task was also captured in a modulated form—after deep inspiration, with a frequency and intensity approximate to what the participant used in the respective task, in T1. For this, in T1 the F0 and the modal intensity of the voice were measured with a DEC-470 sound pressure level meter (Instrutherm, São Paulo, Brazil). Frequency was measured with the simultaneous analysis software *Harmonicity Meter* version 1.11 (Keuwlsoft, London, UK) with a 44-kHz sampling rate, installed in a smartphone (Moto-G4, Lenovo Group Ltda, Quarry Bay, Hong Kong).

In order to assess each participant's MVC, the following tasks were performed, all of them with effort: incomplete swallowing (SHs)[24]; tongue retracted with open mouth (bilateral infrahyoids)[24]; head turning to the right and to the left (bilateral sternocleidomastoids),[25] and elevation of shoulders (bilateral trapezius muscles).[25]

Signal analysis was performed with *Miograph 2.0* software (Biotec). An online bandpass filter was added at frequencies from 20 to 500 Hz. For all data captures, the first and the last seconds of the recordings were excluded from the analyses.[21] The analysis sequence was raw signal subjected to Fast Fourier Transform, inclusion of offline filters, extraction of root mean square (RMS) values, average of the three RMS values for each activity, and signal normalization. The normalized percentage values (%) for the phonatory task and for the resting condition were calculated from the mean of the MVCs.[22]

Voice therapy

Voice therapy was performed with the Voice Therapy Program (VTP).[26] The VTP was developed for the rehabilitation of individuals with behavioral dysphonia and has as general objectives to equalize phonation, to improve knowledge, and to provide strategies for the participant to improve vocal health, production, and behavior. In addition, the VTP sets specific goals and strategies for each session. The VTP methodology was organized based on the Voice Therapy Taxonomy[27] and consists of three general categories of instruments: indirect intervention, direct intervention, and intervention administration methodology.[27] In addition, the VTP comprises an on-site portion and an at-home portion.

In this study, VTP[26] was associated with electromyographic biofeedback, which employed the same equipment, configurations, sanitization procedures, and electrode positioning as the electromyographic evaluation. Electromyographic biofeedback was applied to the SH, RSCM, and LSCM muscles.

To perform the biofeedback procedure, participants from both groups were instructed to sit on a chair, with back support and without head support, with their hips and knees flexed at 90 degrees, feet resting on the floor, hands resting on their thighs and their usual head position. They faced the computer screen such that it could be seen with the neck in the usual resting position. After that, different electromyographic biofeedback application procedures were employed in the EG and the PG.

Experimental group

Only the EG performed electromyographic biofeedback. This group had alternated sessions according to the objective proposed in each session. The odd sessions (sessions 1, 3, 5, and 7) worked with the SH muscle group, whereas the even sessions (sessions 2, 4, 6, and 8) worked with the RSCM and LSCM muscles.

Considering the VTP[26] based on the Taxonomy of Vocal Therapy,[27] the extrinsic method of administration of the intervention used was the hierarchical method: the intrinsic and extrinsic intersection method was the feedback, whereas the main intrinsic methods expected from the participant were self-perception and self-correction. Electromyographic biofeedback was used as a complementary tool to voice therapy in all sessions of the EG to assist in the specific objective of reducing phonatory effort. In the taxonomy system of direct and indirect intervention, the electromyographic biofeedback fit in the following subsystems: indirect intervention on the counseling by the therapeutic interaction subsystem, direct intervention in the visual processing somatosensory intervention subsystem (direct intervention tool that draws the patient's attention to the visual perception of the position and movement/behavior sense), direct intervention on the discrimination somatosensory intervention subsystem (a direct intervention tool that focuses the attention of the patient on her position and movement in order to reduce the effort and the tension), and direct intervention on the musculoskeletal subsystem of postural alignment (a direct intervention tool that directs the attention of the patient to the modification of muscle, skeletal, and connective tissue to obtain a more efficient alignment of the anatomical structures themselves).

The software used to perform electromyographic biofeedback was Biotrainer (Miotec), which provides the participant with visual feedback of the muscle electrical activity.

In order to normalize the values of muscle electrical activity in the EG, the task-specific MVC of all participants was recorded for the exercises proposed for voice therapy, at maximum effort; that is, strong trill, strong humming, and strong fricative. In each exercise, the task-specific MVCs of the three muscles (SH, RSCM, and LSCM) were obtained, three times each. The

highest peak of each muscle for each of the task specific with exercises was taken as the reference value (100% of the electrical activity of each muscle for task specific) to calculate the conversion of μV to percent of the reference exercise. The normalization was carried out simultaneously with the execution by the software. The reference value, however, was the one captured before the beginning of the sessions.

For each session, a normalized maximum electrical activity goal, called target trace, was established, ranging from 85% to 55% of the initial task-specific MVC peak. The percentage range chosen is considered a safe area of muscular conditioning.[28] The target traces for the sessions followed a hierarchical structure, with a reduction of 10% of the target trace every two sessions, such that the participant gradually decreased the muscle electrical activity during the performance of the voice exercises. The area corresponding to the target trace was shaded red on the screen. In this way, the participants could control and monitor, on the screen, whether they were inside or outside the target trace range. The therapist also provided auditory feedback similar to that of traditional therapy, through verbal co-commands such as "relax" and "lighter". The feedback provided during the voluntary exercises sought to improve the perception and muscle control of the participants.

Placebo group

Only the PG performed the placebo electromyographic biofeedback. Participants in the PG did not perform MVC assessment for normalization, and did not have visual control of muscle activity during exercise. Although attached, the electrodes were not activated during the intervention. During the therapy,[26] the computer screen displayed the software used for the evaluation of EMGs, Miotool 200 software (Biotec, Rio Grande do Sul, Brazil). In this way, the traces that appeared on the screen provided no visual feedback to the participant. However, the therapist used the same auditory feedback as for the EG.

Data analysis

Data analysis was performed through intent to treat,[29] considering all the randomized participants who completed the onsite sessions of the intervention. To prevent compromising the study due to the absence of part of the data, the simple imputation tool was used, with the last observation technique. Data absence was 4.54%.

Statistics software, version 17.0 (Stat Soft Inc., Tulsa, OK), and *SigmaPlot* software, version 13.0 (Systat Software Inc., San Jose, CA) were used for statistical analysis. The level of significance was set at 5% ($P < 0.05$). The normality of quantitative variables was assessed with the Shapiro-Wilk test. The parametric analysis of variance test of paired measures was used for quantitative variables with normal distribution (to compare the times of evaluation, intervention groups, and the association of both), the Friedman test was used for the quantitative variables with non-normal distribution (to compare the times of evaluation), and the Mann-Whitney test was used to compare the intervention groups. The comparison of the intervention groups was performed with the difference between T1 and the evaluation times after intervention T2, T3, and T4 (difference = T1 – value obtained in the other evaluation times). The intrarater and inter-rater agreement of the auditory-perceptual evaluation were calculated using the interclass color-relation coefficient.

RESULTS

Of 56 volunteers, 32 failed to meet the selection criteria for this study. The remaining 24 were included in the randomization. There were two losses before the initial assessments due to nonattendance and inability to contact. Thus, 22 participants were included in the data analysis, 11 in the EG, and 11 in the PG. Two further losses occurred during follow-up, between T2 and T3, one due to time unavailability and the other due to pregnancy.

Table 1 shows that the EG had a significant reduction in the parameter strain during sustained production of the vowel /a:/, and in the parameters grade, roughness, breathiness, and strain, during number counting. For a sustained vowel /a:/ production, the intrarater reliability was between 0.20 and 0.78 and the inter-rater reliability was between 0.20 and 0.43. For number counting, the intrarater reliability was between 0.42 and 0.85 and the inter-rater reliability was between 0.44 and 0.64.

As shown in Table 2, there was a significant increase in the SPI acoustic parameter from T1 to T3, independent of the intervention group.

Table 3 shows a significant reduction, in the PG, of the electrical activity at rest of the RSCM muscle from T1 to T2. There was no difference between intervention groups.

As shown in Table 4, in the EG a significant reduction in electrical activity occurred for the LSCM muscle, between T1 and T2, for the SH muscles, between T1 and T3, and for the RSCM muscle, between T1 and T4, during the sustained production of the habitual vowel /a:/. In the EG, a significant reduction in electrical activity occurred for the RIH muscle, between T1 and T3, during the production of the modulated vowel /a:/. The electrical activity of the RSCM during the production of the habitual vowel /a:/ decreased significantly more in the EG than in the PG from T1 to T4.

DISCUSSION

In the voice field, there is unanimous opinion[3,7,10] for the need for studies with greater methodological rigor. Thus, the present study analyzed the effectiveness of voice therapy associated with electromyographic biofeedback, in women with behavioral dysphonia, through a randomized clinical trial.

The first primary outcome was the auditory-perceptual evaluation of voice quality. The EG displayed lower values than the PG for grade, roughness, breathiness, and strain during number counting, as well as for strain during the sustained production of the vowel /a:/, regardless of the time of evaluation. However, values for both groups stayed close to their baseline, which already had an initial mean difference greater than 10 mm. Their difference is considered the minimum difference, in a visual analogue scale of auditory-perceptual evaluation, for a voice to be clinically different.[30] The only exception were the values for the strain during number counting. Comparing evaluation times, differences were less than 10 mm for all these parameters for both groups, meaning that the parameters remained stable. This indicates that the difference between the intervention groups was

TABLE 1.
Analysis and Comparison of the Auditory-Perceptual Evaluation of the Voice Quality of Women With Behavioral Dysphonia According to Intervention Group and Time of Evaluation

			EG		PG				
Sample	Parameter	Time	Mean	SD	Mean	SD	Effect	*P* Value	Tukey Test
Vowel /a:/	Grade	T1	45.24	13.17	59.21	10.48	Group	0.105	
		T2	50.58	10.47	53.48	16.38	Time	0.909	
		T3	47.85	10.46	52.91	14.61	Time × group	0.273	
		T4	48.33	14.18	55.97	14.92			
	Roughness	T1	39.03	15.30	51.52	14.24	Group	0.070	
		T2	39.61	12.70	46.79	17.92	Time	0.850	
		T3	39.36	13.52	45.82	17.10	Time × group	0.606	
		T4	37.55	15.22	51.24	17.02			
	Breathiness	T1	38.79	13.43	52.00	15.76	Group	0.388	
		T2	50.18	11.53	48.79	14.69	Time	0.593	
		T3	46.27	11.73	47.21	13.37	Time × group	0.090	
		T4	45.36	15.31	45.36	15.31			
	Strain	T1	34.63	9.89	46.36	13.14	Group	0.037*	PG > EG
		T2	34.06	11.09	38.85	12.10	Time	0.580	
		T3	35.76	9.38	40.36	15.46	Time × group	0.223	
		T4	35.73	8.99	44.64	12.45			
	Instability	T1	29.00	9.97	35.73	10.14	Group	0.424	
		T2	34.64	11.42	33.00	11.49	Time	0.691	
		T3	29.76	8.53	32.61	9.76	Time × group	0.418	
		T4	32.03	12.49	35.18	11.20			
Number counting	Grade	T1	56.70	16.05	67.12	12.83	Group	0.023*	PG > EG
		T2	54.91	14.70	68.21	13.68	Time	0.941	
		T3	53.67	15.99	68.27	14.03	Time × group	0.806	
		T4	55.36	11.31	65.12	13.83			
	Roughness	T1	40.73	17.60	58.91	20.63	Group	0.007*	PG > EG
		T2	42.61	13.91	58.12	18.40	Time	0.963	
		T3	40.88	15.29	60.79	18.56	Time × group	0.795	
		T4	45.48	13.17	58.09	18.57			
	Breathiness	T1	40.03	15.53	51.24	18.15	Group	0.047*	PG > EG
		T2	44.79	15.85	54.55	14.46	Time	0.496	
		T3	41.24	18.55	57.94	12.81	Time × group	0.496	
		T4	45.00	11.78	52.82	14.04			
	Strain	T1	47.36	12.39	54.73	11.98	Group	0.028*	PG > EG
		T2	42.36	13.45	53.70	15.04	Time	0.147	
		T3	39.97	15.09	52.00	12.08	Time × group	0.871	
		T4	39.24	11.11	49.48	14.95			

* $P < 0.05$—ANOVA of paired measures.
Abbreviations: ANOVA, analysis of variance; SD, standard deviation; T, time.

due to a difference in the initial baseline, and thus without clinical relevance.

The EG displayed values within the limits for normal speech variability, a mild to moderate degree for strain during sustained vowel production, and also for roughness, breathiness, and strain during number counting, with only the grade rated moderate at all times.[31] On the other hand, the PG displayed a moderate degree for grade, roughness, and stiffness during number counting. Only strain showed deviation between mild and moderate, and moderate, respectively,[31] during vowel production and during number counting. Thus, the interventions had no influence on the auditory-perceptual evaluation of the voice quality of the participants.

Studies show that electromyographic biofeedback generally seems to help reduce excess tension,[15,16,19] being effective in cases of dysphonia associated with excessive musculoskeletal tension. It is believed that this happened because this is a procedure aimed at modifying neuromuscular behavior, as there is no direct relationship of electromyographic biofeedback with voice quality but rather with the tension of the muscles involved in phonation.[32] There are some indications of improvement in voice quality in dysphonic individuals after electromyographic biofeedback, but they were findings of series of cases that involved associating this procedure with several treatment modalities, preventing the assessment of the effects of this intervention.[13]

TABLE 2.
Analysis and Comparison of Acoustic Parameters of Voice Quality of Women With Behavioral Dysphonia According to Intervention Group and Time of Evaluation

		EG		PG				
Parameter	Time	Mean	SD	Mean	SD	Effect	*P* Value	Tukey Test
F0	T1	193.72	15.03	195.42	30.97	Group	0.759	
	T2	191.95	13.17	187.14	26.14	Time	0.391	
	T3	191.56	18.89	188.61	32.58	Time × group	0.276	
	T4	188.76	15.98	187.67	28.43			
jitt	T1	1.54	0.68	1.60	0.79	Group	0.634	
	T2	2.29	0.79	1.70	0.73	Time	0.210	
	T3	2.11	0.92	1.65	0.84	Time × group	0.151	
	T4	1.84	0.94	1.82	1.05			
vF0	T1	1.55	0.58	1.58	0.57	Group	0.926	
	T2	2.03	0.64	1.83	0.60	Time	0.121	
	T3	1.84	0.68	1.71	0.64	Time × group	0.622	
	T4	1.75	0.64	1.76	0.80			
shimm	T1	3.67	1.21	3.42	1.15	Group	0.951	
	T2	3.58	0.96	3.54	1.10	Time	0.989	
	T3	3.29	0.46	3.73	1.93	Time × group	0.623	
	T4	3.60	1.12	3.58	1.07			
vAm	T1	8.77	1.89	10.03	4.36	Group	0.696	
	T2	9.11	2.28	11.12	2.88	Time	0.666	
	T3	9.85	3.17	10.33	2.28	Time × group	0.210	
	T4	10.32	3.22	9.54	2.90			
NHR	T1	0.14	0.02	0.13	0.02	Group	0.528	
	T2	0.14	0.02	0.13	0.01	Time	0.156	
	T3	0.12	0.03	0.13	0.02	Time × group	0.079	
	T4	0.13	0.02	0.13	0.02			
VTI	T1	0.04	0.01	0.04	0.01	Group	0.274	
	T2	0.04	0.01	0.04	0.01	Time	0.114	
	T3	0.04	0.01	0.04	0.01	Time × group	0.290	
	T4	0.04	0.01	0.04	0.01			
SPI	T1	13.35	7.41	14.95	6.66	Group	0.263	
	T2	17.37	7.71	18.45	8.02	Time	0.002*	T1 < T3
	T3	19.49	11.59	21.08	12.06	Time × group	0.184	
	T4	17.27	7.34	13.34	5.32			

* $P < 0.05$—ANOVA of paired measures.
Abbreviations: ANOVA, analysis of variance; jitt, jitter percent; NHR, noise-harmonic ratio; SD, standard deviation; shimm, shimmer percent; T, time; vAm, amplitude variation; vF0, fundamental frequency variation; VTI, voice turbulence index.

The second primary outcome was acoustic evaluation of voice quality. Comparing the acoustic evaluation along different times of evaluation revealed a significant increase in the SPI acoustic parameter from T1 to T3, independent of the intervention group. SPI is one of the 33 parameters of the *Multi-Dimensional Voice Program* (Kay Elemetrics Corporation) software and measures how smooth or compressed the glottic closure is using the ratio between the low- and high-frequency voice harmonic components.[33,34]

It seems that the increase in SPI was due to the VTP, unrelated to electromyographic biofeedback. Considering the goals of voice therapy and the tasks used in the present study, it was possible to attribute the modification of SPI values to the therapy. Instruments used included both indirect intervention, through educational measures, and direct intervention, through exercises and participation grouped into five subsystems.

In the educational intervention, the clinician sought to improve the participant's knowledge about voice production and aspects of vocal hygiene and provided strategies to improve vocal health, adapted specifically to obtain changes in the vocal behavior of each participant. In the direct intervention, the participants performed tasks with the use of semioccluded vocal tract (SOVT) exercises such as trill, humming, and fricative. These exercises, among other actions, reduce the phonatory effort, soften the production, and mobilize the mucosa besides promoting the improvement of respiratory support and of pneumo-phono-articulatory coordination. In addition, the partial occlusion of the airflow during SOVT exercises, regardless of its degree, causes a retroflex resonance that decreases the supraglottic tension pattern, increases the level of transglottic sound pressure, and modifies the mucosal waveform. This results in the reduction of the approximation velocity, of the coaction force, and of the

TABLE 3.
Analysis and Comparison of the Normalized Electrical Activity of the Laryngeal, Cervical, and Scapular Girdle Muscles in the Rest of Women With Behavioral Dysphonia According to Time of Evaluation* and Intervention Group†

		EG					PG						
Muscle	T	Q1	Median	Q3	*P* value	Tukey Test	Q1	Median	Q3	*P* Value	Tukey Test*	Difference between the Times†	*P* Value
LT	T1	1.74	5.25	7.56	0.849		1.71	3.52	6.20	0.382			
	T2	1.75	3.52	5.40			3.02	4.53	6.74			T1–T2	0.450
	T3	2.77	4.30	5.54			2.81	4.77	6.47			T1–T3	0.178
	T4	2.32	4.07	7.48			1.53	6.75	10.97			T1–T4	0.123
LSCM	T1	3.54	4.37	8.37	0.214		2.65	5.15	8.20	0.247			
	T2	1.96	3.88	6.92			2.93	3.80	5.26			T1–T2	0.577
	T3	3.14	4.27	6.75			1.97	3.77	4.45			T1–T3	0.158
	T4	2.59	3.98	9.94			2.20	2.88	3.80			T1–T4	0.200
LIH	T1	4.14	7.08	17.81	0.993		5.10	5.93	16.59	0.173			
	T2	3.64	6.70	13.74			3.06	8.29	15.46			T1–T2	0.622
	T3	5.38	6.53	9.95			4.81	5.51	9.56			T1–T3	0.279
	T4	3.37	7.61	15.74			5.08	6.75	10.09			T1–T4	0.412
SH	T1	4.38	6.04	10.96	0.410		4.86	6.62	17.04	0.052			
	T2	4.49	6.16	7.27			6.11	7.27	10.11			T1-T2	0.718
	T3	3.50	5.15	5.71			5.70	7.01	8.53			T1–T3	0.670
	T4	4.45	5.15	6.63			5.29	6.18	9.36			T1–T4	0.577
RIH	T1	5.41	10.27	15.93	0.450		5.14	9.09	17.43	0.247			
	T2	4.04	8.54	17.17			3.79	7.11	13.18			T1–T2	0.533
	T3	5.53	12.89	15.55			4.60	5.87	10.87			T1–T3	0.491
	T4	5.27	12.66	17.17			3.90	7.41	8.08			T1–T4	0.491
RSCM	T1	4.88	8.39	9.83	0.064		4.13	5.27	9.60	0.027*	T1 > T2		
	T2	3.05	4.47	7.51			2.34	4.03	8.70			T1–T2	0.974
	T3	3.76	5.81	8.48			2.12	4.06	8.69			T1–T3	0.922
	T4	3.02	4.64	6.66			3.17	4.86	6.78			T1–T4	0.533
RT	T1	2.43	2.98	9.23	0.763		1.32	2.58	5.05	0.960			
	T2	1.46	2.12	11.07			1.78	3.30	5.26			T1–T2	0.533
	T3	2.01	4.02	6.42			0.71	2.64	4.13			T1–T3	0.922
	T4	1.91	4.04	9.36			1.56	3.77	5.60			T1–T4	0.670

* $P < 0.05$ —Friedman Test and Tukey test.
† $P < 0.05$—Mann-Whitney test.
Abbreviations: LT, left trapezius; Q1, first quartile; Q3, third quartile; RT, right trapezius; T, time.

coefficient of containment between the vocal folds, keeping them slightly abducted.[35,36] In addition, performing the SOVT exercises together with pitch modulation works mainly through the action and relaxation of the cricothyroid and thyroarytenoid muscles. Stretching the vocal folds to produce sound with an acute pitch relies on the activation of the cricothyroid muscle, and the shortening of the thyroarytenoid muscle produces a deeper pitch sound. These exercises also help balance the tension of the other intrinsic muscles of the larynx as well as increase muscle endurance and assist in the rehabilitation of postural changes in vocal folds, improving glottic closure. Such actions are directly related to the increase in SPI values, which indicates the complete adduction of the vocal folds or the smoothing in their coaptation.[34] Despite the decrease in tension and the increase in the softness of the production, the SPI values measured seemed to indicate that there was still a predominance of incomplete glottic closure among participants of both groups. No studies analyzing the effects of electromyographic biofeedback on acoustic aspects of voice quality were found. Thus, VTP promoted a decrease in excessive tension at the glottic level and the smoothing of glottic closure, although its effects on voice quality were perceptible only through acoustic evaluation, without the effect of electromyographic biofeedback.

To complement the source-filter findings, allowing the analysis of vocal and postural voice behavior, an electromyographic surface evaluation was performed, analyzing the electrical activity of the muscles of the laryngeal, scapular, and cervical waist regions.

In the rest state, a significant reduction in the normalized electrical activity of the RSCM muscle from T1 to T2 was observed in the PG with no difference between intervention groups. Thus, voice therapy decreased the electrical activity of the RSCM muscle at rest in the short term (T2) without the influence of electromyographic biofeedback.

The SCM muscle causes the head movements of heterolateral rotation, homolateral inclination, prostration, extension, and flexion.[6] In addition, SCM is one of the accessory muscles of the diaphragm during inspiration. Its contraction, simultaneously with the external intercostal and scalene muscles and together with the diaphragm, promotes the expansion of the

TABLE 4.
Analysis and Comparison of the Normalized Electrical Activity of the Laryngeal, Cervical, and Scapular Girdle Muscles in the Sustained Production of the Vowel /a:/ of Women With Behavioral Dysphonia According to Time of Evaluation* and Intervention Group†

			EG					PG					Difference between	
Sample	Muscle	T	Q1	Median	Q3	*P* value	Tukey Test	Q1	Median	Q3	*P* Value	Tukey Test*	the Times†	*P* Value
Habitual vowel /a:/	LT	T1	1.77	5.40	8.98	0.625		1.64	2.65	4.71	0.628			
		T2	2.75	4.07	6.14			2.69	6.04	8.68			T1–T2	0.279
		T3	2.86	4.26	10.68			3.22	4.67	7.15			T1–T3	0.670
		T4	2.91	4.45	10.25			1.71	7.90	11.74			T1–T4	0.375
	LSCM	T1	4.39	10.23	14.30	0.018*	T2 < T1	3.24	6.76	11.22	0.461			
		T2	2.37	4.80	10.81			3.99	6.02	8.04			T1–T2	0.309
		T3	3.77	5.59	11.52			2.15	5.05	6.50			T1–T3	0.341
		T4	3.04	5.66	12.20			2.96	4.33	6.02			T1–T4	0.974
	LIH	T1	6.14	12.06	30.22	0.735		7.62	12.46	26.85	0.341			
		T2	5.55	10.67	13.24			6.90	14.53	26.76			T1–T2	0.375
		T3	6.91	8.76	12.94			8.37	11.71	15.31			T1–T3	0.622
		T4	5.11	8.76	21.58			7.10	10.51	18.44			T1–T4	0.768
	SH	T1	8.97	11.52	13.25	0.014*	T3 < T1	6.99	12.50	16.44	0.049*	*P* > 0.05		
		T2	7.75	9.87	10.68			7.64	12.42	16.70			T1–T2	0.224
		T3	5.85	8.66	11.00			8.31	12.03	14.91			T1–T3	0.491
		T4	6.22	8.77	11.09			6.56	10.72	13.09			T1–T4	0.922
	RIH	T1	10.05	14.67	20.94	0.280		8.71	11.52	16.61	0.165			
		T2	5.19	10.31	33.93			7.05	11.79	14.93			T1–T2	0.533
		T3	10.27	12.19	15.48			10.79	13.29	15.69			T1–T3	0.533
		T4	6.75	13.13	20.64			6.30	11.79	15.65			T1–T4	0.670
	RSCM	T1	4.69	9.32	14.77	0.014*	T4 < T1	2.94	7.67	9.11	0.109			
		T2	3.42	4.46	9.11			4.02	5.57	11.27			T1–T2	0.071
		T3	4.00	6.29	7.44			2.53	5.18	8.34			T1–T3	0.140
		T4	3.64	4.53	7.06			2.71	5.76	7.55			T1–T4	0.045*
	RT	T1	2.64	3.20	11.29	0.219		1.36	3.52	4.82	0.247			
		T2	1.65	2.23	11.52			3.15	5.01	7.18			T1–T2	0.082
		T3	1.98	3.96	11.11			1.02	3.51	6.57			T1–T3	0.622
		T4	1.55	3.94	12.31			1.68	4.26	5.71			T1–T4	0.224
Modulated vowel /a:/	LT	T1	1.77	5.40	8.98	0.460		1.64	2.65	4.71	0.382			
		T2	2.52	4.72	5.26			2.33	4.72	7.33			T1–T2	0.178
		T3	2.57	4.61	9.79			2.79	5.38	8.09			T1–T3	0.309
		T4	3.28	5.22	9.49			1.78	7.81	10.60			T1–T4	0.279
	LSCM	T1	4.39	10.23	14.30	0.051		3.24	6.76	11.22	0.202			
		T2	2.67	7.84	14.41			4.22	5.78	7.58			T1–T2	0.200
		T3	4.56	5.54	14.95			1.86	5.67	6.83			T1–T3	0.818
		T4	3.15	6.64	13.78			3.07	5.67	8.11			T1-T4	0.768
	LIH	T1	6.14	12.06	30.22	0.806		6.27	12.46	26.85	0.141			
		T2	6.60	10.26	14.36			6.32	12.20	34.98			T1–T2	0.279
		T3	6.46	8.58	14.98			6.69	8.99	17.36			T1–T3	0.922
		T4	4.90	8.84	15.57			6.81	10.37	25.42			T1–T4	0.922
	SH	T1	8.97	11.52	13.52	0.863		7.48	12.50	16.44	0.247			
		T2	6.77	9.97	14.93			7.39	13.87	17.98			T1–T2	0.412
		T3	5.59	9.19	13.85			9.61	13.22	16.81			T1–T3	0.622
		T4	6.46	11.39	12.67			6.35	10.74	14.83			T1–T4	0.718
	RIH	T1	10.05	14.67	20.94	0.024*	T3 < T1	8.71	11.52	16.61	0.577			
		T2	6.10	10.25	27.01			7.30	9.53	27.14			T1–T2	0.061
		T3	8.62	9.62	18.22			8.55	13.43	15.13			T1–T3	0.341
		T4	7.11	8.89	28.64			8.00	10.39	15.52			T1–T4	0.450
	RSCM	T1	4.69	9.32	14.77	0.116		2.94	7.67	9.11	0.483			
		T2	3.64	4.27	11.31			2.79	5.48	7.96			T1–T2	0.577
		T3	4.53	6.45	11.31			2.71	6.21	8.62			T1–T3	0.412
		T4	4.50	6.45	10.39			2.71	6.32	8.38			T1–T4	0.450
	RT	T1	2.64	3.20	11.29	0.493		1.36	3.52	4.82	0.483			
		T2	1.61	4.43	7.80			2.28	5.12	7.82			T1–T2	0.108
		T3	2.43	5.03	6.53			0.79	4.94	7.82			T1–T3	0.200
		T4	1.90	4.91	7.11			1.68	4.65	7.00			T1–T4	0.178

* $P < 0.05$—Friedman test and Tukey test.
† $P < 0.05$—Mann-Whitney test.
Abbreviations: LT, left trapezius; Q1, first quartile; Q3, third quartile; RT, right trapezius; T, time.

thoracic cavity in the anteroposterior and longitudinal dimension, reducing intrathoracic pressure and thus allowing air to enter the lungs.[6] Studies have shown that SCM electrical activity may increase in dysphonic individuals at rest[23] in a head forward, leading to stretching and increased tension of the entire neck musculature. This kind of adjustment, associated with laryngeal and pharyngeal compression, may change the position and shape of the vocal tract. This adjustment leads to vocal fold stretching and tapering. The recruitment of other supraglottic structures is part of a compensatory adjustment to improve incomplete glottic closure and promote increased loudness.[37] Although the VTP does not directly act on body posture, the tasks with their activities and participation performed in the direct intervention axis of VTP worked with the five subsystems: auditory, vocal, somatosensory, musculoskeletal, and respiratory. The association of the three SOVT techniques that sought to promote efficient, balanced, and normotensive voice production may have also caused an expansion of the supraglottic cavity, improving airflow direction with the improvement of respiratory support, besides softening the production and reducing phonatory effort.[36] Thus, the overall improvement of the clinical presentation may have rebalanced the laryngeal musculature, enlarged the vocal tract, lowered the larynx, and promoted the improvement of respiratory support and neck posture. This may in turn have caused the reduction in the resting electrical activity of the SCM muscle.

Confirming this interpretation, descriptive analysis of the data shows that, in the RSMC, the median electrical activity in the EG was 8.39%, and the median electrical activity in the PG was 5.27%, in T1, while in T2 both groups had a median of 4%. Few studies have analyzed the muscle electrical activity of dysphonic individuals,[22,23] with some authors reporting lower[22] and others higher[23] electrical activity in dysphonic individuals than in individuals with normal voices. Although there is no recommended norm for normalized muscle electrical activity, the percentage obtained for the SCM muscle was similar to that reported by a study[23] in individuals with healthy voices. This indicates that although the reduction was significant only in the PG, both groups displayed a pattern of muscle electrical activity similar to that of normal individuals after the intervention and maintained this pattern in the long term (T4). No study was found that analyzed the effect of electromyographic biofeedback on the electrical activity of the SCM muscle of adults with behavioral dysphonia.

During the habitual production of the vowel /a:/, the normalized electrical activity of the RSCM muscle decreased significantly more in the EG than in the PG in the long term (T4). There was also a significant reduction during the habitual production of the vowel /a:/ in the electrical activity of the LSCM muscle in the short term (T2) and of the SH muscle in the medium term (T3). In addition, there was a significant reduction during the modulated production of the vowel /a:/ in the electrical activity of the RIH muscle in the medium term (T3).

Electromyographic biofeedback was able to improve muscle electrical activity during phonatory activity without influencing the electrical potential at rest. This may have occurred because the purpose of the method is precisely to improve muscle control during phonatory behavior, as the feedback is concurrent with the execution of the function.[13]

The participants who performed the electromyographic biofeedback improved their muscle pattern during the performance of habitual phonation and could maintain the muscle pattern balanced during modulated phonation. This may be due to their improved perception, facilitating more balanced muscle adjustments. A study emphasizes that working with electromyographic biofeedback distinguishes therapeutic practices, as the focus becomes specifically the muscle groups recruited in phonation, whereas those performing traditional voice therapy typically focus on voice tasks.[38] Thus, electromyographic biofeedback seem to have enabled better control of vocal behavior in the EG both in the habitual activities and in those requiring specific muscle adjustments.

Electromyographic biofeedback improved the right-sided muscle pattern (SH, RSCM, and RIH) in addition to LSCM improvement. Other authors have also reported asymmetry in electrical activity in the bilateral muscles or muscle groups,[23] attributed to several factors, including laterality. Thus, the present study supports the findings of an integrative literature review that emphasized the importance of exploring the laterality of muscles related to phonation.[39] Voluntary movements performed by the human body generally have a well-defined lateral preference associated with motor performance and functional specialization of the cerebral hemispheres. Most people have a lateral preference for the right side.[40] Thus, individuals may have developed better feedback on the right side of the body. However, further studies are better needed to understand this asymmetry in electrical activity in the bilateral muscles.

Electromyographic biofeedback reduced the muscle electrical activity of the majority of the muscles analyzed on the right side as well as of the LSCM. It is difficult and even impracticable to compare the findings of the present study with previous studies that evaluated the muscle electrical activity of dysphonic individuals, as there is a large variability in samples and methodological characteristics among the studies.[39] Nevertheless, data from the present study are similar to findings of previous studies that demonstrated that electromyographic biofeedback helped reduce the electrical activity of the infrahyoid muscles,[19] the thyrohyoid region,[15,16] and the cricothyroid region.[32] This could be because the electromyographic biofeedback provides the patient with objective and simultaneous information on the underlying muscle activity.[13] When combined with voice therapy including activities and participation tasks, it enables the rehabilitation and rebalancing of the phonatory function together with the improvement of the perception and control of the behavior of the laryngeal and corporal muscles. Thus, during the therapy sessions, the participants may have been able to learn to control their muscles and vocal and corporal adjustments during phonation, as they moved from specific activities to tasks of participation. The hierarchy employed sought to improve the clinical manifestation and facilitate the generalization of the balanced vocal behavior learned in therapy. Thus, the gains in on-site sessions and with the daily exercises at home, associated with the improvement of the perception and the greater feedback in the EG, may have allowed a better

control and, consequently, a better performance with the exercises performed independently at home between T3 and T4. But it is important to notice that the EG group appeared to have significantly lower perceived strain for structured tasks assessed. All of these factors may have promoted positive long-term results in the EG. Further evidence are necessary to confirm these findings.

Thus, the set of therapy procedures (VTP) focused on voice tasks from the beginning of the intervention added to the improvement of vocal and corporal perception, and the neuromuscular control of vocal behavior provided by electromyographic biofeedback may have increased retention of knowledge and automation of acquired behavior in voice therapy. The present study supports the literature of the field,[16,18,19,32] indicating that biofeedback is a recommended procedure for the voice field when voice disorders associated with vocal behavior, whose main characteristic is muscle hyperfunction or hypertension, are considered.

The literature[41] reports that biofeedback is efficient when there is agreement between the outcome measures (muscle tension) and the purpose of its use (reduce muscle tension), being inadequate only when the outcome measures something for which the biofeedback was not developed. Furthermore, this study supports the findings of a literature review study that biofeedback is generally effective in improving dysphonia or has better effect than traditional voice therapy with respect to the muscle component, especially the corporal muscle component, of behavioral dysphonia. Accordingly, the outcome of the surface electromyographic measurements that directly analyzed the muscle component (especially extrinsic of the larynx, waist, and cervical girdle) was more sensitive in detecting the effects of the electromyographic biofeedback.

This study may assist the clinician in choosing the best procedure for cases of behavioral dysphonia. The results indicated that electromyographic biofeedback was equivalent to traditional voice therapy for improving dysphonia and better in cases where there was excessive body tension associated with altered voice behavior.

The limitations of the present study concern the low intrarater and inter-rater agreement in the auditory-perceptual evaluation of the voice and the not controll regarding previous vocal training of the individuals. Clinical trials with individuals from both sexes are also required to determine whether the results of the present study can be generalized for males with behavioral dysphonia and whether there are differences between individuals with and without prior vocal training.

CONCLUSION

The VTP promoted muscle relaxation at the glottic and supraglottic levels, and functional improvements of the larynx and better phonatory balance as well as positive effects on voice quality and resting muscle electrical activity in women with behavioral dysphonia, with emphasis on the phonatory and behavioral aspects of voice production at the glottic level. Electromyographic biofeedback promoted positive results in the electrical activity of the extrinsic laryngeal and cervical musculature in the phonatory activities of women with behavioral dysphonia besides helping to modify body behavior associated with phonation and to maintain or improve the results in the medium and long term.

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