Journal of Communication Disorders 82 (2019) 105923

Contents lists available at ScienceDirect

Journal of Communication Disorders

journal homepage: www.elsevier.com/locate/jcomdis

Effects of transcutaneous electrical nervous stimulation (TENS) associated with vocal therapy on musculoskeletal pain of women with behavioral dysphonia: A randomized, placebo-controlled double-blind clinical trial

Larissa Thais Donalonso Siqueira[a], Vanessa Veis Ribeiro[b], Pamela Aparecida Medeiros Moreira[c], Alcione Ghedini Brasolotto[c], Rinaldo Roberto de Jesus Guirro[d], Kelly Cristina Alves Silverio[c,*]

[a] Universidade Estadual do Centro-Oeste – UNICENTRO, Irati, Paraná, Brazil
[b] Centro Universitário do Cerrado Patrocínio – UNICERP, Patrocínio, Minas Gerais, Brazil
[c] Disorders Department of the Faculdade de Odontologia de Bauru/Universidade de São Paulo – FOB/USP, Bauru, São Paulo, Brazil
[d] Faculdade de Medicina de Ribeirão Preto/Universidade de São Paulo – FMRP/USP, Ribeirão Preto, São Paulo, Brazil

ARTICLE INFO

Keywords:
Voice
Voice training
Transcutaneous electric nerve stimulation

ABSTRACT

Recently, electrical stimulation in vocal rehabilitation has been the subject of studies. This treatment has shown promising results regarding the decrease of vocal/laryngeal symptoms, pain and the improvement of vocal tension. In addition to decreasing pain symptoms, TENS treatments may lead to muscle relaxation. There is no data on the effects of this resource as a vocal therapy in women with behavioral dysphonia. Research in this area may provide evidence to assist the clinical decision related to the treatment of women with complaints of behavioral dysphonia and musculoskeletal pain.

Objective: To verify the effects of low-frequency TENS in association with vocal therapy on musculoskeletal pain in women with behavioral dysphonia.

Methods: Participants included 27 women with vocal nodules randomized into two groups. The experimental group (EG) - 13 women received 12 sessions of TENS (pulse of 200 μs, frequency at 10 Hz, in motor threshold) with electrodes placed bilaterally on the trapezius muscle and submandibular area for 20 min followed by 30 min of vocal therapy, and the control group (CG) - 14 women received 12 sessions of 20 min of a placebo TENS followed by 30 min of vocal therapy. We investigated the frequency and intensity of the musculoskeletal pain in several body regions, as well as the intensity of pain at rest and in the application of pressure with an algometer applied to the descending fibers of the trapezius muscle. The pressure-pain threshold (PPT) was also investigated. All evaluations occurred before, immediately after, and at one and three months after treatment in both groups.

Results: We observed a reduction in the frequency of pain in the larynx after treatment of both groups, but only the EG showed a decrease in pain intensity in this region. It was verified with an algometer to the trapezius muscle that the electrical stimulation associated with the vocal therapy decreased the intensity of pain during the application of pressure and increased the PPT.

* Corresponding author at: Department of Speech Hearing and Language Disorders – Bauru School of Dentistry/University of São Paulo, Al. Dr. Octávio Pinheiro Brisolla, 9-75, Bauru, SP, 17012-901, Brazil.

E-mail addresses: larisiqueira_4@hotmail.com (L.T.D. Siqueira), fgavanessavr@gmail.com (V.V. Ribeiro), pamela_moreria15@yahoo.com.br (P.A.M. Moreira), alcione@usp.br (A.G. Brasolotto), rguirro@fmrp.usp.br (R.R. de Jesus Guirro), kellysilverio@usp.br (K.C. Alves Silverio).

https://doi.org/10.1016/j.jcomdis.2019.105923
Received 26 April 2018; Received in revised form 27 May 2019; Accepted 25 July 2019
Available online 30 July 2019

There were no significant differences with regard to variables investigated in the comparison between the interventions. On the other hand, there was decreased pain in the trapezius muscle for the EG in comparison to the pre- and post-intervention.
Conclusion: The vocal therapyprogram reduced the frequency and intensity of the musculoskeletal pain in the regions proximal to the larynx of women with behavioral dysphonia. In addition, TENS followed by vocal therapy increased the threshold of sensitivity to muscular pain in the trapezius, demonstrating that it is a good resource to use in conjunction with traditional vocal therapy in cases of behavioral dysphonia associated with pain and muscle tension.

1. Introduction

Behavioral dysphonia occurs due to a frequent presence of vocal behaviors that affect the quality of voice, such as shouting, speaking loudly, effort when speaking, no respiratory pauses, non-optimal pitch, etc. One of the etiologies of behavioral dysphonia is excessive muscle tension in the muscles of the laryngeal, cervical, and scapular girdle during phonation (Ramos, Floro, Ribeiro, Brasolotto, & Silverio, 2017; Behlau, Zambon, Moreti, Oliveira, & de Barros Couto, 2017; Cielo et al., 2014; Menoncin, Jurkiewicz, Silvério, Camargo, & Wolff, 2010; Silverio, Siqueira, Lauris, & Brasolotto, 2014; Zielińska-Bliźniewska, Pietkiewicz, Miĺoński, Urbaniak, & Olszewski, 2013) and even in rest position (Balata, Da Silva, Pernambuco, De Oliveira, & Moraes, 2015).

Depending on the muscles involved in the phonatory adjustments of behavioral dysphonia, it is possible to identify different configurations of the vocal tract and larynx, as well as several types of vocal quality (Pedrosa, Pontes, Pontes, Behlau, & Peccin, 2016; Roy et al., 2003). The main signs presented are shortening of the neck and shoulder muscles, elevated shoulders, constant activation of the muscles responsible for forced inspiration that generates a superior respiratory pattern (Ribeiro, Siqueira et al., 2018), a hyperextended head, and a restricted and tense facial expression (Behlau et al., 2017; Cielo et al., 2014; Alves Silverio et al., 2015; da Silva Vitor et al., 2017; Mathieson et al., 2009; Menoncin et al., 2010; Ramos, Floro et al., 2017; Reimann, Siqueira, Rondon, Brasolotto, & Silverio, 2016; Rubin, Blake, & Mathieson, 2007; Van Houtte, Van Lierde, & Claeys, 2011).

In addition to these symptoms, dysphonic women present a higher frequency and intensity of musculoskeletal pain when compared to vocally healthy women, which may negatively influence the quality of life of this population (Ramos, Floro et al., 2017). Musculoskeletal pain is subjective and complex, and the symptoms are multifactorial (International Association for the Study of Pain - IASP). The symptoms that may be present in patients with behavioral dysphonia include suffering, anxiety, depression, sleep disorders and fatigue. Therefore, muscle tension is an important factor associated with the development and maintenance of behavioral dysphonia, and the speech-language clinician must pay attention to this aspect during the vocal treatments (Silverio et al., 2014).

The presence of myofascial trigger points is observed in the pathological process of cervicalgia. These points can express muscle pain. Myofascial pain can lead to a psychophysiological disorder involving the central nervous system pain regulators, resulting in physiological responses. In this context, there is a metabolic impairment due to an increase in muscle activity. This impairment leads to an increase in intramuscular pressure with the mechanical compression of the muscular blood vessels and physiological responses, such as a reduced supply of oxygen and muscle glucose; inoperability of aerobic metabolism for the formation of adenosine triphosphate (ATP); activation of anaerobic metabolism for ATP formation; an accumulation of lactic acid and reduction of intramuscular hydrogenation potential; a reduction of acetylcholinesterase activity and increased acetylcholine action; an increased concentration of intracellular calcium, resulting in increased interactions between actin and myosin; and inflammation and muscle damage (Bron & Dommerholt, 2012; Moraska, Hickner, Kohrt, & Brewer, 2013).

Vocal techniques and transcutaneous electric nerve stimulation have been proposed for reducing excessive muscle tension and reestablishing muscular functionality and mobility in the extrinsic region of the larynx and the scapular and cervical girdles. In addition, this therapeutic behavior has been shown to reduce musculoskeletal pain by favoring normotensive voice production and providing positive results in the treatment of behavioral dysphonia (Alves Silverio et al., 2015; Guirro et al., 2008; Van Lierde, De Bodt, Dhaeseleer, Wuyts, & Claeys, 2010).

One resource that has been used in the treatment of dysphonia is electrical stimulation (Guirro et al., 2008; Alves Silverio et al., 2015; Siqueira et al., 2017). There are several types of electric currents, and each has a specific therapeutic objective that varies depending on the frequency, intensity, and pulse width of the current, as well as the location of the electrodes. For the treatment of behavioral dysphonia, the most commonly used is an analgesic electrical stimulation called transcutaneous electrical nerve stimulation (TENS) of low frequency. TENS aims to provide analgesia, improve the vascularization of the stimulated region, and promote muscle relaxation (Sluka & Walsh, 2003). The literature showed effectiveness in the use of this electric current for the modulation of pain in several pathologies by releasing opioids without causing adverse effects (García-Pérez et al., 2018). There is scientific evidence that TENS promotes strong vibrations in the larynx when applied to the submandibular region and descending fibers of the trapezius muscle at a low frequency and with strong intensity at the motor threshold (trigger points) (Alves Silverio et al., 2015).

Studies of applying TENS to women with behavioral dysphonia have shown that the technique improves the vocal quality while showing a significant decrease in muscle pain in the cervical region (Conde et al., 2018; Guirro et al., 2008). It has also been shown to reduce the frequency of the vocal and laryngeal symptoms such as high-pitched voice and effort to speak (Guirro et al., 2008; Alves Silverio et al., 2015), as well as the electrical activity of the sternocleidomastoid muscles after 10 (Guirro et al., 2008) or 12 application sessions (Alves Silverio et al., 2015). Therefore, it is observed the literature reports positive results with the use of low-frequency TENS in dysphonic women. However, the published studies are case series (Guirro et al., 2008) and comparisons of the immediate effects (Conde et al., 2018) that diverge from the clinical reality, and studies comparing the effect of TENS to manual laryngeal therapy (Alves Silverio et al., 2015). There are no studies that have verified the association of TENS with a direct and indirect vocal therapy approach.

To our knowledge, no longitudinal studies have analyzed the effect of TENS associated with vocal therapy or the follow-up of dysphonic individuals, which would help to better understand the effects of TENS in a vocal clinical practice for behavioral dysphonia. In addition, there is no data on the possible effects of this resource on the symptomatology of pain measured qualitatively and quantitatively. Such data may provide evidence to help the clinical decision in patients with behavioral dysphonia and musculoskeletal pain complaints in order to improve their quality of life. Thus, the objective of the present study was to verify the efficacy of low-frequency TENS associated with vocal therapy on self-perception of the frequency and intensity musculoskeletal pain and pressure pain threshold in women with behavioral dysphonia.

2. Methods

2.1. Design Study and ethical aspects

This randomized, double-blind controlled clinical trial was carried out using the PICO strategy (**P**opulation – women with vocal nodules, **I**ntervention – TENS application associated vocal therapy, **C**omparison – TENS placebo associated vocal therapy; **O**utcomes – self-assessment of musculoskeletal pain and evaluation of muscular pain in the descending fibers of the trapezius with a digital algometer) following the recommendations of CONSORT (Moher et al., 2012; Schulz, Altman, & Moher, 2010).

The study was approved by the Research Ethics Committee of the institution under number 556.273. All participants signed the Informed Consent Form.

2.2. Professionals

The present clinical trial was conducted by a group of researchers to enable the masking of research steps and the impartiality of the data. The tasks and masking of the professionals were carried out as follows:

- Professional 1 was a speech-language pathologist responsible for the randomization of participants and their allocation to the intervention groups. She was blinded in relation to the other stages of the research, i.e., the evaluation and treatment of participants and the analysis of treatment data.
- Professional 2 was a speech-language pathologist responsible for the selection of the sample and evaluation of the outcome variables. She was responsible for the application of the low-frequency TENS or placebo and was blinded regarding randomization of the sample. Professional 2 was the only one who knew treatment each participant was receiving.
- Professional 3 was a speech-language pathologist responsible for the application of voice therapy and editing the materials regarding the outcome variables for statistical analysis. She was blinded in relation to the selection and randomization of the sample, the collection of outcome variables, and the type of electrostimulation, i.e., TENS or placebo.

2.3. Sample

The sample size was calculated in a pilot study with 10 women with vocal nodules and voice complaints, and all 10 women also participated in the main study. The largest standard deviation found for the difference between the two means of the dependent groups was used as an estimate of variability (19.42 mm on the analogue visual scale). We adopted a level of significance of 0.05 (α = 5%) and 80% test power (β = 80%) to detect a minimum difference between the groups equal to one standard deviation. A sample size of at least 12 participants was required, allowing for an attrition rate of 20% during data collection evaluation and intervention.

The participants in this study were women with behavioral dysphonia, aged between 18 and 45 years old, who had already performed vocal screenings and laryngology examinations (e.g., nasolaryngoscopy, telelaryngoscopy, and laryngostroboscopy). They showed a presence of benign vocal fold lesions, e.g., bilateral vocal nodules or mucosal edema, and incomplete glottal closure. Laryngological examinations were used as routine clinical procedures and were designed to determine whether participants met the inclusion criteria. We emphasize that the same otorhinolaryngologist conducted the exams.

To enable the selection of participants, after the laryngology diagnosis was performed by an otorhinolaryngologist, the participants underwent a perceptual-auditory evaluation performed by a speech-language pathologist to determine the overall degree of the voice quality impairment. This evaluation aimed to verify if the participants had vocal alterations. Participants with vocal alterations from the waiting list for vocal treatment of the speech therapy clinic at the study's origin institution were recruited.

Participants who had received speech therapy before, who had reported any general neurological changes or thyroid changes, or who had undergone clinical treatment for hormonal control (except for the use of a contraceptive pill) were excluded. Further exclusion criteria were drug or surgical treatments of the larynx, menopause, cardiac problems, arterial hypertension, rheumatoid arthritis, hyper- or hypothyroidism even if clinically controlled, and previous use of TENS for any type of treatment. Participants with a history of smoking or alcoholism were excluded.

Therefore, based on the selection criteria, 27 women with behavioral dysphonia were selected. The participants were randomly assigned to two groups: an experimental group (EG) consisting of 13 women with behavioral dysphonia who received low-frequency

TENS associated with vocal therapy, and a control group (CG) consisting of 14 women with behavioral dysphonia who received placebo TENS associated with vocal therapy. The average age of participants for the EG was 29 years old and for the CG participants was 31 years and 6 months old. There was no statistical difference between the groups (paired t-test).

2.4. Outcomes

After signing the Informed Consent Form, all the participants underwent evaluation of the outcome variables. The selected outcomes were an investigation of the frequency and intensity of musculoskeletal pain and an evaluation of muscular pain in the descending fibers of the trapezius with a digital algometer, which considers the threshold of pain under pressure as well as the tolerance to pain. The evaluation of the outcome variables was performed in four moments: before the intervention (Time0), after the intervention (Time1), one month after the end of the intervention (Time2), and three months after the end of the intervention (Time3). Assessments of Time0 were performed up to one week prior to the first intervention session and from Time1 to one week after the end of the last session (12th).

2.4.1. Self-perception of musculoskeletal pain —frequency and intensity

The localization of pain was investigated using a protocol called the Musculoskeletal Pain Investigation Questionnaire (Silverio et al., 2014) that is based on a drawing of the body parts corresponding to the items to be marked. The investigated parts were the posterior and anterior region of the neck, shoulders, upper and lower back, temporal region, masseters, submandibular region, and larynx. For each body region, individuals were asked to indicate the intensity of the pain present at the time of evaluation on a visual analogue scale with a length of 100 mm with anchors at the end of the scale. Participants drew a vertical stroke on the scale to the point that characterized the intensity of the pain, the left end referred to no pain and the right was the worst pain possible. The assessment of pain intensity in these body regions was subjective and not induced. Subsequently, this mark was measured with a ruler in millimeters for the data analysis. The frequency of pain was indicated on a four-point Likert scale from zero (never) to three (always). Participants were instructed to indicate the frequency of pain during the prior 30 days.

2.4.2. Pressure Pain Threshold—PPT

For the descending fibers of the trapezius muscle, the pain threshold was measured at rest and during pressure and was obtained in kilogram-force (kgF) using a digital algometer model DDK 20 (KRATOS, Cotia, São Paulo) with an active tip 12 mm in diameter. This was positioned perpendicular to the fibers of the trapezius muscle, bilaterally in the belly of each muscle, in order to locate the trigger point at a distance of approximately 8 cm from the seventh cervical vertebra. Pressure was gradually applied until the participant reported the onset of a painful sensation on the spot, which was measured using a 100-millimeter analogue visual scale. At that moment, the algometer was paralyzed and the applied pressure recorded.

2.5. Vocal intervention

Twelve sessions of vocal therapy lasting approximately 50 min each were performed twice a week. To control the treatment, it was established that the participants could not have more than three consecutive absences and that all absences must be rescheduled. The sessions were divided into two parts: TENS application and vocal therapy.

Application of TENS was the first procedure to be performed and consisted of the application of low-frequency TENS. EG participants received a traditional TENS application. CG participants received a TENS placebo application. The duration of the procedure for both groups was 20 min. We emphasize that the decision to use TENS as the first procedure was because it provides analgesia and relaxation in the region of application and prepares the musculature for the execution of the posterior vocal exercises.

Vocal therapy was performed immediately after the application of TENS. The same therapy protocol was used for the EG and CG for a duration of 30 min.

2.5.1. Application of TENS

The equipment used for the application of low-frequency TENS was the Quark brand Dualpex 961 (Piracicaba, São Paulo, Brazil)

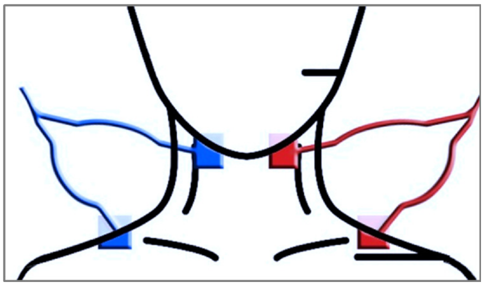

Fig. 1. The same color means same channel in the equipment. The same channel of the equipment stimulates the trapezius muscle and submandibular area.

with two channels. The parameters used were symmetrical biphasic quadratic pulse, 200μs phase, 10 Hz frequency, and motor threshold intensity (mA). Four electrodes of silicon-carbon with a size of 3 cm by 5 cm were used (Alves Alves Silverio et al., 2015).

To reduce impedance, the skin was cleaned with gauze and alcohol gel bilaterally in the descending fibers of the trapezius muscle and submandibular area. The electrodes were coated with electroconductive gel, positioned on the pain areas and/or motor points in the above mentioned muscles, and fixed to the skin with hypoallergenic adhesive tape. The areas of pain and/or motor points was established through palpation by Professional 2 for each participant. Professional 2 verified the area of greater muscle rigidity in the trapezius muscle and questioned whether the participant reported a pain sensation in that palpated region.

One channel was used for placement of two electrodes on the right side, one electrode was placed on the trapezius muscle and other electrode on the submandibular area. The second channel was used for placement of two electrodes on the left side, one electrode was placed on the trapezius muscle and other electrode on submandibular area (Guirro et al., 2008; Alves Silverio et al., 2015). Placement of the electrodes can be seen in Fig. 1.

The choice of electrode placement in this region was made because women with behavioral dysphonia have a higher frequency of pain in the shoulder, upper back (corresponding to the trapezius muscles), anterior and posterior neck, submandibular region, and larynx (Silverio et al., 2014). Thus, the application of TENS through the placement of electrodes on the fibers of the trapezius muscle, along with the placement of another electrode of the same channel in the mandibular region (bilateral electrode placement) generated an electric field in this region, promoting strong vibrations that led to decreased pain in the cervical and perilaryngeal/laryngeal regions. Therefore, the application protocol of this study was based on stimulating the cervical and laryngeal region through the electrodes in the trapezius muscle and submandibular region (Siqueira et al., 2017).

For the application of the procedure, all participants were invited to position themselves in a supine position on a portable stretcher and were instructed to remain at rest and to not perform any vocal emissions.

In the EG, the intensity of the stimulus was increased during the first 10 min until muscle contraction was observed in the region of the suprahyoid and trapezius-descendent fibers. The intensity was raised by 2 mA during each increase. For the next 10 min the stimulation intensity remained constant. The increase was performed according to the individual sensitivity (self-reported by each volunteer) and was intended to be comfortable.

In the CG, the equipment was affixed to the patient in the same way; however, the unit did not emit stimulation as an electric current. In other words, the equipment was turned off during the session. The participants were blinded regarding the use or non-use of TENS.

2.5.2. Vocal therapy

The therapy program for behavioral dysphonia incorporated corporal stretching and manual laryngeal therapy at the beginning of the therapeutic sessions in both groups. The corporal stretching and manual laryngeal therapy were followed by vocal exercises to promote voice balance, reduce the overload in the laryngeal and cervical musculature, and provide more efficient vocal function.

Thus, the objectives of vocal therapy were raising awareness about the laryngeal and vocal alterations found in the evaluations, providing guidance on vocal health, relaxing the cervical muscles, reducing the phonatory effort, mobilizing the mucosa of the vocal folds, promoting complete glottic closure, balancing resonance and articulatory pattern, and improving coordination between the respiratory and phonatory systems. The program was developed based on the exercises and methods described in the literature and clinical experience in order to achieve the established objectives (Behlau, 2005; Behlau, Madazio, Yamasaki, Vieira, & Pontes, 2013; Mathieson et al., 2009; Reimann et al., 2016) and was applied in both groups of this study. The therapy program can be seen in Table 1.

The vocal exercises were performed for a total of 3–5 min. The choice of the duration of therapy and the execution of the exercises followed the scientific evidence already available in the literature (Menezes et al., 2011; Paes & Behlau, 2017). The participants were instructed to perform the tasks for 1 min twice a day and to record audio during one of the two at-home tasks. The participants sent the audio file by mobile phone to the therapist for control, and the participants wrote down on paper the days and times they performed the vocal exercises.

2.6. Statistical analysis

The Shapiro-Wilk test was applied to verify the normal distribution of the data. All the results were nonnormal, so we used the Friedman test to compare the times of evaluation and the Mann-Whitney test to compare the intervention groups. In cases where there was a significance in the Friedman test, a multiple comparison was performed using the Wilcoxon test. Differences were obtained by subtracting the measures at the three times after intervention from the preintervention measure. The data were analyzed using SPSS® 25.0. All tests had a confidence interval of 95% ($p < 0.05$).

3. Results

In general, we found significant differences within the group effects but not between the groups. We observed positive gains regarding pain characteristics when associating TENS with vocal therapy. However, these gains are not potentially greater than those observed with only vocal therapy. Only the statistically significant results will be detailed below.

Fig. 2 shows that in the experimental group (EG) there was a reduction in the frequency of pain in the masseter muscle region from Time0 to Time1 and from Time1 to Time2, although the frequency of pain increased again in Time3. In addition, Fig. 3 shows that the frequency of pain in the laryngeal region decreased at Time1, increased again at Time2 and remained the same at Time3,

Table 1
Vocal Therapy Program.

Session 1	**Objectives** Guide how much vocal and laryngeal diagnosis Relax cervical muscles Mobilize mucosa of the vocal folds **Activities in the sessions** ● Presentation and discussion of a video about production and vocal behavior ● Stretching of the entire body (lower and upper limbs, trunk and head) (Behlau et al., 2013) ● Vibration of tongue or lip or fricative in usual pitch for two minutes (Behlau et al., 2013; Ribeiro, Siqueira et al., 2018) ● Vibration of tongue or lip or fricative with frequency variation for one minute (Behlau et al., 2013) **Daily activities for home, twice a day** ● Vibration of tongue or lip or fricative in usual pitch for two minutes ● Vibration of tongue or lip or fricative with frequency variation for one minute
Sessions 2 and 3	**Objectives** Relax cervical muscles Reducing the phonatory effort Mobilize mucosa of the vocal folds Promote complete glottic closure Balance resonance **Activities in the sessions** ● Guidance on vocal habits ● Stretching of the entire body (lower and upper limbs, trunk and head) (Behlau et al., 2013) ● Laryngeal Manual Therapy for ten minutes (Alves Silverio et al., 2015; Reimann et al., 2016) ● Humming /m/ in usual pitch associated with horizontal head movement for three minutes (Behlau, 2005) ● Sound-blowing with tube of resonance in usual pitch for three minutes (Behlau et al., 2013; Antonetti et al., 2018) ● Vibration of tongue or lip or fricative in usual pitch for two minutes (Behlau et al., 2013; Ribeiro, Ramos et al., 2018) ● Vibration of tongue or lip or fricative with frequency variation for one minute (Behlau et al., 2013) **Daily activities for home, twice a day** ● Humming /m/ in usual pitch for one minute ● Vibration of tongue or lip or fricative in usual pitch for one minute ● Vibration of tongue or lip or fricative with frequency variation for one minute ● Sound-blowing with tube of resonance in usual pitch for one minute
Sessions 4 to 6	**Objectives** Relax cervical muscles Reducing the phonatory effort Mobilize mucosa of the vocal folds Promote complete glottic closure Balance resonance and articulatory pattern **Activities in the sessions** ● Guidance on vocal habits ● Cervical stretching (Behlau et al., 2013) ● Laryngeal Manual Therapy for ten minutes (Alves Silverio et al., 2015; Reimann et al., 2016) ● Humming / m / at usual pitch associated with horizontal head movement for three minutes (Behlau, 2005) ● Sound-blowing with tube of resonance in usual pitch for two minutes (Behlau et al., 2013; Antonetti et al., 2018) ● Sound-blowing with tube resonance with frequency variation for one minute ● Vibration of tongue or lip at usual pitch for one minute (Behlau et al., 2013; Ribeiro, Siqueira et al., 2018) ● Vibration of tongue or lip with frequency variation for two minutes (Behlau et al., 2013) ● Humming / m / chewing associated with speech for three minutes (Behlau et al., 2013; Ribeiro, Ramos et al., 2018) **Daily activities for home, twice a day** ● Humming / m / in usual pitch followed by vowels for one minute ● Vibration of tongue or lips with frequency variation for one minute ● Sound-blowing with tube resonace for one minute ● Humming / m / associated with chewing
Session 7	**Objectives** Relax cervical muscles Reducing the phonatory effort Mobilize mucosa Promote complete glottic closure Balance resonance and articulatory pattern **Activities in the sessions** ● Guidance on vocal habits ● Cervical stretching (Behlau et al., 2013) ● Humming / m / at usual pitch associated with horizontal head movement for one minute (Behlau, 2005) ● Humming / m / in usual pitch followed by vowels for two minutes (Behlau et al., 2013) ● Sound-blowing with tube of resonance at usual pitch for one minute (Behlau et al., 2013; Antonetti et al., 2018) ● Sound-blowing with tube of resonance with frequency variation for two minutes ● Vibration of tongue or lip at usual pitch for one minute (Behlau et al., 2013) ● Vibration of tongue or lip with frequency variation for two minutes (Behlau et al., 2013) ● Humming / m / at usual pitch associated with chewing, followed by words, for three minutes ● Overarticulation of speech using stopper for three minutes (Behlau et al., 2013) **Daily activities for home, twice a day**

(*continued on next page*)

Table 1 (*continued*)

	● Humming / m / in usual pitch followed by vowels for one minute ● Vibration of tongue or lips with frequency variation for one minute ● Sound-blowing with tube resonanc for one minute ● Overarticulation of speech using stopper for three minutes
Sessions 8 to 12	**Objectives** Relax cervical muscles Reducing the phonatory effort Mobilize mucosa of the vocal folds Promote complete glottic closure Balance resonance Improve pneumo-phono-articulatory coordination **Activities in the sessions** ● Guidance on vocal habits ● Cervical stretching ● Vibration of tongue or lip at usual pitch associated with horizontal head movement for two minutes (Behlau, 2005) ● Vibration of tongue or lip with frequency variation associated with the associated horizontal head movement for two minutes (Behlau, 2005) ● Fricative / v / at usual pitch followed by vowels for one minute (Behlau et al., 2013) ● Fricative /v/ with frequency variation for two minutes (Behlau et al., 2013) ● Sound-blowing with tube of resonance at usual pitch for one minute (Behlau et al., 2013; Antonetti et al. 2018) ● Sound-blowing with tube of resonance with frequency variation for two minutes ● Overarticulation of speech using stopper for three minutes (Behlau et al., 2013) ● Chanting voice: humming / m / chewing associated with vowels for three minutes **Daily activities for home, twice a day** ● Vibration of tongue or lips with frequency variation for one minute ● Sound-blowing with tube of resonance for one minute ● Overarticulation of speech using a stopper for one minute ● Chanting voice: humming / m / chewing associated with vowels for one minute

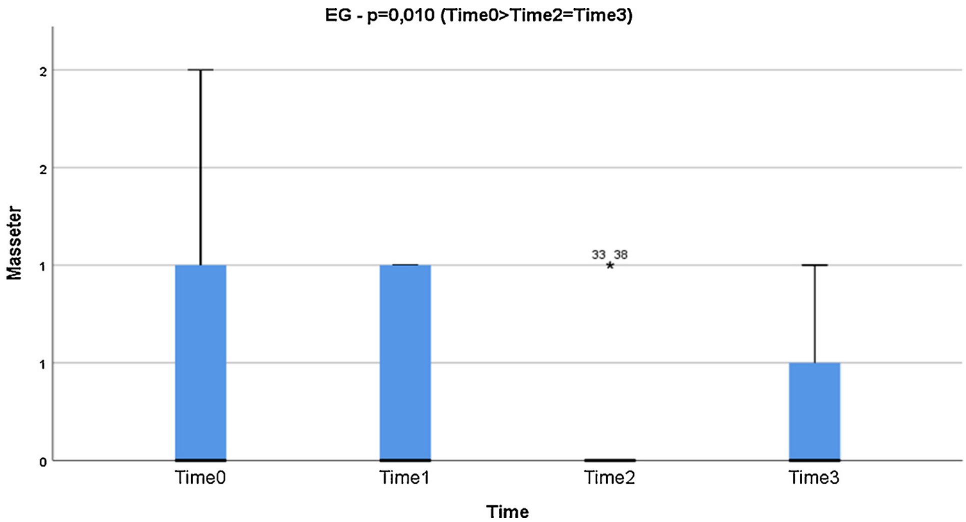

Fig. 2. Results of the intervention on the Experimental Group in the different times of assessment – frequency of pain in the masseter muscle region. *p < 0,05 – Friedman test.

with significant differences between each time. There was no difference to the others regions of the body in EG. Fig. 4 shows that in the control group (CG) there was a statistically significant difference in the frequency of pain in the anterior neck region from Time0 to Time1. Fig. 5 shows that in the control group (CG) there was a statistically significant difference in the frequency of pain in the laryngeal region. There were statistical significant differences in the frequency of pain in the laryngeal region from Time0 to Time1, with pain reduction immediately after treatment, which was maintained after 1 and 3 months. On the other hand, the comparison between the intervention groups (Mann Whitney test) revealed no difference in the frequency of musculoskeletal pain.

It can be observed in Table 2 that in the EG there was a significant reduction in pain intensity in the shoulder region at Time1 and Time2, followed by an increase at Time 3. There was also a significant decrease in pain intensity in the anterior regions of the neck and in the masseter at Time1 and Time2 that remained the same at Time3. In the laryngeal region, there was a significant reduction in the pain intensity at Time 1, Time2, and Time3. In the CG, there was no significant difference in the pain intensity between the moments of evaluation. There was no difference in the intensity of musculoskeletal pain in the comparison between the intervention groups.

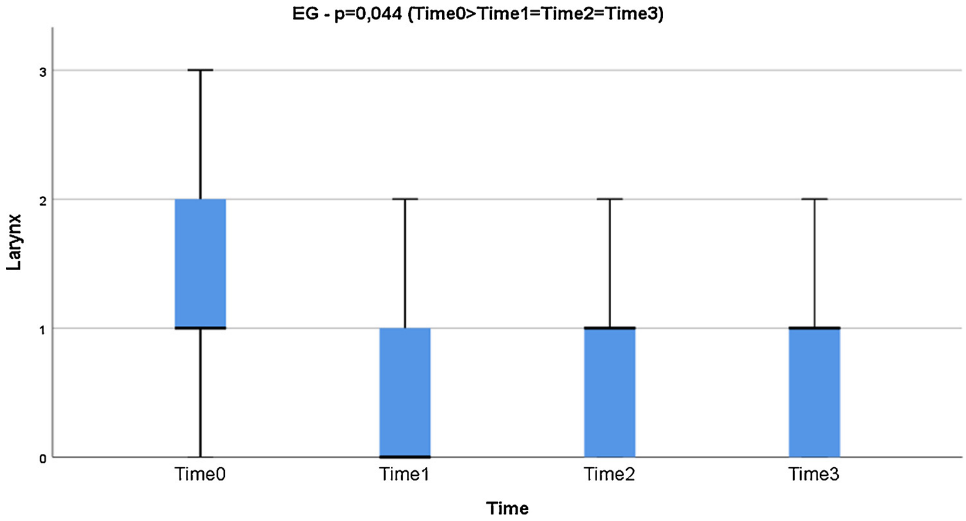

Fig. 3. Results of the intervention on the Experimental Group in the different times of assessment – frequency of pain in the laryngeal region. *p < 0,05 – Friedman test.

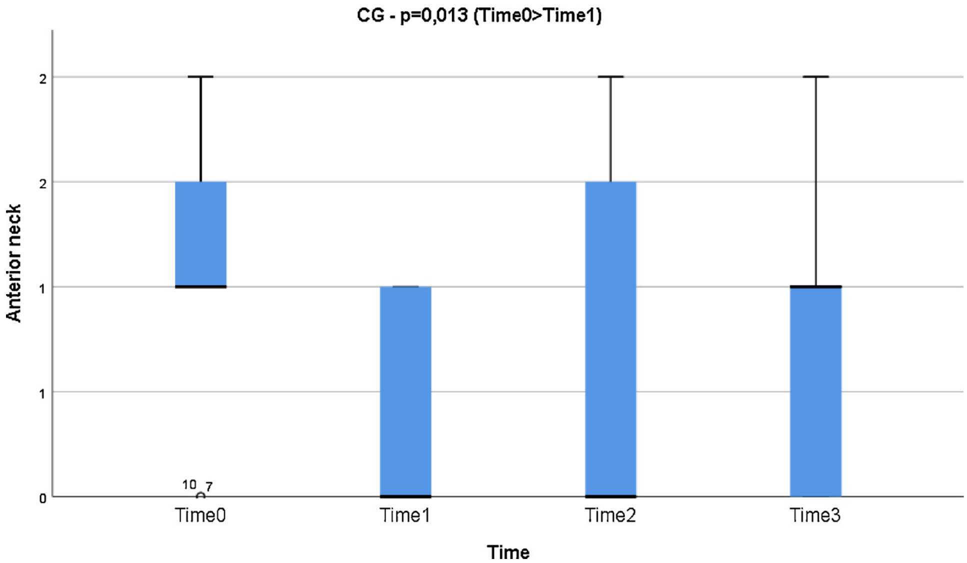

Fig. 4. Results of the intervention on the Control Group in the different times of assessment – frequency of pain in the anterior neck. *p < 0,05 – Friedman test.

Table 3 shows that in both the experimental group (EG) and the control group (CG) there was no significant difference in the pain intensity in the trapezius muscle during rest after the interventions. On the other hand, in the EG there was a decrease in pain in this region during the application of force at Time1, Time2, and Time3 in relation to Time0, on both sides treated. As for the applied force, it increased after the vocal treatment alone in the EG at Time1, Time2 and Time3. In the comparison between the intervention groups, there was no significant difference in the intensity of musculoskeletal pain in the trapezius muscle during rest and load application or in the pain tolerance.

4. Discussion

The literature reports that dysphonic women present a higher frequency and intensity of musculoskeletal pain in the proximal regions of the larynx and cervical (Menoncin et al., 2010; Silverio et al., 2014). This is because women with behavioral dysphonia have vocal behaviors detrimental to voice production and quality that are often associated with the tension of the extrinsic musculature of the larynx and the cervical region (Cielo et al., 2014; Ribeiro, Siqueira et al., 2018; Ribeiro, Ramos et al., 2018; Silverio et al., 2014; Zielińska-Bliźniewska et al., 2013). Previous authors (Bigaton et al., 2010) have found that dysphonic women have more severe craniocervical dysfunction than women without vocal complaints, suggesting that behavioral dysphonia could be more related

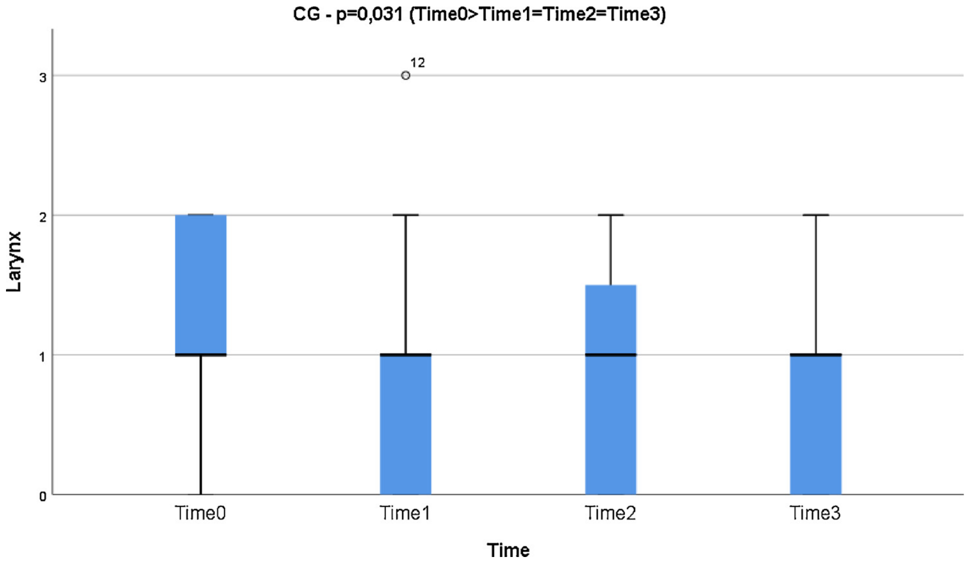

Fig. 5. Results of the intervention on the Control Group in the different times of assessment – frequency of pain in the larynx.
*p < 0,05 – Friedman test.

Table 2
Analysis of the intensity of musculoskeletal pain, in millimeters, in women with behavioral dysphonia as a function of the moment of evaluation of both intervention groups.

Region	Moment	EG				CG				Multiples Comparasion
		Q1	Median	Q3	p-value	Q1	Median	Q3	p-value	
Anterior neck	Time0	0.00	4.00	30.00	0.004*	0.00	2.00	20.00	0.171	Time0 > Time1, Time2 and Time3, only EG
	Time1	0.00	0.00	0.00		0.00	0.00	0.00		
	Time2	0.00	0.00	0.00		0.00	0.00	0.00		
	Time3	0.00	0.00	0.00		0.00	0.00	2.00		
Shoulders	Time0	0.00	1.00	40.00	0.011*	0.00	3.00	13.00	0.205	Time0 > Time1 and Time2, only EG
	Time1	0.00	0.00	8.00		0.00	0.00	2.00		
	Time2	0.00	0.00	0.00		0.00	0.00	0.00		
	Time3	0.00	0.00	11.00		0.00	0.00	5.00		
Masseter	Time0	0.00	0.00	2.00	0.039*	0.00	0.00	3.00	0.064	Time0 > Time1, Time2 and Time3, only EG
	Time1	0.00	0.00	0.00		0.00	0.00	0.00		
	Time2	0.00	0.00	0.00		0.00	0.00	0.00		
	Time3	0.00	0.00	0.00		0.00	0.00	0.00		
Larynx	Time0	0.00	2.00	40.00	< 0.001*	0.00	7.00	14.00	0.134	Time0 > Time1, Time2 and Time3, only EG
	Time1	0.00	0.00	0.00		0.00	0.00	0.00		
	Time2	0.00	0.00	0.00		0.00	0.00	2.00		
	Time3	0.00	0.00	0.00		0.00	0.00	3.00		

Q1 = first quartile; Q3 = third quartile; EG = Experimental Group; CG = Control Group; Time0 = before therapy; Time1 = immediately after therapy; Time2 = after one month of therapy; Time3 = after three months of therapy.
* p < 0.05 - Friedman's test and Wilcoxon Test.

to functional alterations of the cervical region than to postural changes in the same region. We emphasize that other evaluations related to voice have not been addressed in this article, since the focus of interest is the effect of TENS in dysphonic individuals, specifically on pain. However, we emphasize that vocal evaluations, such as auditory and auditory perceptions, should be considered in future studies.

The vocal treatment of behavioral dysphonia, whose etiology is related to excessive muscle tension, is based on promoting the relaxation of the cervical and laryngeal musculature (Mathieson et al., 2009; Roy & Leeper, 1993; Roy, Nissen, Dromey, & Sapir, 2009; Van Houtte et al., 2011; Van Lierde, De Ley, Clement, De Bodt, & Van Cauwenberge, 2004, 2010). Thus, transcutaneous electrical nerve stimulation (TENS) as a therapeutic resource for use in individuals with behavioral dysphonia has found good results, mainly in regard to a decrease in pain symptoms (Silverio et al., 2015; Conde et al., 2018; Fabron et al., 2017; Guirro et al., 2008; de O. Santos, Silvério, Diniz Oliveira, & Gama, 2016; Siqueira et al., 2017). Studies indicate that subjects with chronic pain have metabolic dysfunctions (Larsson et al., 2008; Green, Galvin, Ranney, Tick, & Ouyang, 2011) and vascular disorders (Larsson, Oberg, & Larsson, 1999), which can be restored with low-frequency muscular electrical stimulation. The purpose of TENS is to promote muscle relaxation and analgesia with improved vascularization in the applied region (Sluka & Walsh, 2003). The combination of parameters

Table 3
Analysis of the intensity of pain in the trapezius muscle during rest and of the maximum pain supported during the force applied with algometer in women with behavioral dysphonia as a function of the moment of evaluation of both intervention groups.

Activity	Muscle	Moment	EG				CG				Multiples Comparasions
			Q1	Median	Q3	p-value	Q1	Median	Q3	p-value	
Intensity rest (mm)	RT	Time0	0.00	0.00	44.00	0.819	0.00	3.00	11.00	0.904	
		Time1	0.00	1.00	21.00		0.00	0.00	6.00		——
		Time2	0.00	0.00	10.00		0.00	0.00	4.00		
		Time3	0.00	8.00	31.00		0.00	3.00	8.00		
	LT	Time0	0.00	0.00	43.00	0.479	0.00	0.00	6.00	0.586	
		Time1	0.00	5.00	21.00		0.00	0.00	3.00		——
		Time2	0.00	0.00	10.00		0.00	2.00	3.00		
		Time3	0.00	5.00	35.00		0.00	2.00	5.00		
Intensity with force application (mm)	RT	Time0	62.00	76.00	86.00	< 0.001*	35.00	69.00	74.00	0.151	Time0 > Time1, Time2 and Time3, only EG
		Time1	41.00	57.00	66.00		17.00	23.00	72.00		
		Time2	41.00	50.00	66.00		21.00	36.00	74.00		
		Time3	36.00	47.00	66.00		14.00	29.00	74.00		
	LT	Time0	47.00	75.00	82.00	0.013*	45.00	54.00	79.00	0.967	
		Time1	46.00	64.00	71.00		13.00	34.00	76.00		Time0 > Time1, Time2 and Time3, only EG
		Time2	42.00	50.00	68.00		33.00	39.00	74.00		
		Time3	41.00	51.00	64.00		20.00	46.00	74.00		
Applied force (kgf)	RT	Time0	2.62	4.89	6.35	0.017*	3.15	4.23	4.38	0.132	Time0 < Time2, only EG
		Time1	4.67	5.40	5.87		4.23	5.99	6.94		
		Time2	4.28	5.17	7.83		4.38	4.80	8.27		
		Time3	4.28	5.05	6.38		4.23	4.45	7.95		
	LT	Time0	3.05	4.13	5.63	0.010*	3.07	4.15	6.02	0.280	Time0 < Time2, only EG
		Time1	4.15	5.17	6.01		3.80	6.00	6.75		
		Time2	4.51	5.00	7.79		4.76	6.00	8.74		
		Time3	4.35	4.78	6.80		4.02	6.00	9.03		

Q1 = first quartile; Q3 = third quartile; EG = Experimental Group; CG = Control Group; RT = right trapezius; LT = left trapezius.
* $p < 0.05$ - Friedman's test and Wilcoxon test.

in electrical stimulation is important to match each kind of current to the treatment according to the therapeutic objective. The duration of pulse means the quantity of energy that the current will transport to the tissues. If we combine 200 μs and low frequency (10 Hz) and strong (but comfortable) intensity, we can observe involuntary contractions of the muscles. In this way, the afferent impulses of the spinal medulla can make activity in the intrinsic system that inhibit the function of the A-Delta and C fibers and selectively control the pain (Goldstein, 1976). Therefore, the analgesic effect of this current is longer than another kind of current (Chesterton et al., 2002) and can affect other body areas that are distant from the electrodes through extrasegmental stimulation (Sjölund & Eriksson, 1979).

In this study, we verified a decrease in the frequency of pain in the region of the masseter muscle and the larynx after 12 sessions of electrical stimulation associated with vocal therapy. The group that received the placebo TENS and vocal therapy presented a reduction in the frequency of pain in the anterior region of the neck and larynx (Table 2). There was no significant difference in the comparison between the two intervention groups. Thus, we observed that both groups experienced improvement in the frequency of pain in the laryngeal region and in nearby areas that can be attributed to the vocal therapy program. We emphasize that the vocal therapy program developed was the same for both groups. In this therapeutic model, as previously described, stretching and relaxation of the laryngeal and cervical musculature were performed (Mathieson et al., 2009; Reimann et al., 2016; Siqueira et al., 2017) followed by vocal exercises that reduced the phonatory effort and balance of the articulation (Behlau, 2005). We believe that this vocal therapy program may have contributed to the balance of the systems involved in voice production and generated less tension in the proximal region of the larynx, with a consequential decrease in the frequency of pain. Therefore, we observed that TENS did not influence the frequency of musculoskeletal pain.

TENS associated with vocal therapy was able to improve the intensity of pain in the shoulders, anterior neck, masseter, and larynx and maintain results achieved up to three months after treatment, which did not occur in the group that did not receive TENS (Table 3). These results agree with the literature on the use of TENS to improve pain and muscle relaxation (Alves Silverio et al., 2015). However, when comparing the two intervention groups, there was no statistically significant difference in relation to these investigated variables. The analgesic action of TENS is based on the theory of gates, in which excitation of large-diameter myelin fibers (type A-Beta afferents) blocks or inhibits the transmission of painful impulses driven by small-diameter fibers (A-Delta and C-afferent fibers) in the gray matter of the spinal cord posterior horn (Melzack & Wall, 1965). This type of stimulation is also known as segmental stimulation. Another factor that gives support to its application is the existence of an intrinsic mechanism in which there is a release of endogenous opioids (enkephalin and endorphin) found in the segmental neurons of the spinal cord and the serotonin and noradrenaline-releasing descending pathways. Activating afferent spinal cord impulses can generate activity in this intrinsic system, which releases encephalin and endorphin and inhibits the function evoked by A-Delta and C fibers to selectively control pain (Goldstein, 1976). This type of stimulation is known as extra-segmental.

The results found regarding the reduction of musculoskeletal pain in the proximal regions of the larynx and cervical musculature improved with therapy and were maintained in the long term. This may have occurred due to the adaptation of the musculature during the vocal treatment, where the vocal exercises showed a greater muscle strength through metabolic and physiological changes (Maglischo, 2003), and consequent improvement of muscle performance (Maglischo, 2003). Adapting to training is an individual process that may occur in days or weeks (Mcardle, Katch, & Katch, 2015), with continuous training to maintain the results (Maglischo, 2003). Considering this fact, we consider that the results obtained are also because the participants continued practicing vocal exercises at home until three months after treatment. However, it is important to emphasize that the experimental group had higher initial ratings of pain intensity than the control group for most of the parameters and, thus, showed a larger drop in intensity ratings.

Previous studies have reported a decrease in the frequency of pain in the shoulders and back of the neck and a decrease in pain intensity in the same places and in the upper back after 12 sessions of TENS in women with vocal nodules (Alves Silverio et al., 2015). The data corroborate the results found in the present study.

Although the literature (Bigaton et al., 2010; Menoncin et al., 2010; Balata et al., 2015) shows that individuals with behavioral dysphonia present postural, cervical, and muscular alterations (e.g., amplitude reduction of the cervical movement, pain on palpation or movement, decrease of interdiscal space, and hyperactivity of the extrinsic musculature of the larynx) that can generate muscular tension with consequent onset of musculoskeletal pain, few studies have emphasized work on the relaxation of the cervical and larynx musculature (Ribeiro, Siqueira et al., 2018). No studies found to have investigated the presence of pain in the trapezius muscle during rest and force application with the aid of an algometer. Pressure algometry is a technique used in Physiotherapy to measure the physiology of the nociceptive system. The algometer is applied directly on the peripheral nociceptors responsive to pressure stimuli and allows the study of nociceptive integrity (Piovesan et al., 2001). The use of this technology may provide a more objective assessment for the perception and tolerance of muscle pain.

In the present study, we observed that women who received vocal therapy associated with electrical stimulation presented an increased pressure-pain threshold (PPT) – that is, greater tolerance to pain during pressure in the bilateral trapezius muscle region – after 12 intervention sessions (Table 3). Electrical stimulation of low-frequency and strong intensity can generate rhythmic contractions in the applied musculature, which leads to a release of opioids, as previously mentioned, as well as a decrease in muscular rigidity (Conde et al., 2018; Alves Silverio et al., 2015; Siqueira et al., 2017). It is believed that this may have made it possible to increase the pain tolerance, reducing the pain-tension-pain cycle.

From the results found in this study, we observed that the vocal therapy developed was able to reduce the frequency of musculoskeletal pain in the regions involved with vocal production in women with vocal nodules. The intragroup analysis showed that TENS associated with vocal therapy reduced the intensity of musculoskeletal pain in regions proximal to the larynx. Therefore, we emphasize that TENS associated with vocal therapy could promote results similar to the group that received only vocal therapy in terms of the self-perception of pain in the musculature closest to the larynx.

Systematic reviews have shown that central hypersensitivity can be a prognostic factor for the population with musculoskeletal pain. Thus, it is believed that the evaluation of sensory alterations is a means of identifying the primary area involved in the pain process (Arendt-Nielsen & Yarnitsky, 2009), as well as evidence of its modulation. The literature shows that increased sensitivity to pain in the primary area is considered peripheral sensitization, and it is a central sensitization when this response occurs in distant anatomic areas (Scott, Hons, Jull, & Sterling, 2005). These analyses deserve to be explored in dysphonic women, since they may indicate new therapeutic intervention proposals.

Considering future contributions from this study, we suggest further research with pressure algometry to better understand the applicability of this instrument in clinical practice for individuals with behavioral dysphonia. We also recommend that further studies be carried out to better understand the effects that electrical stimulation through TENS can promote in patients in whom the muscle tension or stiffness component is more evident than the vocal quality and type of laryngeal lesion and considering the diagnosis of the behavioral dysphonia. In the present study, this characteristic was not controlled for because no validated protocol for clinical evaluation of the cervical and laryngeal musculature could be found in the literature that could support the necessary evaluations in this study. This could be considered a limitation of the present study, as well as the use of the invalidated protocol for the self-assessment of the frequency and intensity of musculoskeletal pain.

The participants were selected based on a laryngological diagnosis, and perhaps this type of evaluation is not sufficient for revealing the different muscular characteristics present in behavioral dysphonia. Thus, we assume from the clinical experience, the authors, and from the present study that the behavioral dysphonia may present specific muscular characteristics. For example, there are patients with behavioral dysphonia who present greater muscular tension and stiffness and in other patients the presence of such an aspect is not verified. Therefore, we infer that the benefit of applying TENS may be different for each patient.

In this study, we observe that, according to the objective of the therapeutic process, other resources have already proven to be capable of offering similar benefits to TENS associated with vocal therapy, such as manual laryngeal therapies. TENS can be used by considering the needs of each patient, thus its use should not be indiscriminate. That is, TENS should not be applied in all patients with behavioral dysphonia but in patients who complain of pain in the cervical and laryngeal region, as well as the presence of muscular tension. Some patients with behavioral dysphonia may present alterations in auditory processing (Ramos, Feniman, Gielow, & Silverio, 2017), for example, and another therapeutic approach should be applied during vocal treatment rather than TENS, since the purpose of electric current is to promote muscle relaxation.

To best benefit the dysphonic patient, the clinician should have extensive knowledge about how to configure the current and choose the field to be stimulated, including the location and types of electrodes, as well as the stimulation time, depending on the aim of associating TENS with the vocal treatment.

5. Conclusion

We conclude that in the conditions under which the study was conducted the vocal therapy program decreased the frequency and intensity of musculoskeletal pain in regions proximal to the larynx in women with vocal nodules. This study pointed to benefits in the treatment of TENS associated with vocal therapy as the threshold of sensitivity to muscle pain in the descending fibers of the trapezius increased. However, both treatments were shown to be equivalent in women with behavioral dysphonia.

Funding

Foundation for the Support of Research of the State of São Paulo Brazil (case number 2014/00834-1) - Larissa Thaís Donlaonso Siqueira and Kelly Cristina Alves Silverio.

CRediT authorship contribution statement

Larissa Thais Donalonso Siqueira: Conceptualization, Methodology, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Vanessa Veis Ribeiro:** Writing - original draft, Writing - review & editing, Formal analysis. **Pamela Aparecida Medeiros Moreira:** Data curation, Writing - original draft, Writing - review & editing. **Alcione Ghedini Brasolotto:** Conceptualization, Writing - original draft, Writing - review & editing. **Rinaldo Roberto de Jesus Guirro:** Conceptualization, Writing - original draft, Writing - review & editing. **Kelly Cristina Alves Silverio:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision.

Declaration of Competing Interest

None.

Acknowledgements

The author would like to thank the Foundation for the Support of Research of the State of São Paulo Brazil for providing the doctoral scholarship that supported the execution of the present study (case number 2014/00834-1).

References

Alves Silverio, K. C., Brasolotto, A. G., Thaís Donalonso Siqueira, L., Carneiro, C. G., Fukushiro, A. P., & Roberto de Jesus Guirro, R. (2015). Effect of application of transcutaneous electrical nerve stimulation and laryngeal manual therapy in dysphonic women: Clinical trial. *Journal of Voice, 29*(2), 200–208. https://doi.org/10.1016/j.jvoice.2014.06.003.

Antonetti, A. E., Ribeiro, V. V., Moreira, P., Brasolotto, A., & Silverio, K. C. A. (2018). Voiced High-frequency Oscillation and LaxVox: Analysis of Their Immediate Effects in Subjects With Healthy Voice. *J Voice*.

Arendt-Nielsen, L., & Yarnitsky, D. (2009). Experimental and clinical applications of quantitative sensory testing applied to skin, muscles and viscera. *The Journal of Pain, 10*(6), 556–572.

Balata, P. M. M., Da Silva, H. J., Pernambuco, L. D. A., De Oliveira, J. H. P., & Moraes, S. R. A. D. (2015). Normalization Patterns of the Surface Electromyographic Signal in the Phonation Evaluation. *Journal of Voice, 29*(1), https://doi.org/10.1016/j.jvoice.2014.03.010 129.e1–129.e8.

Behlau, M. (2005). *Voz: o livro do especialista* (2nd ed.). Rio de Janeiro: Revinter.

Behlau, M., Madazio, G., Yamasaki, R., Vieira, V. P., & Pontes, P. (2013). Presentation of the Comprehensive Vocal Rehabilitation Program for the treatment of behavioral dysphonia. *CoDAS, 25*(5), 492–496. Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2317-17822013000500492.

Behlau, M., Zambon, F., Moreti, F., Oliveira, G., & de Barros Couto, E. (2017). Voice self-assessment protocols: Different trends among organic and behavioral dysphonias. *Journal of Voice, 31*(1), https://doi.org/10.1016/j.jvoice.2016.03.014 112.e13–112.e27.

Bigaton, D., Silvério, K., Berni, K., Distefano, G., Forti, F., & Guirro, R. (2010). Craniocervical posture in dysphonic women. *Revista Da Sociedade Brasileira de Fonoaudiologia, 15*(8), 329–334.

Bron, C., & Dommerholt, J. D. (2012). Etiology of myofascial trigger points. *Current Pain and Headache Reports, 16*(5), 439–444.

Cielo, C. A., Christmann, M. K., Ribeiro, V. V., Hoffmann, C. F., Padilha, J. F., dos S. Steidl, E. M., et al. (2014). Síndrome de tensão musculoesquelética, musculatura laríngea extrínseca e postura corporal: Considerações teóricas. *Revista CEFAC, 16*(5), 1639–1649. https://doi.org/10.1590/1982-0216201410613.

Chesternon, L. S., Barlas, P., Foster, N. E., Lundeberg, T., Wright, C. C., & Baxter, G. D. (2002). Sensory stimulation (TENS): effects of parameter manipulation on mechanical pain thresholds in healthy human subjects. *Pain,* 253–262.

de C. M. Conde, M., Siqueira, L. T. D., Vendramini, J. E., Brasolotto, A. G., de J. Guirro, R. R., & Silverio, K. C. A. (2018). Transcutaneous Electrical Nerve Stimulation (TENS) and Laryngeal Manual Therapy (LMT): Immediate effects in women with dysphonia. *Journal of Voice, 32*(3), https://doi.org/10.1016/j.jvoice.2017.04.019 385.e17-385.e25.

da Silva Vitor, J., Siqueira, L. T. D., Ribeiro, V. V., Ramos, J. S., Brasolotto, A. G., & Silverio, K. C. A. (2017). Musculoskeletal pain and occupational variables in teachers with voice disorders and in those with healthy voices—A pilot study. *Journal of Voice, 31*(4), https://doi.org/10.1016/j.jvoice.2016.12.021 518.e7-518.e13.

Fabron, E. M. G., Petrini, A. S., de M. Cardoso, V., Batista, J. C. T., Motonaga, S. M., & de C. Marino, V. C. (2017). Immediate effects of tongue trills associated with transcutaneous electrical nerve stimulation (TENS). *CoDAS, 29*(3), 1–9. https://doi.org/10.1590/2317-1782/20172015311.

García-Pérez, S., García-Ríos, M. C., Pérez-Mármol, J. M., Tapia-Haro, R. M., Albornoz-Cabello, M., Valenza, M. C., et al. (2018). Effectiveness of transcutaneous electrical nerve stimulation energy in older adults: A pilot clinical trial. *Advances in Skin & Wound Care, 31*(10), 462–469. https://doi.org/10.1097/01.ASW.0000544614.18501.b4.

Green, H. J., Galvin, P., Ranney, D. A., Tick, H., & Ouyang, J. (2011). Are abnormalities in sarcoplasmic reticulum calcium cycling properties involved in trapezius myalgia?: Case studies on three females. *American Journal of Physical Medicine & Rehabilitation, 90*, 834–843.

de J. Guirro, R. R., Bigaton, D. R., Silvério, K. C. A., dos S. Berni, K. C., Distéfano, G., dos Santos, F. L., et al. (2008). Estimulação elétrica nervosa transcutânea em mulheres disfônicas. *Pró-Fono Revista de Atualização Científica, 20*(3), 189–194. https://doi.org/10.1590/S0104-56872008000300009.

Goldstein, A. (1976). Opioid peptides (endorphins) in pituitary and brain. *Science, 193*, 1081–1087.

Larsson, B., Rosendal, L., Kristiansen, J., Sjøgaard, G., Søgaard, K., Ghafouri, B., et al. (2008). Responses of algesic and metabolic substances to 8 h of repetitive manual work in myalgic human trapezius muscle. *Pain, 140*, 479–490.

Larsson, R., Oberg, P. A., & Larsson, S. E. (1999). Changes of trapezius muscle blood flow and electromyography in chronic neck pain due to trapezius myalgia. *Pain, 79*, 45–50.

Maglischo, E. W. (2003). *Swimming fastest.* Champaign: Human Kinetics.

Mathieson, L., Hirani, S. P., Epstein, R., Baken, R. J., Wood, G., & Rubin, J. S. (2009). Laryngeal manual therapy: A preliminary study to examine its treatment effects in the management of muscle tension dysphonia. *Journal of Voice, 23*(3), 353–366. https://doi.org/10.1016/j.jvoice.2007.10.002.

Mcardle, W. D., Katch, F. I., & Katch, V. L. (2015). *Exercise physiology nutrition, energy, and human performance* (8th ed.). Philadelphia: Exercise physiology nutrition, energy, and human performance.

Melzack, R., & Wall, P. D. (1965). Pain mechanisms: A new theory. *Science, 150*(3699), 971–978. https://doi.org/10.1126/science.150.3699.971.

Menezes, M. H. M., Ubrig-Zancanella, M. T., Cunha, M. G. B., Cordeiro, G. F., Nemr, K., & Tsuji, D. H. (2011). The relationship between tongue trill performance duration and vocal changes in dysphonic women. *Journal of Voice, 25*(4), 167–175. https://doi.org/10.1016/j.jvoice.2010.03.009.

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia (Impresso), 14*(4), 461–466. https://doi.org/10.1590/S1809-48722010000400014.

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., et al. (2012). CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. *International Journal of Surgery, 10*(1), 28–55. https://doi.org/10.1016/j.ijsu.2011.10.001.

Moraska, A. F., Hickner, R. C., Kohrt, W. M., & Brewer, A. (2013). Changes in blood flow and cellular metabolism at a myofascial trigger point with trigger point release (Ischemic compression): A proof-of-Principle pilot study. *Archives of Physical Medicine and Rehabilitation, 94*(1), 196–200.

Paes, S. M., & Behlau, M. (2017). Dosage dependent effect of high-resistance straw exercise in dysphonic and non-dysphonic women. *CoDAS, 29*(1), 1–9. https://doi.org/10.1590/2317-1782/20172016048.

Pedrosa, V., Pontes, A., Pontes, P., Behlau, M., & Peccin, S. M. (2016). The effectiveness of the comprehensive voice rehabilitation program compared with the vocal function exercises method in behavioral dysphonia: A randomized clinical trial. *Journal of Voice, 30*(3), https://doi.org/10.1016/j.jvoice.2015.03.013 377.e11–377.e19.

Piovesan, E. J., Tatsui, C. E., Kowacs, P. A., Lange, M. C., Pacheco, C., & Werneck, L. C. (2001). Utilização da algometria de pressão na determinação dos limiares de percepção dolorosa trigeminal em voluntários sadios: Um novo protocolo de estudos. *Arquivos de Neuro-Psiquiatria, 59*(1), 92–96. https://doi.org/10.1590/S0004-282X2001000100019.

Ramos, A. C., Floro, R. L., Ribeiro, V. V., Brasolotto, A. G., & Silverio, K. C. A. (2017). Musculoskeletal pain and voice-related quality of life in dysphonic and non-dysphonic subjects. *Journal of Voice*. https://doi.org/10.1016/j.jvoice.2017.05.019.

Ramos, J. S., Feniman, M. R., Gielow, I., & Silverio, K. C. A. (2017). Correlation between voice and auditory processing. *Journal of Voice*. https://doi.org/10.1016/j.jvoice.2017.08.011.

Reimann, A. P., Siqueira, L. T. D., Rondon, A. V., Brasolotto, A. G., & Silverio, K. C. A. (2016). Immediate effect of laryngeal manual therapy in dysphonic individuals. *CoDAS, 28*(1), 59–65. https://doi.org/10.1590/2317-1782/20162015089.

Ribeiro, V. V., de Oliveira, A. G., da Silva Vitor, J., Siqueira, L. T. D., Moreira, P. A. M., Brasolotto, A. G., et al. (2018). The effect of a voice therapy program based on the taxonomy of vocal therapy in women with behavioral dysphonia. *Journal of Voice*. https://doi.org/10.1016/j.jvoice.2017.10.019.

Ribeiro, V. V., de Oliveira, A. G., da S. Vitor, J., Ramos, A. C., Braoslotto, A. G., & Silverio, K. C. A. (2018). Effectiveness of voice therapy associated with electromyographic biofeedback in women with behavioral dysphonia: Randomized controlled double-blind clinical trial. *Journal of Voice*. https://doi.org/10.1016/j.jvoice.2017.12.015.

Roy, N., & Leeper, H. A. (1993). Effects of the manual laryngeal musculoskeletal tension reduction technique as a treatment for functional voice disorders: Perceptual and acoustic measures. *Journal of Voice, 7*(3), 242–249. https://doi.org/10.1016/S0892-1997(05)80333-9.

Roy, N., Nissen, S. L., Dromey, C., & Sapir, S. (2009). Articulatory changes in muscle tension dysphonia: Evidence of vowel space expansion following manual circumlaryngeal therapy. *Journal of Communication Disorders, 42*(2), 124–135. https://doi.org/10.1016/j.jcomdis.2008.10.001.

Roy, N., Weinrich, B., Gray, S. D., Tanner, K., Stemple, J. C., & Sapienza, C. M. (2003). Three treatments for teachers with voice disorders. *Journal of Speech Language and Hearing Research, 46*(3), 670. https://doi.org/10.1044/1092-4388(2003/053).

Rubin, J. S., Blake, E., & Mathieson, L. (2007). Musculoskeletal patterns in patients with voice disorders. *Journal of Voice, 21*(4), 477–484. https://doi.org/10.1016/j.jvoice.2005.02.001.

de O. Santos, J. K., Silvério, K. C. A., Diniz Oliveira, N. F. C., & Gama, A. C. C. (2016). Evaluation of electrostimulation effect in women with vocal nodules. *Journal of Voice, 30*(6), https://doi.org/10.1016/j.jvoice.2015.10.023 769.e1–769.e7.

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. *Trials, 11*(32), 1–8.

Scott, D., Hons, B. P., Jull, G., & Sterling, M. (2005). Widespread sensory hypersensitivity is a feature od chronic whiplash-associated disorder but not chronic idiopathic neck pain. *The Clinical Journal of Pain, 21*, 175–181.

Silverio, K. C. A., Siqueira, L. T. D., Lauris, J. R. P., & Brasolotto, A. G. (2014). Muscleskeletal pain in dysphonic women. *CoDAS, 26*(5), 374–381. https://doi.org/10.1590/2317-1782/20142013064.

Siqueira, L. T. D., Silverio, K. C. A., Brasolotto, A. G., de J. Guirro, R. R., Carneiro, C. G., & Behlau, M. (2017). Effects of laryngeal manual therapy (LMT) and transcutaneous electrical nerve stimulation (TENS) in vocal folds diadochokinesis of dysphonic women: a randomized clinical trial. *CoDAS, 29*(3), 1–9. https://doi.org/10.1590/2317-1782/20172016191.

Sluka, K. A., & Walsh, D. (2003). Transcutaneous electrical nerve stimulation: Basic science mechanisms and clinical effectiveness. *Journal of Pain, 4*(3), 109–121. https://doi.org/10.1054/jpai.2003.434.

Sjölund, B. H., & Eriksson, M. B. (1979). The influence of naloxone on analgesia produced by peripheral conditioning stimulation. *Brain Res, 173*, 295–301.

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: A review of the current knowledge. *Journal of Voice, 25*(2), 202–207. https://doi.org/10.1016/j.jvoice.2009.10.009.

Van Lierde, K. M., De Bodt, M., Dhaeseleer, E., Wuyts, F., & Claeys, S. (2010). The treatment of muscle tension dysphonia: A comparison of two treatment techniques by means of an objective multiparameter approach. *Journal of Voice, 24*(3), 294–301. https://doi.org/10.1016/j.jvoice.2008.09.003.

Van Lierde, K. M., De Ley, S., Clement, G., De Bodt, M., & Van Cauwenberge, P. (2004). Outcome of laryngeal manual therapy in four Dutch adults with persistent moderate-to-severe vocal hyperfunction: A pilot study. *Journal of Voice, 18*(4), 467–474. https://doi.org/10.1016/j.jvoice.2004.02.003.

Zielińska-Bliźniewska, H., Pietkiewicz, P., Miĺoński, J., Urbaniak, J., & Olszewski, J. (2013). Acoustic and capacity analysis of voice academic teachers with diagnosed hyperfunctional dysphonia by using DiagnoScope Specialist software. *Otolaryngologia Polska, 67*(3), 144–148. https://doi.org/10.1016/j.otpol.2013.02.001.