# Transcutaneous Electrical Nerve Stimulation (TENS) and Laryngeal Manual Therapy (LMT): Immediate Effects in Women With Dysphonia

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**Summary: Purpose.** This study aimed to verify the immediate effect of low-frequency transcutaneous electrical nerve stimulation (TENS) and laryngeal manual therapy (LMT) in musculoskeletal pain, voice quality, and self-reported signs in women with dysphonia.

**Method.** Thirty women with behavioral dysphonia were randomly divided into the TENS group and the LMT group. All participants fulfilled the pain survey and had their voices recorded to posterior perceptual and acoustic analysis before and after intervention. The TENS group received a unique low-frequency TENS session (20 minutes). The LMT group received LMT (20 minutes) with soft and superficial massage in the sternocleidomastoid muscle, suprahyoid muscles, and larynx. Afterward, the volunteers reported their voice, larynx, breathing, and articulatory signs. Pre and post data were compared by parametric and nonparametric tests.

**Results.** After TENS, a decrease in pain intensity in the posterior or anterior region of the neck, shoulders, upper or lower back, and masseter was observed. After LMT, a decrease in pain intensity in the neck anterior region, shoulders, lower back, and temporal region was observed. Also, after TENS, there was an improvement in vowel /a/ instability; after LMT, there was a general improvement in voice quality, decrease in tension, and decrease in breathiness in speech. Positive voice and laryngeal signs were reported after TENS, and positive laryngeal signs and articulation were reported after LMT.

**Conclusion.** TENS and LMT may be used in voice treatment of women with behavioral dysphonia, and both may be considered important therapy resources that reduce musculoskeletal pain and cause positive laryngeal signs. Both TENS and LMT are able to partially improve voice quality, but TENS presented better results.

**Key Words:** Voice–Larynx–Transcutaneous electrical nerve stimulation–Massage–Musculoskeletal pain.

## INTRODUCTION

Behavioral dysphonia, which may be functional or organic-functional, may be related to muscle tension, and present cervical disturbances as musculoskeletal pain during rest or phonation.[1,2] Women with vocal fold nodules have significantly higher indexes of craniocervical dysfunction than women without voice complaints, which means that women with dysphonia have greater amplitude of cervical deviation, pain during movement or to palpation, and reduced cervical joint function. Furthermore, women with dysphonia also have more frequent and more intense muscle pain close to the larynx and cervical region than women without dysphonia.[3] Therefore, the treatment for dysphonia associated with muscle tension must prioritize relaxation of the larynx and perilaryngeal muscles.

Transcutaneous electrical nerve stimulation (TENS) has been used as a relaxation technique for the perilaryngeal muscles in women with dysphonia.[4,5] Researchers have pointed out that electrical stimulation can be used to treat several voice disturbances, such as vocal fold paralysis,[6,7] vocal fold bowing,[8] spasmodic dysphonia,[9] and swallowing disorders.[10–14] In all these studies, neuromuscular electrical stimulation (NMES) was used; its purpose is to promote muscle strengthening. NMES is different from TENS, which is characterized by an analgesic current that improves vascularization in the applied region, leading to muscle relaxation.[4,5,15]

NMES is generally used to promote muscle strengthening, motor recovery, or mass gain. In voice studies,[6–14] a current with a 400-µs pulse width and a frequency around 80 Hz has been used for stimulating motor nerves. This type of current presents a quadratic configuration and does not promote analgesia. TENS is characterized by a biphasic (asymmetrical or symmetrical) quadratic wave, which is used to promote analgesia in the region of application.[4] However, when this current is used at a low frequency, analgesia occurs at the motor level, with a high-intensity threshold; because muscle contraction and endorphin release occur, this also provides stimulated muscle relaxation. The voice researchers who used this current configured it with a 200-µs pulse width and a frequency of 10 Hz.[4,5,16]

Researchers[4,5] have reported the use of low-frequency TENS to treat women with vocal fold nodules. Low-frequency TENS is associated with the current intensity in the motor threshold, with the electrodes placed in the submandibular area. The trapezius muscles (descending fiber) have been shown to be a good therapeutic resource for this type of laryngeal disturbance.

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Researchers have shown that women with dysphonia experience positive results in the long term, including decreases in the frequency and intensity of musculoskeletal pain in the laryngeal region and improved vocal quality.[4,5]

Laryngeal manual therapy (LMT) is another technique for laryngeal and perilaryngeal muscle relaxation in dysphonia associated with muscle tension. LMT, as recommended by Mathieson et al,[17] consists of a soft and superficial massage of the sternocleidomastoid and suprahyoid muscles, as well as the thyroid-hyoid membrane[17]; the patient is silent during the therapy. The issue of whether LMT balances the deviated phonation function is addressed in the current study. This technique is different from the one used by Aronson[18] and Roy et al,[19] who proposed manipulating the supralaryngeal region using descending movements that extend from the submandibular region to the sternum, in addition to lateral displacements of the larynx and rotational movements of the thyroid membrane concomitant with the emission of short vowels by the patient. Mathieson et al[17] performed a single session of LMT, each lasting 10 minutes, for each patient, and observed decreases in the frequency and intensity of vocal tract discomfort and improvements in vocal quality. Another group of researchers[20] showed that, after 20 minutes of LMT, patients reported decreased pain and positive signs in the laryngeal region. Silverio et al[5] performed 12 sessions of LMT in women with vocal fold nodules and observed significantly reduced pain in the anterior and posterior neck regions.

TENS and LMT are commonly used to treat functional dysphonia because they are intended to relax tense muscles and rebalance the phonatory function. However, few researchers have reported immediate effects[16,17,20] or effects after several sessions[4,5]; in addition, no study has compared the immediate effect of these resources (TENS and LMT), which requires an investigation of the techniques used in vocal treatment. Therefore, the purpose of this study is to verify the immediate effect that TENS and LMT have on muscle pain, vocal quality, and self-reported signs of dysphonia.

## METHODS

### Participants

The participants in this study comprised 30 women aged 18–45 years (28.70 ± 6.75 years); all of them had been experiencing a voice complaint for at least 12 months. In the screening process, all participants exhibited deviated voices and functional dysphonia (with or without lesions in the vocal folds), caused by misuse or intense use of the voice; an otolaryngologist diagnosed the dysphonia (Table 1). Volunteers were excluded if they were more than 45 years old or in menopause and if they had neurologic dysphonia or any other neurologic condition, previous laryngeal surgery, hormone or thyroid deviation, or a vascular or cardiologic disorder.

The volunteers who fulfilled the inclusion criteria were randomized and placed in either the TENS group or the LMT group, each with 15 women. All volunteers answered the musculoskeletal pain survey both before and immediately after the therapy, and all their voices were recorded for posterior perceptual and acoustic analysis. Each also answered a questionnaire about self-reported signs after undergoing the therapy. These evaluations were performed immediately after a 20-minute intervention with TENS or LMT. The institution's Research Ethics Committee approved the research (099/2011), and all volunteers signed the informed consent form.

**TABLE 1.**
**Distribution of the Women into the TENS and the LMT Groups According to the ENT Diagnosis; n = 15**

| ENT Diagnosis | TENS Group | TML Group |
|---|---|---|
| Bilateral nodules and dual chink | 6 (40%) | 7 (46.66%) |
| Pseudocyst or cyst, contralateral nodule reaction, and hourglass chink | 7 (46.66%) | 5 (33.33%) |
| Medium-posterior chink | 1 (6.67%) | 1 (6.67%) |
| Mucosal thickening | 1 (6.67%) | 2 (13.34%) |

### Outcomes measures

#### *Musculoskeletal Pain Investigation*

The Musculoskeletal Pain Investigation[3] questionnaire was used to investigate the participants' musculoskeletal pain intensity. The questionnaire features a sketch of body parts that match the items under investigation. The investigated body parts were the temporal region, masseter, submandibular region, larynx, anterior neck and posterior neck, shoulders, upper back and lower back, elbows, and hands (including wrists and fingers). A 100-mm visual analog scale was used to measure the musculoskeletal pain intensity; the volunteer was instructed to use a vertical line to mark the point corresponding to the pain. The left limit meant no pain, and the right limit was equivalent to the worst possible pain. Separate scales were used to asses each body part in which pain was reported.[3] This procedure was repeated immediately after TENS or LMT.

Each volunteer's voice was recorded at the institution's Speech-Language Pathology Voice Clinic Studio, both before and after the TENS or LMT was performed. The recordings were then acoustically treated. *Sound Forge* (Sony, New York, NY) professional audio software was used, with a 44.1-kHz sample rate and a 16-bit mono channel. The voices were recorded with an AKG microphone (C 444 PP model; AKG Acoustics GmbH, Vienna, Austria) that was plugged into a computer. The participants were requested to produce the vowel /a/ for a long time after inspiration and to speak freely at their usual pitch and loudness while answering two questions: "What do you think of your voice?" and "Tell me about your work."

#### *Perceptual analysis*

Each participant's voice samples were grouped in pairs by participant (before and after) and then organized randomly. Three expert judges, speech-language pathologists or voice specialists, who were blinded to the procedure, performed the perceptual analysis. Each judge was instructed to choose the better voice of the sample pair shown; if the samples were similar, the judge was to choose "no difference." The options corresponded to the phases of the intervention: before and after treatment. The experts noted their global impressions of each voice's quality, roughness, breathiness, strain, and instability based on the vowel /a/; they also analyzed the resonance and articulation of the participants' overall speech. The answer in each pair that the judges chose more often was used in the statistical analysis. When the judges did not agree on the assessment, the "no difference" option was used in the analysis.

### *Acoustic voice analysis*

Acoustic voice analysis was performed for the vowel /a/ using the *Multidimensional Voice Program* (model 5105, Kay Elemetrics, Lincoln Park, NJ). The beginning and the end of the vowel were discharged using the most stable portion of the emission; this lasted for 3 seconds. The following parameters were analyzed: fundamental frequency, jitter (%), shimmer (%), and noise-to-harmonic ratio.

### *TENS application*

TENS was applied for 20 minutes in a single session according to the procedure used in Guirro et al[4] and Silverio et al[5]; the participants were in a restful supine position and were instructed not to produce any sounds during the procedure.

For the stimulation, Dualpex 961 (Quark, Piracicaba, São Paulo, Brazil) was used with the following parameters: symmetrical biphasic rectangular pulse, 200 µs phase, 10 Hz frequency, and motor threshold intensity. The silicon electrodes ($5 \times 4$ cm) were placed on the motor point of the trapezius muscle (on the descending fiber) and on both sides of the submandibular region—four points in total. Conductive gel was applied to the electrodes, which were then fixed using antiallergenic tape.

### *LMT application*

LMT was also applied for 20 minutes in a single session; the participants were seated comfortably in chairs. The therapist stood behind each participant and started to massage the sternocleidomastoid, suprahyoid, and laryngeal muscles on both sides, using circular and descending movements to knead and stretch each muscle group. This technique was based on Mathieson et al's[17] study, but the time was extended from 10 to 20 minutes to ensure proper posterior comparison with TENS. The participants were requested to remain silent, breathe quietly, relax their shoulders and jaws, and unclench their teeth for the entire procedure.

Therefore, adapting Mathieson et al's[17] recommendations, the following times were proposed for each region of the massage: 5 minutes for the suprahyoid, 5 minutes for the sternocleidomastoid, 3 more minutes for the suprahyoid, 3 more minutes for the sternocleidomastoid, 2 minutes of lowering movement of the larynx, and 2 minutes of displacement movements for the thyroid. The volunteers were instructed to be silent for the entire LMT procedure.[5,20]

### *Self-reported signs after intervention*

After the application of TENS or LMT, the participants completed a questionnaire regarding their voice, larynx, breathing, and articulation signs to report their sensations after TENS and LMT (either positive or negative) and provide information about any perceived changes due to the procedures.

### *Analysis*

The Shapiro-Wilk test was used to verify the data normality, and the Wilcoxon test was used to analyze the musculoskeletal pain intensity before and after the interventions. In the perceptual analysis, the most frequent answer was chosen to be analyzed, and the sign test was used to compare pre and post moments. The kappa concordance test was used to analyze the reliability of judges. Paired *t* test was used to compare the acoustic measures pre and post TENS and LMT. The sign test was also used to analyze the signs reported post TENS and LMT. All the statistical tests used 5% of significance level. The data were analyzed using Statistica software version 7.0 (Chicago, IL).

## RESULTS

Table 2 presents a comparison of the pain intensity results before and after the intervention for both the TENS and the LMT groups. A significant decrease in pain was observed after TENS in the posterior and anterior neck, shoulders, upper and lower back, and masseter. After LMT, a significant decrease in pain was observed in the posterior neck, shoulders, lower back, and temporal region.

The concordance between the judges in the perceptual analysis indexes for the sustained vowel /a/ and overall speech ranged from 38% to 88% for both groups, according to the kappa test. The intrajudge concordance was 30% for the sustained vowel /a/ and 70% for speech in both groups.

The comparison of the vocal quality results regarding the sustained vowel /a/ (Table 3) indicated a significant improvement in the instability parameter after TENS, with no cases of worsening; after LMT,there was an improvement in the overall impression of vocal quality and strain, but in some cases (40% and 33% of cases, respectively), with worsening. Regarding vocal quality in speech (Table 4), no parameter significantly improved after TENS; after LMT, breathiness worsened in 20% of the group. No changes in articulation were observed after either procedure.

Table 5 presents the acoustic results before and after TENS and LMT. There were no differences in the acoustic parameters after either procedure.

Table 6 shows the signs that the participants reported after TENS and LMT. The self-reported signs after TENS included significant positive results for the voice and larynx. The signs after LMT were positive for the larynx and articulation.

## DISCUSSION

Functional dysphonia may be related to imbalance and pain in the laryngeal, perilaryngeal, and cervical muscles.[1] In addition to providing vocal training with voice exercises, the purpose of the treatment for this type of dysphonia is to relax the perilaryngeal and cervical muscles, thus reducing muscle strain. The treatment uses techniques such as LMT[17] and TENS on the cervical muscles and larynx.[4,5] However, in a voice clinic, these resources are combined with vocal training, which makes it

**TABLE 2.**
**Comparison of the Moments Before and After Application of TENS and LMT, in Relation to the Intensity of Pain, in Millimeters; n = 15**

| | TENS | | | LMT | | |
|---|---|---|---|---|---|---|
| Pain | Before Mean (SD) | After Mean (SD) | *P* Value | Before Mean (SD) | After Mean (SD) | *P* Value |
| Back of the neck | 15.27 (21.96) | 7.20 (19.33) | 0.043* | 17.27 (25.52) | 5.40 (13.52) | 0.012* |
| Shoulders | 11.93 (21.32) | 3.20 (6.65) | 0.042* | 11.73 (17.79) | 5.47 (12.14) | 0.028* |
| Upper back | 12.53 (22.92) | 2.67 (6.29) | 0.012* | 16.60 (23.76) | 9.13 (13.44) | 0.050 |
| Elbow | 3.67 (12.64) | 0.20 (0.77) | 0.180 | 4.33 (13.58) | 1.87 (5.51) | 0.109 |
| Fists, hands, or fingers | 2.07 (4.37) | 0.47 (1.36) | 0.144 | 9.13 (16.70) | 2.80 (5.17) | 0.051 |
| Lower back | 11.73 (19.95) | 3.13 (7.32) | 0.018* | 13.87 (19.68) | 5.27 (9.39) | 0.012* |
| Temporal region | 5.13 (13.71) | 2.80 (6.84) | 0.285 | 13.47 (25.64) | 5.73 (13.44) | 0.028* |
| Masseter | 6.67 (13.99) | 3.13 (6.76) | 0.027* | 11.87 (23.82) | 5.07 (13.27) | 0.063 |
| Submandibular area | 2.13 (5.74) | 3.00 (7.59) | 0.465 | 8.00 (16.05) | 4.53 (9.57) | 0.351 |
| Larynx | 12.00 (22.36) | 5.60 (12.57) | 0.138 | 24.67 (31.28) | 8.93 (17.16) | 0.051 |
| Front of the neck | 7.67 (14.48) | 2.93 (6.83) | 0.034* | 14.67 (25.28) | 6.13 (13.21) | 0.263 |

SD, standard deviation.
Wilcoxon test (*$P < 0.05$).

impossible to investigate their immediate effects. Researchers have conducted clinical studies with both techniques,[4,5,17] but these studies included more sessions than are in this study and did not include an immediate-effect analysis. Therefore, an aim of this study was to verify the immediate effects that a single session of TENS or LMT had (in terms of musculoskeletal pain, vocal quality, and self-reported signs) on women with functional and organic-functional dysphonia.

Women were chosen for the study because they are more frequently found in voice clinics than men; behavioral dysphonia occurs more often in women than in men because the female glottis is proportionally smaller.[3]

## Pain intensity

Musculoskeletal pain is an unpleasant symptom that may be present in subjects with dysphonia due to improper voice be-

**TABLE 3.**
**Auditory-Perceptual Judgment Regarding the Best Vowel Emission, Compared With Peers, Before and After Application of TENS and Laryngeal Manual Therapy (LMT); n = 15**

| | TENS | | | TML | | |
|---|---|---|---|---|---|---|
| Parameters Vowel /a/ | N | % | *P* Value | N | % | *P* Value |
| Global impression of voice quality | | | 0.146 | | | 0.002* |
| Worsened | 3 | 20.0 | | 6 | 40.0 | |
| Improved | 9 | 60.0 | | 9 | 60.0 | |
| No difference | 3 | 20.0 | | 0 | 0 | |
| Roughness | | | 0.180 | | | 0.140 |
| Worsened | 2 | 13.3 | | 1 | 6.8 | |
| Improved | 7 | 46.7 | | 4 | 26.6 | |
| No difference | 6 | 40.0 | | 10 | 66.6 | |
| Breathiness | | | 0.580 | | | 0.143 |
| Worsened | 3 | 2.0 | | 4 | 26.6 | |
| Improved | 6 | 40.0 | | 3 | 20.0 | |
| No difference | 6 | 40.0 | | 8 | 53.4 | |
| Strain | | | 0.344 | | | 0.001* |
| Worsened | 3 | 20.0 | | 5 | 33.4 | |
| Improved | 7 | 46.7 | | 6 | 40.0 | |
| No difference | 5 | 33.3 | | 4 | 26.6 | |
| Instability | | | 0.031* | | | 0.796 |
| Worsened | 0 | 0.00 | | 3 | 20.0 | |
| Improved | 6 | 40.0 | | 5 | 33.4 | |
| No difference | 9 | 60.0 | | 7 | 46.6 | |

Signal test (*$P < 0.05$).

**TABLE 4.**
**Auditory-Perceptual Judgment Regarding the Best Spontaneous Speech, Compared With Peers, Before and After Application of TENS and Laryngeal Manual Therapy (LMT); n = 15**

| | TENS | | | TML | | |
|---|---|---|---|---|---|---|
| Parameters Spontaneous Speech | N | % | *P* Value | N | % | *P* Value |
| Global impression of voice quality | | | 0.581 | | | 0.520 |
| Worsened | 5 | 33.4 | | 6 | 40.0 | |
| Improved | 8 | 53.3 | | 1 | 6.6 | |
| No difference | 2 | 13.3 | | 8 | 53.4 | |
| Roughness | | | 0.344 | | | 0.190 |
| Worsened | 3 | 20.0 | | 7 | 46.7 | |
| Improved | 7 | 46.6 | | 1 | 6.6 | |
| No difference | 5 | 33.4 | | 7 | 46.7 | |
| Breathiness | | | 0.453 | | | 0.019* |
| Worsened | 2 | 13.3 | | 3 | 20.0 | |
| Improved | 5 | 33.4 | | 1 | 6.6 | |
| No difference | 8 | 53.3 | | 11 | 73.4 | |
| Strain | | | 0.549 | | | 0.220 |
| Worsened | 4 | 26.7 | | 1 | 6.6 | |
| Improved | 7 | 46.6 | | 0 | 0 | |
| No difference | 4 | 26.7 | | 14 | 93.4 | |
| Resonance | | | 0.219 | | | 0.222 |
| Worsened | 1 | 6.6 | | 2 | 13.3 | |
| Improved | 5 | 33.4 | | 0 | 0 | |
| No difference | 9 | 60.0 | | 13 | 86.7 | |
| Articulation | | | NA | | | NA |
| Worsened | 0 | 0 | | 0 | 0 | |
| Improved | 0 | 0 | | 0 | 0 | |
| No difference | 15 | 100 | | 15 | 100 | |

Signal test (**P* < 0.05).

haviors, which are often associated with muscle stiffness from excessive effort of the cervical and laryngeal muscles.[2,3,21,22] Silverio et al[3] verified that, despite women with dysphonia having lower pain levels on the visual analog scale than those without dysphonia, around 18 mm, they have muscle pain more often and more intensely than do vocally healthy women, especially in areas close to the larynx. Silverio et al[3] also recommend that those who experience functional or organic-functional dysphonia be more careful on the musculoskeletal pain assessment. The presence of pain should be considered in voice therapy, and analgesia and muscle relaxation should be promoted in areas near the larynx.

In this research, as in the Silverio et al[3] study, women with dysphonia had low muscle pain levels before TENS was applied, but their pain was more intense when closer to the cervical region and larynx (around 15 mm). However, after TENS was applied, they experienced a significant decrease in pain in the shoulders, posterior and anterior neck, upper back, and masseter (Table 1). Another study by Silverio et al[5] also showed a decrease in musculoskeletal pain in the posterior neck, shoulders, and upper back after 12 TENS sessions. Another study[4] revealed a significant decrease in trapezius muscle pain on both sides after 10 sessions of TENS in women with dysphonia. The musculoskeletal pain decrease presented in these studies may

**TABLE 5.**
**Acoustic Parameters Before and After Application of TENS and Laryngeal Manual Therapy (LMT); *n* = 15**

| | TENS | | | LMT | | |
|---|---|---|---|---|---|---|
| Acoustic Parameters | Before Mean (SD) | After Mean (SD) | *P* Value | Before Mean (SD) | After Mean (SD) | *P* Value |
| F0 | 196.78 (26.50) | 192.96 (27.62) | 0.153 | 205.95 (15.34) | 208.49 (22.08) | 0.335 |
| Shimmer | 1.68 (0.84) | 1.52 (0.93) | 0.325 | 2.56 (1.14) | 2.77 (1.36) | 0.290 |
| Jitter | 3.73 (1.58) | 3.54 (0.88) | 0.569 | 1.66 (1.33) | 1.93 (1.59) | 0.349 |
| NHR | 0.13 (0.03) | 0.13 (0.02) | 0.734 | 0.12 (0.02) | 0.12 (0.02) | 0.645 |

F0, fundamental frequency; SD, standard deviation.
Paired *t* test (*P* < 0.05).

**TABLE 6.**
**Immediate Sensations Reported by Individuals After TENS and Laryngeal Manual Therapy (LMT); *n* = 15**

| | TENS | | | | LMT | | | |
|---|---|---|---|---|---|---|---|---|
| Sensations | Positive | Negative | No Difference | *P* Value | Positive | Negative | No Difference | *P* Value |
| Voice | 11 (73.33%) | 1 (6.66%) | 3 (20%) | 0.006 | 11 (73.33%) | 3 (20%) | 1 (6.66%) | 0.057 |
| Larynx | 12 (80%) | 2 (13.33%) | 1 (6.66%) | 0.013 | 11 (73.33%) | 2 (13.33%) | 2 (13.33%) | 0.022 |
| Articulation | 5 (33.33%) | 0 (0%) | 10 (66.66%) | 0.063 | 7 (46.66%) | 0 (0%) | 8 (53.33%) | 0.016 |
| Breathing | 4 (26.66%) | 0 (0%) | 11 (73.33%) | 0.125 | 3 (20%) | 3 (20%) | 9 (60%) | 1.000 |

Signal test ($P < 0.05$).

be justified by the electrical stimulation method. Low-frequency TENS, when associated with high intensity in the motor threshold, promotes strong but comfortable muscle contractions in the stimulus area, which results in muscle relaxation and decreased pain.[5]

The reduced pain intensity in places that are not directly involved in the electrical stimulation (eg, the shoulders and lower back) may be related to the placement of electrodes on the trapezius muscle's descending fiber, which is a myofascial trigger point; this may minimize pain in related areas. Patients with myofascial disorders may have increased muscle activity when at rest, which results in higher intramuscular pressure and mechanical compression of the vessels that irrigate the muscle.[23,24] In this scenario, TENS may reduce pain because it increases blood flow in the muscles.

Another explanation for how low-frequency TENS in the motor threshold can cause muscle pain reduction is that opioid peptides are released in the cerebrospinal fluid and human plasma in a frequency-dependent way.[25–27] The spinal cord's afferent impulses may cause activity in this intrinsic system and, therefore, inhibit the evoked function of the A delta and C fibers, which selectively control pain.[28] Thus, the analgesic effect caused by this current lasts longer[29] and may affect body parts that are far from the electrodes (ie, extrasegmental stimulation). The systemic blocking of opioid receptors using naloxone prevents the analgesia that is promoted by low-frequency TENS.[30]

A decrease in pain intensity in the temporal region, neck, and shoulders was observed after LMT (Table 1). One reason for this pain decrease is related to the way the laryngeal massage works. LMT is intended to promote relaxation in the perilaryngeal muscles, including the sternocleidomastoid muscle, the suprahyoid muscle, and the thyroid-hyoid membrane.[17] The main purpose of LMT is to relax excessively tight muscles, which inhibit balanced phonation. This massage also promotes better blood flow and reduces muscle resistance in the head and neck region, which may be tight in subjects with dysphonia.[1–3,18,31] In the current study, the LMT time was longer than the time Mathieson et al[17] recommended because the purpose of the research was to compare the effects of TENS and LMT. However, LMT for 20 minutes was shown to be effective in easing the muscle pain in several body parts for subjects with dysphonia. Reimann et al[20] obtained the same result; women with dysphonia had LMT for 20 minutes and experienced reduced pain intensity in several body parts.

The decrease in muscle pain in the lower back may be related to the participant's seated position when receiving LMT; they were at rest and relaxed, and the therapist corrected their body posture. Such a situation may not be linked to dysphonia, but some researchers in physiotherapy have reported imbalances in muscle chains.[32,33] These authors declare that the body movements and posture adaptations are the result of actions in the muscle chains—muscles working together in the same direction and manner. Otherwise, in the presence of a posture disturbance, the body reorganizes itself in compensation chains, looking for an adaptive reaction. In addition, the shortened muscle creates compensations in other muscles, which can be far or close.[34] Thus, if the muscle chain is considered, a massage of the sternocleidomastoid, upper larynx, and larynx may help improve pain in the lower back region; nevertheless, the massage's purpose was not to affect this region.

Silverio et al[5] found a significant decrease in pain intensity after 12 sessions of LMT, focusing only on the posterior neck region. Other types of massage are recommended in the literature to relax excessively tight muscles in the laryngeal and perilaryngeal regions; such tightness may inhibit normal phonation.[18] Studies have also been conducted using other types of manual massage in the laryngeal region, sometimes including vocal exercises.[19,35] These studies showed that, after anywhere from 1 session[19] to 25 sessions[35] of massage, the complaints of patients with dysphonia, including muscle hypertonicity, painful palpation, and tight larynx, diminished or disappeared.

The results regarding the pain reduction after TENS and LMT show that pain is an important sign of muscle tension dysphonia. Therefore, both techniques may be effective in treating behavioral dysphonia that is associated with muscle pain.

## Voice perceptual analysis

Regarding voice perceptual analysis, TENS promoted significant improvement in instability of the vowel /a/ in women with dysphonia. After TENS, there was no significant change in the other vocal parameters for this vowel or for all speech. The improvement in the instability parameter may be due to the enhancement of the vocal fold's mucosal wave. TENS generates strong vibrations in the larynx because the physical parameters chosen—a low frequency, a high-intensity motor threshold, and a 200-μs phase—may promote balance in the intrinsic and extrinsic laryngeal muscles and may contribute to proper closure of the vocal folds and balance in the aerodynamic and myoelastic forces. Therefore, the vocal folds' mucosa wave would enlarge, causing phonation to become more stable. Future analyses of laryngeal images are needed to investigate what is happening in the larynx after this therapy. Researchers have already pointed out that women with vocal nodules experienced improved vocal closure during phonation after a single TENS session.[16] However, this study uses a different electrode placement, electrical field, and form of electrical stimulation.

The current study does not corroborate Guirro et al's[4] study because the participants' speech in the current study showed a significant decrease in general dysphonia, roughness, and breathiness after TENS. However, Guirro et al's[4] study used 10 sessions of 30 minutes each, and the current study used a single session of 20 minutes. In another study,[5] an analysis of the vowel /a/ showed that 60% of female participants reported significantly improved strain parameter after TENS; the other parameters did not significantly change. No other studies using just one TENS session were found in the literature, so a comparison of the current study's results to those of other studies was not possible.

The LMT group's overall vocal quality and strain parameters showed statistically significant improvement in the vowel /a/ analysis (Table 3). However, 40% of the LMT group had a decrease in overall vocal quality, and 33.3% of that group had more strain. Speech perceptual analysis also showed significant worsening in the breathiness parameter for 20% of the group after LMT (Table 4). Reimann et al[20] observed no significant changes in vocal quality for a sustained vowel after 20 minutes of LMT in a single session; they also observed a worsening in roughness during speech. Reimann et al[20] explained that this worsening was due to the laryngeal muscles' relaxation, which was in turn caused by LMT. Once the LMT removes the larynx's tension, this causes, at first, a worse vocal quality, which may have happened in this study. Thus, a single session of therapy may be enough to improve tension in the larynx, but it is too short to improve vocal quality.

Although both the applied techniques are aimed at muscle relaxation, LMT and TENS are different in terms of vocal effects. The LMT action occurs directly on the muscles: sternocleidomastoid, suprahyoid, and infrahyoid. Although the larynx is affected by stiff and tense muscles, it is indirectly hit by LMT, causing a more relaxed voice. On the other hand, the application of TENS presupposes a strong contraction of the musculature in the cervical and perilaryngeal regions and, consequently, a strong vibration in the larynx. Thus, this relaxation action is twofold: it relaxes the cervical and perilaryngeal muscles and strongly vibrates the larynx. Ceasing this vibration causes great relief and relaxation in the larynx, which may then have better vocal quality than can be achieved with LMT.

Table 4 presents the improvements for both techniques (TENS and LMT). In general, the TENS group has better percentage improvements than the LMT group has, but no statistical test has been used to compare the observed differences. The strain parameter did not improve for any LMT participant, which was not expected. LMT uses a soft and superficial massage that promotes the relaxation of the extrinsic laryngeal muscles and that could thus improve strain in the intrinsic muscles, resulting in phonation balance (as reported in the literature[17]); however, this did not occur in this study.

On the other hand, TENS improved the strain parameter for 46.6% of women. The small number of participants in each group may not have been enough to reveal significant differences. The judges' concordance in the voice perceptual analysis was also low; this may be a point to be considered in vowel /a/ analysis. Sample calculations and judges' calibrations may be the best ways to analyze reliably the parameters in future studies.

### Acoustic parameters

The studied therapeutic techniques did not cause any changes in the acoustic parameters (Table 5). No improvement in vocal quality was demonstrated in fundamental frequency, jitter, shimmer, or noise-to-harmonic ratio after TENS or LMT. The vocal quality improvement may be related not to the glottis but to the vocal tract. Future researchers may continue this analysis using other acoustic parameters to better understand what is happening in the glottis and vocal tract. This study's findings corroborate those of Santos et al,[16] who showed that, after a single TENS session, women with vocal nodules did not experience changes in various acoustic measures. However, studies using healthy subjects and electrical stimulation, with different physical and time criteria from those used in this study, have indicated an increase in fundamental frequency, a reduction in sound pressure level,[36,37] and an increase in phonation instability.[37]

Regarding LMT, the acoustic data in this study agree with those in the literature. In the current study, there was no acoustic parameter change after 20 minutes of LMT. Mathieson et al[17] observed an improvement in relative acoustic perturbation after 1 week of the technique but not immediately after LMT. Van Lierde et al[38] showed that jitter and shimmer were enhanced after a 45-minute session of manual circumlaryngeal therapy in patients with muscle tension dysphonia. This last technique is different from LMT because it uses vocalization, whereas LMT does not. However, LMT also does not promote such changes in acoustic parameters in women with dysphonia, it only decreases jitter in vocally healthy women.[20]

### Self-perception signs

After TENS, the participants reported significant positive signs related to their voices and larynges. The most commonly reported voice signs were that the voice was "more relaxed," "less rough," "cleaner," "stronger," and "clearer"; all occurred in 73.33% of participants. The most common laryngeal signs were that talking required "less strain" and "less effort" (80%); most participants reported no changes in breathing (73.33%) or articulation (66.66%) after TENS.

The LMT group reported significant changes in the larynx and in articulation. The most common laryngeal signs were that it was "lighter," "more relaxed," and had "less phlegm" (each in 73.33% of participants). It is important to note that, although the majority of LMT participants (53.34%) reported no difference in their joints after the massage, the other participants (46.66%) reported positive signs such as "clearer speech," "easier speech," and "less strain"; no one mentioned any negative signs. Although the voice signs were not significant, most participants (73.33%) reported "fewer breaks," "less roughness," and a "cleaner and clearer voice." Most participants (60%) did not report changes in breathing.

Furthermore, not all of the participants benefited from TENS or LMT, and some reported negative signs. Some participants in the TENS group reported negative voice signs such as that their voices were "rougher than before" (6.66%); others reported laryngeal "discomfort," "pain under the chin," and "more secretion" (13.33%). The LMT group reported more negative voice signs ("rough voice," 20%), laryngeal signs ("sore throat," 13.33%), and breathing signs ("trouble breathing," 20%). Thus, more studies are needed to better understand the possible effects of these two therapy resources. In future studies, it will be necessary to adjust both TENS and LMT in terms of the time of stimulation and the muscles they are applied to. In addition, behavioral dysphonia is complex; a single session of either TENS or LMT may not be enough to cause lasting effects on vocal quality, as previously discussed.

A limitation of the current study is that it does not assess the participants after an extended period of time, such as a week; doing so would promote comparisons between the current study and others in the literature. In addition, no placebo-group comparison was performed to better demonstrate the effectiveness of the voice therapies; this comparison should be done in future studies. Therefore, it is necessary to investigate TENS and LMT to better understand the proper uses of these techniques in voice treatment.

## CONCLUSION

TENS and LMT may be used in the voice treatment of women who have functional or organic-functional dysphonia; both techniques are important therapeutic resources that can decrease muscle pain and positively affect the larynx. In observations of the immediate effects of a single session, both TENS and LMT partially improved vocal quality, but TENS showed better results.


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