Effect of Application of Transcutaneous Electrical Nerve Stimulation and Laryngeal Manual Therapy in Dysphonic Women: Clinical Trial

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Summary: Objective. To verify the effect of the Transcutaneous Electrical Nerve Stimulation (TENS) and of Laryngeal Manual Therapy (LMT) and to compare the two techniques in relation to vocal/laryngeal symptoms, pain, and vocal quality after these resources were administered in dysphonic women.

Study Design. Control trial.

Method. A total of 20 women with bilateral vocal nodules participated. All of the volunteers underwent investigation of vocal/laryngeal symptoms, musculoskeletal pain, and vocal register. The volunteers were subdivided into: 1. TENS Group (10 volunteers)—TENS application; 2. LMT Group (10 volunteers)—LMT application; both groups received 12 sessions of treatment, twice a week, lasting 20 minutes each. After treatment, the initial assessments were repeated. Data were statistically analyzed by Wilcoxon and signal test ($P < 0.05$).

Results. After TENS, there was significant improvement in the "high pitched voice" and "effort to speak" symptoms; there was significantly lower frequency of pain in the posterior neck and shoulder; TENS significantly reduced the intensity of pain in the posterior neck, shoulder, and upper back. The auditory perceptual analysis showed improvement only in the strain parameter after TENS. After LMT, there was improvement of the "sore throat," significantly lower incidence of pain in the anterior neck, and the pain intensity in the posterior neck decreased.

Conclusion. When compared with the LMT, TENS appeared to be a treatment method intended to be used as a complement to voice therapy, considering the parameters evaluated and controlled.

Key Words: TENS–Dysphonia–Massage–Voice–Larynx.

INTRODUCTION

Hyperfunctional voice disorders associated with prolonged, strong contraction of the larynx muscles are commonly associated with high laryngeal position in voices that have a strong component of muscle tension.[1–3]

Prolonged phonation in the presence of increased laryngeal muscle tension causes excessive force on the physiology of the vocal tract and can lead to changes in its function and changes in the mucosa, such as nodules, polypoid degeneration, and chronic laryngitis.[4,5] Specifically, the presence of vocal nodules is a difficult condition to study and treat, especially when the etiology is not fully understood.[6] Clinically, it has been observed that sometimes the vocal nodules are associated with changes defined as muscle tension dysphonia (MTD).[7–10]

MTD is defined as a voice disorder that is characterized by excessive force on the laryngeal and perilaryngeal muscles[7,8,10,11] with incomplete glottic closure, median constriction of the vocal folds, median constriction in the laryngeal vestibule, change in vocal fold mucosa, high larynx, tension in the suprahyoid muscles, breathiness, vocal attack, and strained voice with changes in resonance.[5,10–12] Recently, MTD was defined as a clinical and diagnostic term describing a spectrum of disorder of vocal folds behavior caused by increased muscle tension and was considered a "bridge" between functional and organic dysphonia.[13]

Although many causal factors and methods of diagnosis have been described,[14] the literature shows the use of only a few techniques that have been proven effective in the treatment of dysphonia associated with hyperfunctional disorders.[13] Thus, we describe the use of techniques that prioritize the relaxing of the larynx such as the circumlaryngeal manual therapy[10,15,16] and Laryngeal Manual Therapy (LMT).[2,17] The main goal of manual therapy in the laryngeal and perilaryngeal area is to relax the excessively tense muscles that ultimately inhibit balanced phonation, such as the high position of the larynx in the neck that can influence phonation by changing the length control function and stiffness of the vocal folds, contributing to the imbalance in voice quality.[2,10,13,18–21]

A literature review conducted in 2011[13] indicates other treatment options for MTD such as indirect therapy: vocal hygiene and patient education; direct therapy: voice therapy and Circunlaryngeal Manual Therapy; medical treatment; and surgery for secondary organic lesions.

Specifically, for the treatment of patients with vocal nodules, another study[6] suggests using standardized protocols to improve data comparisons in the treatment of patients. The authors suggest five phases for the treatment: vocal hygiene; relaxation exercises; respiratory exercises; direct facilitation with reduction of loudness and yawn-sigh, which is a frequently used approach for reducing muscular tension, decreasing effort,

Accepted for publication June 5, 2014.

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Journal of Voice, Vol. 29, No. 2, pp. 200-208
0892-1997/$36.00

http://dx.doi.org/10.1016/j.jvoice.2014.06.003

and reducing abruptness of vocal onset, thereby helping to reduce vocal hyperfunction; and carryover: with the aim to transfer the newly learned vocal behaviors to real-life situations outside of the therapy setting.

In recommending laryngeal relaxation and shoulder girdle in individuals with hyperfunctional dysphonia, the application of transcutaneous electrical nerve stimulation (TENS) may be an effective therapeutic tool. This resource involves the application of percutaneous electrodes aiming to excite the nerve fibers by means of an electric current with a typically biphasic waveform, symmetric or asymmetric, which can be transmitted through the skin without interruption. TENS uses pulses with low or high frequencies that can vary from one to over 100 Hz and also variable pulse widths, which can be brief or not, depending on the way one wishes to use the stimulation.[22,23]

It is noteworthy that the electrical current TENS described in this study differs from other types of electrical currents used to treat swallowing and dysphonia by speech therapists, such as neuromuscular electrical stimulation (NMES) or transcutaneous electrical stimulation (TES) with reports of improvement in voice quality.[24–27] The main purpose of the electrical stimulation was to treat cervical pain that often occurs in these patients.

The objective of the current TENS as described in this study is to promote muscle relaxation of the perilaryngeal and cervical areas with the placement of surface electrodes on suprahyoid muscles and superior fibers of trapezius muscles (Figures 1 and 2). This is done with low frequency and high intensity current, whereas in studies using other types of currents, the stimulation is performed directly on perilaryngeal muscles in the hyoid bone area, thyrohyoid membrane and even in the region of the cricothyroid muscle to recruit the cricothyroid muscle fibers and then improve glottic closure.[24–27]

TENS is widely used by physical therapists for muscle relaxation and symptomatic treatment of musculoskeletal pain in various body parts. Besides analgesia, TENS is able to promote improved vascularization in the application area and assists in muscle relaxation.[28,29] With an analgesic purpose, whether the pain is from an acute injury or due to chronic processes,[23,29,30] TENS is one of the simplest forms of electrotherapy and one of the most used techniques in the field of electrotherapy.[23] With regard to the treatment of dysphonia in which the muscular tension is present, there is only one study in the literature that the authors observed in which the exclusive application of TENS provided a significant improvement of pain in the cervical muscles and of vocal quality for women with muscle tension dysphonia. However, the authors affirmed that further studies are needed to better understand the muscle and vocal behavior after the application of this resource.[31]

The aim of this study highlights the need to develop further research with TENS and LMT in individuals with voice problems, and to develop more research on the effect of the application of both techniques in dysphonic individuals. The objective of this clinical, controlled, and prospective study was to verify the effect of TENS and LMT application and to compare the two techniques in relation to vocal and laryngeal symptoms, pain, and vocal quality after these resources were administered in dysphonic women.

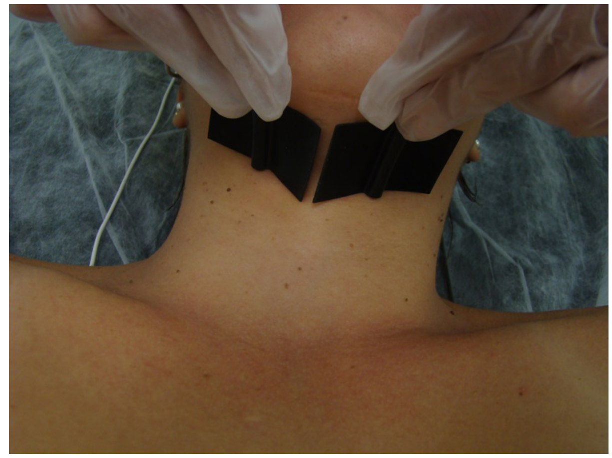

FIGURE 1. Surface electrodes on submandibular area during TENS stimulation.

METHODOLOGY

Sample

This research protocol was approved by the Ethics Committee in Research of the University (CEP/FOB/USP 099/2011). For this study, 20 women were selected, aged 18–45 years old. The calculation of the sample size was based on the study of Lagorio, Carnaby-Mann, and Crary[25] that considered a value of $P < 0.05$ ($\alpha = 5\%$) and a test force of 90% ($\beta > 0.90$), which indicates the need of six individuals.

To form the groups, women were sought who were enrolled for vocal treatment in the Department of Speech and Language Pathology Clinic, FOB/USP, and who were complaining of vocal disorders. To participate in the study, the volunteers had to present complaints of voice alteration, altered voice evidenced by an auditory perceptual pre-assessment, bilateral vocal nodules or mucosal thickening, and incomplete glottic closure, as evidenced by the otolaryngology evaluation.

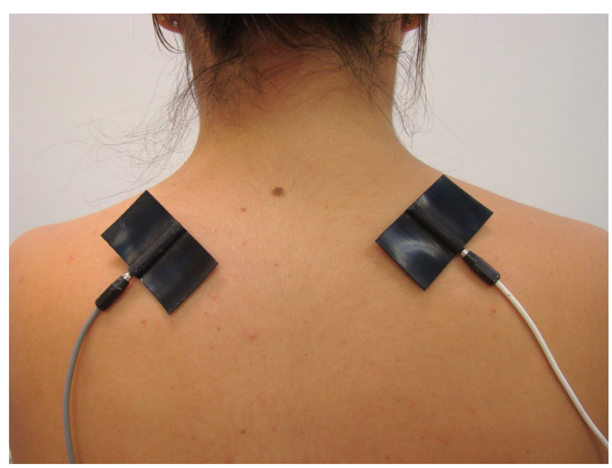

FIGURE 2. Surface electrodes on trapezius—upper fibers muscle during TENS stimulation.

Thus, subjects who met the inclusion criteria for the treatment groups were subdivided into: TENS Group—to receive TENS application according to Guirro et al[31]; and LMT group—to receive application of LMT according to Mathiesson et al[20] The distribution of volunteers in each group was made by drawing lots where 20 pieces of papers with the same appearance and with the names of each treatment (10 pieces of paper for TENS; 10 pieces of paper for LMT) were placed in a box. The therapist picked out the piece of paper and applied the treatment.

All patients who received vocal speech therapy or previous larynx surgery, who were with changes of the thyroid or hormonal changes, who presented cardiac or vascular problems and who were older than 45 years were excluded to isolate variables such as changes resulting from the natural process of aging including muscular changes.

After consideration of the inclusion criteria, 10 volunteers who participated in the study were randomly assigned to the TENS group (mean = 28.7) and 10 volunteers were randomly assigned to the LMT Group (mean = 30.1). After the project presentation and clarification of doubts, all subjects signed a formal informed consent.

Procedure

The study was divided into two phases:

Phase 1. Evaluations before treatment—after detecting the otolaryngology diagnosis and meeting the inclusion criteria, the volunteers underwent an interview, evaluation of symptom of musculoskeletal pain and vocal register. Both the TENS and LMT voluntary groups participated in this phase. No guidance was given to the volunteers in relation to vocal health, voice care, or hydration.

Phase 2. Evaluations after treatment for the TENS and LMT groups (12 sessions, in 6 weeks), repeating the same evaluation of phase 1. These assessments occurred in the same day and immediately after completion of the chosen treatment.

Evaluations

Vocal and laryngeal symptoms. After the interview that addressed issues related to the profession and activities with voice use, voice complaints, health behavior, and general health aspects, the laryngeal and vocal symptoms were investigated with questions adapted from the questionnaire developed by Ferreira et al,[32] especially regarding the frequency of symptoms: never, rarely, often, and always. Phase 1: the volunteers were asked about the frequency of symptoms in the last 6 months; phase 2: the volunteers were asked about the frequency of symptoms in the last 6 weeks.

Musculoskeletal pain. To investigate the symptom of pain, the Nordic musculoskeletal symptoms questionnaire—NMSQ (validated in Brazil by Pinheiro, Tróccoli, and Carvalho[33]) —was used. This is a questionnaire that investigates musculoskeletal pain with a design of the parts of the body corresponding to the items in which the volunteer marked the frequency of pain if it was present in the last 12 months in phase 1 and in the last 6 weeks in the phase 2. The parts investigated were shoulders, upper back, elbows, wrists/hands/fingers, lower back, hips/thighs, knees, ankles/feet. For this study, the following parts were added: temporal region, masseter, submandibular, larynx, anterior, and posterior neck.

To measure the intensity of musculoskeletal pain, a visual analog scale[34] was used, with length of 100 mm, where the volunteer marked a vertical line crossing at the point that characterizes the level of pain, if present at the time before the application of therapeutic action. The left edge referred to no pain and the right referred to the worst possible pain. A visual analog scale was created for each investigated site of pain.

Vocal quality. The assessment of vocal quality consisted of the auditory perceptual analysis of voice. The voice record was carried out in a quiet environment, treated acoustically, later providing the auditory perceptual and acoustic voice. The *Sony Sound Forge Pro 10 software* (Sony Creative Software Inc, USA) was used in a sampling rate of 44 100 Hz, 16 bit mono channel, installed on the Intel Pentium 4, 2.040 GHz with Creative Sound Blaster model Audigy II (Creative Technology Ltd, Singapore) and AKG C444 model headset microphone (AKG Acoustics GmbH, Vienna, Austria), together with the computer. After placement of the microphone, each volunteer sat in a chair facing the examiner and was instructed to emit the speech situations: vowel /a/ sustained, isolated and after deep inspiration in pitch and usual loudness—three replicates were performed; spontaneous speech, in speed, articulation, usual pitch and loudness, answering the questions, “What do you think of your voice?” and “Tell me about your work.”

To perform the auditory perceptual analysis, the vocal records were randomized, paired, and sent to three judges—speech voice specialists with expertise in auditory perceptual voice analysis. The judges were blind in relation to the type and phase of treatment. The assessment of the vocal parameters was performed randomly and paired (before and after a therapeutic procedure or vice versa), in which the judge indicated which of the two samples had a better voice quality or if there was no difference between the two samples. The following parameters were analyzed: global degree of vocal quality, which refers to the overall impression of voice quality, roughness, breathiness, and strain. In the analysis of spontaneous speech, the following parameters were added: resonance and speech articulation. For each parameter, the reviewer conducted an evaluation protocol, marking an “x” in a table corresponding to each volunteer in terms of which emission was best: whether emission “a” or emission “b” was better, or whether “a” and “ b” were equal. After the evaluations, allowing the application of statistical tests for the statistical calculations, the most common of three responses was elected.

Treatments

Application of TENS (TENS group). The application of TENS was performed with the volunteers in a supine position, resting on a stretcher. The equipment used was the Dualpex 961—two channels of the Quark brand (Quark, Piracicaba/SP, Brazil). The parameters used were the low frequency TENS which was a Symmetrical biphasic square pulse, phase 200 μs, frequency 10 Hz and motor threshold intensity.[31] The

TABLE 1.
Mean, Standard Deviation and *P* Value of the Vocal and Laryngeal Symptoms Frequency Reported by TENS and LMT Groups Before and After Treatment

Vocal and Laryngeal Symptoms	TENS			LMT		
	Before	After		Before	After	
	Mean (SD)	Mean (SD)	*P* Value	Mean (SD)	Mean (SD)	*P* Value
Hoarseness	3.2 (0.79)	2.3 (1.42)	0.087	3.1 (0.88)	2.8 (0.92)	0.429
Voice loss	1.8 (1.23)	1.2 (1.23)	0.118	1.8 (1.23)	1.8 (1.03)	0.941
Voice failure	2.1 (1.29)	1.5 (1.08)	0.167	2.9 (0.99)	2.6 (0.97)	0.333
Shortness of breath while speaking	1.5 (1.65)	0.8 (0.92)	0.084	1.5 (1.35)	1.4 (1.17)	0.853
High-pitched voice	1.1 (0.99)	0.1 (0.32)	0.023	1.6 (1.26)	1.4 (1.26)	0.317
Low-pitched voice	1.5 (1.35)	1.2 (1.48)	0.379	1.6 (1.35)	1.4 (1.07)	0.580
Weak voice	1.3 (1.34)	0.7 (1.06)	0.160	2.2 (1.32)	1.8 (1.55)	0.304
Effort to speak	2.3 (1.16)	1.1 (1.37)	0.035	2.6 (0.70)	2.7 (1.06)	0.738
Vocal fatigue	1.7 (1.25)	1.5 (1.08)	0.680	2.3 (1.06)	2.5 (1.35)	0.557
Lump in the throat	0.6 (0.84)	0.8 (1.32)	0.891	1.7 (1.57)	1.4 (1.35)	0.517
Accumulation of mucus in the throat	2.1 (0.99)	1.6 (1.07)	0.095	2.5 (1.08)	2.3 (0.67)	0.738
Dry cough	1.7 (0.82)	1.1 (0.88)	0.097	2.3 (1.06)	1.9 (0.74)	0.205
Cough with phlegm	1.1 (0.57)	0.9 (0.88)	0.414	1.5 (0.71)	1.2 (0.79)	0.317
Pain with voice use	0.7 (0.95)	0.4 (0.84)	0.449	1.6 (0.97)	1.7 (0.95)	0.738
Pain when swallowing	0.6 (0.84)	0.3 (0.67)	0.449	1.4 (0.97)	1.4 (0.52)	1.000
Difficulty in swallowing	0.4 (0.70)	0.2 (0.42)	0.479	1.2 (1.14)	1.2 (1.23)	0.860
Sore throat	1.2 (1.23)	0.9 (1.10)	0.365	2.3 (0.48)	1.9 (0.57)	0.045
Dry throat	2.2 (1.32)	1.9 (0.99)	0.595	2.6 (0.97)	2.7 (1.25)	0.792
Tickling in the throat	1.2 (1.14)	0.8 (0.92)	0.256	2.1 (1.20)	1.8 (0.63)	0.429
Burning	0.6 (0.84)	0.4 (0.84)	0.414	1.8 (1.23)	1.2 (0.92)	0.197

Abbreviation: SD, Standard Deviation.
Notes: 0, never; 1, rarely; 2, sometimes; 3, often; 4, always.
Wilcoxon test ($P < 0.05$).

electrodes (5.0 × 5.0 cm) were placed on the trapezius region—upper fibers, bilaterally, and in the submandibular region, also bilaterally, bringing the number to four (Figures 1 and 2). The electrodes were fixed to the skin with allergenic tape after being anointed with electro-conductive gel. All subjects were instructed not to perform any vocal utterance during the procedure. A total of 12 sessions were performed, twice a week, each lasting 20 minutes.

Laryngeal manual therapy (LMT group). The LMT was applied with the volunteer sitting comfortably in a chair, without any vocal utterance. The therapist stood behind the volunteer and initiated a massage in the sternocleidomastoid, suprahyoid, and larynx muscles, bilaterally, with circular downward movements, kneading and stretching each muscle group based on the study of Mathiesson et al,[20] but with adaptations due to the massage time proposed to obtain the same treatment conditions of the TENS group volunteers. Thus, this study adapted the recommendations of Mathiesson et al,[20] proposing different times of massage for each region: a 5-minute massage of the sternocleidomastoid muscles; a five-minute massage of the suprahyoid region; a repeat of three additional minutes of massage of the sternocleidomastoid muscles and three more minutes of massage of the suprahyoid region, two-minute movements of landslides and drawdown in the larynx region and 2 minutes of movement of dislocations in the thyroid region. During the procedure, the volunteers were silent and were asked to breathe quietly to relax the shoulders and jaw and the teeth.

Data analysis

For the statistical analysis, the qualitative data regarding the frequency of vocal and laryngeal symptoms were transformed into numbers according to the Likert scale (never, 0; rarely, 1; sometimes, 2; often, 3, always, 4). The same was done for the frequency of symptoms of muscle pain.

For comparisons of variations in the results between the phases before and after treatment in each group, the Wilcoxon test was used. For all calculations, the critical level of 5% ($P < 0.05$) was fixed.

Regarding the auditory perceptual analysis, the most common result of three responses of the judges was elected (coincident responses) and applied to the signal test (significance level of 0.05) for comparison between the groups after treatment, with the vowel /a/ and spontaneous speech as a sample.

TABLE 2.
Numerical Summaries of Mean, Standard Deviation and *P* Value of the Frequency of Pain Reported by TENS and LMT Groups Before and After Treatment

	TENS			LMT		
	Before	After		Before	After	
Location of Pain	Mean (SD)	Mean (SD)	*P* Value	Mean (SD)	Mean (SD)	*P* Value
Temporal	1 (1.05)	0.7 (0.95)	0.276	2.2 (1.03)	1.4 (0.84)	0.086
Masseter	0.7 (1.06)	0.3 (0.95)	0.102	1.6 (1.26)	1 (0.94)	0.095
Submandibular	0.3 (0.67)	0.2 (0.42)	0.563	1.5 (1.18)	0.9 (0.88)	0.131
Larynx	1.7 (0.82)	0.7 (1.25)	0.074	1.9 (0.74)	1.7 (0.95)	0.414
Anterior neck	0.8 (1.03)	0.2 (0.42)	0.108	1.9 (1.10)	1.1 (0.74)	0.019
Posterior neck	1.9 (1.45)	1.2 (1.32)	0.038	2.8 (1.03)	2.3 (1.16)	0.205
Shoulders	1.6 (1.35)	1 (1.33)	0.033	1.6 (1.07)	1.3 (1.06)	0.317
Upper back	1.5 (1.18)	0.9 (1.10)	0.083	1.6 (0.84)	1.7 (1.06)	0.705
Elbows	0 (0.00)	0 (0.00)	1.000	0.6 (0.97)	0.3 (0.48)	0.414
Wrists/hands/fingers	0.4 (0.97)	0 (0.00)	0.179	1.6 (1.07)	0.8 (1.23)	0.051
Lower back	1 (1.15)	1 (1.25)	1.000	1.4 (0.97)	1.2 (1.40)	0.588
Hips/thighs	0.2 (0.42)	0.1 (0.32)	0.317	1 (1.25)	0.7 (1.25)	0.083
Knees	0.3 (0.48)	0.1 (0.32)	0.157	1.5 (0.97)	0.8 (0.92)	0.082
Ankle/feet	0.9 (1.52)	0.6 (1.26)	0.179	1.3 (0.95)	1.3 (1.34)	1.000

Abbreviation: SD, Standard Deviation.
Notes: 0, never; 1, rarely; 2, sometimes; 3, often; 4, always.
Wilcoxon Test ($P < 0.05$).

RESULTS

Table 1 shows the results of the variation of values in relation to the frequency of vocal and laryngeal symptoms between the phases before and after treatment of the TENS and LMT groups. It was observed that women in the TENS group had symptoms that significantly improved from "thin voice" and "effort to speak" at 12 sessions of treatment, whereas women in the LMT group significantly improved with regard to the "sore throat" symptom after the treatment.

Table 2 reveals the results of comparing the variance of the mean frequency of pain reported by women in the TENS and LMT groups, before and after treatment. It was observed that women who underwent treatment with TENS reported a significantly lower frequency of pain in the posterior neck and shoulder than women who were treated with LMT. On the other hand, women in the LMT group reported a significantly lower frequency of pain in the anterior neck after treatment, when compared with women of the TENS group.

Table 3 contains the results of comparing the mean intensity of pain reported by women in the LMT and TENS groups in the stages before and after treatment, using a visual analog scale. The women of the TENS group had significantly decreased pain intensity after treatment in the posterior region of the neck, shoulder, and upper back, whereas women of the LMT group had significantly decreased pain in the posterior neck.

Table 4 shows the results of the auditory perceptual assessment performed by three judges from the moments before and after treatment with TENS or LMT, blindly. In the analysis of the vowel /a/, we found that 60% of the women receiving TENS application significantly improved the "tension" parameter in voice, after application of this resource, which did not occur with the women of the LMT group. In the analysis of spontaneous speech, no significant differences were found in all of the parameters that we analyzed.

The Kappa test[35] was used to verify the concordance of the auditory perceptual analysis among the judges. For spontaneous speech, the correlation to the Global degree of vocal quality was 0.53, roughness was 0.56, breathiness was 0.5, strain was 0.6, resonance was 0.6, and articulation was 0.96. For the vowel, the correlation to the Global degree of vocal quality was 0.45, roughness was 0.42, breathiness was 0.58, strain was 0.6, instability was 0.47, and resonance was 0.47. Thus, it was observed that the agreement among the judges was moderate.

The reliability of judges ranged from 0.88 to one for spontaneous speech and 0.88 to 0.94 for the vowel, showing that the judges were highly reliable.

DISCUSSION

Vocal/laryngeal symptoms

In the hyperkinetic dysphonia which are composed of the two groups of the present study, prolonged hypercontraction of the laryngeal muscles is reportedly associated with the elevation of the hyoid bone and larynx, with pain and discomfort at the time the circumlaryngeal region is palpated.[1,2,10] Considering these factors, the improvement of the symptoms "high pitched voice" and "effort to speak" is attributed to the muscle relaxation that low frequency TENS causes the tissues.[31]

TABLE 3.
Mean, Standard Deviation and *P* Value of the Intensity of Pain Reported by TENS and LMT Groups Before and After Treatment

	TENS			TML		
	Before	After		Before	After	
Pain Location	Mean (SD)	Mean (SD)	*P* Value	Mean (SD)	Mean (SD)	*P* Value
Temporal	0.5 (1.5)	0 (0.00)	0.317	8 (22.9)	9.8 (16.3)	0.753
Masseter	5.9 (18.6)	2.4 (7.6)	0.317	10.6 (25.5)	4.4 (7.5)	0.357
Submandibular	1 (3.1)	0 (0.0)	0.317	7.9 (18.8)	6.4 (8.5)	0.916
Larynx	12 (27.7)	5.3 (16.9)	0.067	16.1 (26.2)	10.5 (15.0)	0.575
Anterior neck	1.2 (3.7)	0 (0.0)	0.317	14.5 (27.0)	4.8 (6.0)	0.400
Posterior neck	21 (22.9)	6.6 (15.1)	0.017	16.8 (23.4)	9.5 (12.8)	0.019
Shoulders	18.3 (21.3)	6.8 (15.7)	0.027	17.1 (30.7)	11.7 (21.0)	0.715
Upper back	20.6 (26.8)	1.8 (3.3)	0.043	23.5 (29.3)	17.3 (20.8)	0.612
Elbows	0 (0.00)	0 (0.0)	1.000	6.6 (20.8)	0.4 (1.2)	0.317
Wrists/hands/fingers	4.6 (13.8)	0 (0.0)	0.179	11 (25.9)	0.2 (0.6)	0.144
Lower back	13.1 (17.8)	5.1 (15.4)	0.224	19.5 (29.4)	6.3 (12.7)	0.224
Hips/thighs	1.1 (3.6)	0 (0.0)	0.317	12.8 (21.2)	5.1 (15.1)	0.273
Knees	2.1 (6.6)	0 (0.0)	0.317	9.3 (19.9)	0.8 (1.7)	0.285
Ankle/feet	3.2 (8.8)	4.6 (11.2)	0.654	11.2 (24.2)	0.9 (1.7)	0.224

Abbreviation: SD, Standard Deviation.
Notes: All the values are in millimeters units.
Wilcoxon Test ($P < 0.05$).

In this study, the use of TENS is not based only on the analgesic action that low frequency TENS can promote; this type of current with motor threshold intensity stimulates both nociceptive fibers type A-delta and C, and motor efferent fibers, promoting visible muscle contractions that help in muscle relaxation.[31] This decreases symptoms in the vocal tract, especially the feeling of making an effort to speak.

Thus, it is believed that the application of low frequency TENS under conditions proposed in the present study was effective in improving the laryngeal and voice symptoms in the vocal tract at 12 sessions of treatment. Future studies are needed to investigate the application of this therapeutic resource associated with vocal hygiene or even for traditional therapy guidelines with vocal training included.

After LMT, improvement in the frequency of the symptom "sore throat" was observed. The LMT recommends the massage on the cervical and perilaryngeal muscles. The aim is to reduce the stiffness and contraction of the muscles, decreasing or eliminating the discomfort during the function of phonation and reducing the vocal and laryngeal symptoms after the application.[20]

Mathieson et al[20] reported that patients improved the frequency of symptoms such as dryness, itching, pain, tightness, and sore throat as a result of LMT, although they underwent a session of application that was not observed in the present study.

Musculoskeletal pain

The results on musculoskeletal pain after application of TENS may be related to the region of stimulation on which the treatment acts. Electrodes placed in the submandibular region and in the trapezius—upper fibers induced the setting of the low frequency TENS, which were followed by high intensity muscle contractions, such as vibrations in the neck region to promote muscle relaxation over 6 weeks of treatment. It is worth remembering that the placement of electrodes in the submandibular region is not part of a protocol traditionally used in speech therapy. The physical therapy also used in this study was an attempt to relax the larynx and neck region, because the same method of TENS treatment recommended in the study by Guirro et al[31] was repeated in this study. The analgesic effect of TENS can be proven in the present study for the improvement of the symptoms of muscle pain reported by women in this group, contributing to muscle relaxation in the neck region. However, we cannot confirm this behavior with objective measurements.

The LMT promotes the massage, pressing, and stretching of the perilaryngeal muscles and is intended primarily for the sternocleidomastoid muscles in the early intervention. This study followed these criteria, but there was difference despite the time application. Mathieson et al[20] reported the logic to begin with these areas. This order is based on the clinical observation that many patients with muscle tension dysphonia by the sternocleidomastoid muscles are overly tense. Although these muscles are not directly related to the function of the larynx, patients often complain of stiffness and sensitivity in these muscles. Clinical experience suggests that massaging these muscles reduces the stress, thus reducing the patient's discomfort.

Other types of massage of the larynx are recommended in the literature to relax overly tense larynx and perilaryngeal

TABLE 4.
Numbers and Percentage of Voice Quality Classification According to Perceptual Analyze of Vowel /a/ and Speech After Treatment of TENS and LMT Groups

	Vowel /a/						Speech					
	TENS			LMT			TENS			LMT		
Parameters of Voice Quality	N	%	*P*	N	%	*P*	N	%	*P*	N	%	*P*
Global			1.000			1.000			0.727			0.625
Before better	4	40		4	40		5	50		1	10	
After better	3	30		4	40		3	30		3	30	
No difference	3	30		2	20		2	20		6	60	
Roughness			0.625			0.375			0.688			0.219
Before better	3	30		1	10		4	40		1	10	
After better	1	10		4	40		2	20		5	50	
No difference	6	60		5	50		4	40		4	40	
Breathiness			1.000			0.375			1.000			0.500
Before better	3	30		1	10		1	10		0	0	
After better	2	20		4	40		1	10		2	20	
No difference	5	50		5	50		8	80		8	80	
Strain			0.031			0.289			1.000			1.000
Before better	0	0		2	20		2	20		1	10	
After better	6	60		6	60		1	10		0	0	
No difference	4	40		2	20		7	70		9	90	
Instability			1.000			0.289	NE		NE	NE		NE
Before better	1	10		2	20							
After better	2	20		6	60							
No difference	7	70		2	20							
Resonance	NE		NE	NE		NE						1.000
Before better							1	10		1	10	
After better							1	10		2	20	
No difference							8	80		7	70	
Articulation	NE		NE	NE		NE						1.000
Before better							0	0		0	0	
After better							0	0		0	0	
No difference							10	100		10	100	

Abbreviations: N, numbers; %, percentage; NE, Not Evaluable.
Notes: Sign Test ($P \leq 0.05$).

muscles, which inhibit normal phonation. This fact is evident in the literature; using vocalizations often is associated with massage in the larynx.[1,15,36] Meanwhile, the decrease in pain intensity in the region manipulated by the application of LMT reveals that pain is an important signal of muscle stiffness that eventually becomes part of the framework for muscle tension dysphonia and should be considered when treating patients with this type of dysphonia.

Vocal quality

The auditory perceptual analysis is still a matter for discussion in the clinical and speech research for the subjectivity that it presents, although it is considered an important method for assessment. The data shown are results of consistent responses from at least two of the three judges, and in a few situations, when there was disagreement between the three judges, the evaluation was judged as "no difference". Considering the variables that can affect the results of the study, as the type of auditory perceptual analysis chosen, the sample size can also be a factor that contributed to these results.

In the situation of spontaneous speech, no significant difference was found in both therapeutic resources. Although both the TENS and the LMT may have benefits on the cervical and laryngeal muscles, with improvement of some vocal and laryngeal symptoms, such therapeutic resources did not significantly improve voice quality, with the exception of vocal strain that was judged with improvement after TENS in the vowel /a/.

The low frequency and high intensity associated with surface electrodes placed on the submandibular region and trapezius–upper fiber muscles induce a strong vibration in the submandibular region, larynx, and cervical muscles, which causes muscle relaxation. The improvement of strain in the vocal quality can be justified for the relaxation of the larynx, because the larynx receives a strong vibration with this type of current. Guirro et al[31] also found no significant differences after application of TENS on the auditory perceptual analysis of the vowel /e/, but found a significant decrease in the degree of dysphonia, hoarseness, breathiness, and strain in the spontaneous speech. Importantly, in the study of Guirro et al[31] that applied TENS in the same conditions as the women of the TENS group in this study, the authors chose the GRBAS scale[37] that has only four measures of deviation of each parameter's scale, zero (no deviation) to three (intense deviation).

Finally, the present study had limitations that may have influenced the results such as the limitation of the number of volunteers that prevented the formation of a control group; the application time of LMT had to be set to 20 minutes, so that the sample was matched with the time of TENS application, which may also have contributed to some less favorable outcomes related to the LMT. Thus, future randomized controlled trials should be designed to improve the scientific evidence regarding the treatment of dysphonic women with vocal nodules and with muscle tension dysphonia.

CONCLUSIONS

In this study, the methodology criteria that was submitted showed that the application of low frequency TENS for 12 sessions was able to reduce some vocal and laryngeal symptoms in relation to their frequency—"high pitched voice" and "effort to speak"; the application of low frequency TENS was able to reduce the frequency and intensity of musculoskeletal pain in the posterior neck and shoulders and to improve the vocal quality in the parameter "strain" in dysphonic women. On the other hand, the LMT for 12 sessions was able to reduce the frequency of the "sore throat" symptom, was able to reduce the frequency of musculoskeletal pain in the anterior neck and to reduce the intensity of musculoskeletal pain in the posterior neck, but did not improve the vocal quality. There was no significant change in acoustic parameters after both treatments were applied.

When compared with LMT, TENS appeared to be a complementary treatment method, considering the parameters evaluated and controlled, suggesting that both TENS and LMT are good therapeutic resources, but need the addition of speech therapy and vocal training and guidelines regarding vocal health, for example, to further enhance the voice quality and laryngeal aspects.

Acknowledgments

The authors acknowledge FAPESP—The São Paulo Research Foundation—(process: 2010/19470–9) for the financial support provided to this research.

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