Original Article
Artigo Original

Effects of laryngeal manual therapy (LMT) and transcutaneous electrical nerve stimulation (TENS) in vocal folds diadochokinesis of dysphonic women: a randomized clinical trial

Efeitos da terapia manual laríngea e da estimulação elétrica nervosa transcutânea (TENS) na diadococinesia laríngea em mulheres disfônicas: estudo clínico randomizado

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Keywords

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Dysphonia
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ABSTRACT

Purpose: To verify and compare the effect of transcutaneous electrical nerve stimulation (TENS) and laryngeal manual therapy (LMT) on laryngeal diadochokinesis (DDK) of dysphonic women. **Methods:** Twenty women with bilateral vocal nodules participated and were equally divided into: LMT Group – LMT application; TENS Group – TENS application; both groups received 12 sessions of treatment, twice a week, with a duration of 20 minutes each, applied by the same therapist. The women were evaluated as to laryngeal DDK at three moments: diagnostic, pre-treatment, and post-treatment, which produced three groups of measurements. The DDK recording was performed with intersected repetition of vowels /a/ and / i/. The analysis of vowels was performed by the program Motor Speech Profile Advanced (MSP)-KayPentax. The DDK parameters of the three evaluations were compared by means of the paired t-test ($p \leq 0.05$). **Results:** The measurements of laryngeal DDK parameters were similar in the phase without treatment, indicating no individual variability over time. There was no change with respect to the speed of DDK after intervention, but after LMT, DDK of the vowel /i/ was more stable in terms of the duration of the emissions and intensity of emissions repeated. These results show improved coordination of vocal folds movement during phonation. There were no changes in the DDK parameters following TENS. **Conclusion:** LMT provides greater regularity of movement during laryngeal diadochokinesis in dysphonic women, which extends knowledge on the effect of rebalancing the larynx muscles during phonation, although TENS does not impact laryngeal diadochokinesis.

Descritores

Estimulação Elétrica Nervosa Transcutânea
Disfonia
Massagem
Voz
Laringe
Fonoaudiologia

RESUMO

Objetivo: Verificar e comparar os efeitos da terapia manual laríngea (TML) e da estimulação elétrica nervosa transcutânea (TENS) na diadococinesia laríngea de mulheres disfônicas. **Método:** Participaram 20 mulheres com nódulos vocais, divididas igualmente por sorteio em: Grupo TML–aplicação de TML; Grupo TENS–aplicação de TENS; ambos receberam 12 sessões de tratamento, duas vezes por semana, 20 minutos cada, pelo mesmo terapeuta. As mulheres foram avaliadas quanto à diadococinesia (DDC) laríngea em três momentos, diagnóstico, pré-tratamento e pós-tratamento, o que produziu três grupos de medidas. A gravação da DDC foi realizada por meio da repetição entrecortada das vogais: /a/ and /i/. A análise da DDC foi realizada pelo programa *Motor Speech Profile Advanced* (MSP)-*KayPentax*. Os parâmetros da DDC das três avaliações foram comparados entre si pelo teste t pareado ($p \leq 0{,}05$). **Resultados:** Parâmetros DDC se apresentaram semelhantes na fase sem tratamento, indicando que não houve variabilidade individual ao longo do tempo. Não houve modificação em relação à velocidade da DDC após intervenções, mas após TML, a DDC da vogal /i/ se apresentou mais estável em relação à duração do período e à intensidade das emissões. Estes resultados indicam que TML melhorou a coordenação de movimentos das pregas vocais à fonação. Não houve modificações dos parâmetros da DDC em relação à estabilidade das emissões após TENS. **Conclusão:** TML promove maior regularidade de movimentos diadococinéticos das pregas vocais em mulheres disfônicas, o que amplia o conhecimento sobre o efeito do reequilíbrio da musculatura laríngea na função fonatória, já TENS não proporciona efeitos na diadococinesia laríngea.

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INTRODUCTION

The definitions of conduct for vocal rehabilitation depend mainly on the knowledge about the manifestations of dysphonia as to the individual's vocal quality and larynx. Behavioral dysphonia associated with muscle tension is traditionally administrated with vocal speech-language therapy, for which several authors recommend that laryngeal relaxation be prioritized by means of techniques of digital manipulation of the larynx[1,2], circunlaryngeal manual therapy[3,4] or manual laryngeal therapy[5], as well as production smoothing and emission stabilization techniques, along with mucosal wave stimulation, in order to regress mass lesions on the vocal folds, if present[6].

Laryingeal manual therapy (LMT) prioritizes work with sternocleidomastoid and suprahyoid muscles, and thyrohyoid membrane regions[5]. This technique aims mainly to relax the excessively tense musculature that hinders balanced phonatory function[5], a characteristic observed in behavioral dysphonias. Another technique capable of relaxing the cervical and perilaryngeal musculature is transcutaneous electrical nerve stimulation (TENS), which can be applied to this type of dysphonia. In addition to analgesia, TENS can promote an improvement of vascularization in the region[7]. However, the choice of current as to frequency, intensity and pulse width, as well as the placement of electrodes, influence the type of stimulus that the larynx musculature can receive. Low frequency and strong intensity TENS, with application of electrodes in the submandibular region and trapezius muscle descending fibers, promotes strong vibrations of the larynx[8]. This type of current has led to the improvement of the vocal quality of dysphonic women, as well as to a reduction of electrical activity of sternocleidomastoid muscles after 10 sessions[6]. Thus, TENS can be an adjuvant for treatment of behavioral dysphonia[6,8].

One of the ways to assess the effects of vocal therapy is acoustic analysis. Diadochokinesis (DDK) is among the many types of analysis. It is defined as the ability to perform fast repetitions of relatively simple patterns composed of oppositional contractions[9], which may suggest information about individuals' neuromotor integration and maturation[9]. This acoustic evaluation has been used in several cases and populations, such as in children with speech sound disorders[10], cochlear implants[11], and fluency disorder[12], in neurological patients[13-16], healthy elderly individuals[17], youngsters and children[18,19], as well as in patients with behavioral dysphonia[20,21]. Considering the DDK evaluations in clinical speech-language practice, laryngeal DDK aims to investigate neuromotor control of vocal folds[22], being used mainly for the assessment of voice disorders[13,15,17,18,20,22].

Since changes in vocal fold movement length and velocity may reflect changes in production rate, duration patterns, and transglottal airflow velocity during DDK[23], it is recommended that this assessment be included In the rehabilitation procedures of patients with voice disorders, even in the absence of neurological problems[21].

It may be considered that strategies aimed at relaxation of overly tense perilaryngeal musculature, such as laryngeal manual therapy and TENS, can improve glottal function[5] and possibly velocity, rhythm, and neuromotor laryngeal control in women with vocal nodules, as an unbalance of the extrinsic musculature of the larynx may influence the activity of the intrinsic musculature, thus causing changes in such vocal parameters following intervention. Thus, the objective of this study was to verify and compare the effects of laryngeal manual therapy (LMT) and transcutaneous electrical nerve stimulation (TENS) on laryngeal diadochokinesis in dysphonic women.

METHODS

This work is part of a larger study, which was approved by the Research Ethics Committee of the institution (099/2011). All individuals have signed the Informed Consent.

Twenty women between 18 and 45 years old, with a mean age of 29.4 years, were selected for this study. The sample calculation performed in a previous study[8], to which the diadochokinesis data used in this study belongs, was based on the study by Lagorio et al.[24] who, considering a value of $p<0.05$ ($\alpha = 5\%$) and a test strength of 90% ($\beta > 0.90$), indicated the need for 6 individuals, which was maintained for the current study.

To form the groups, the women enrolled for voice treatment at the Voice Sector of the Speech-Language Pathology Clinic of the institution were contacted. In order to participate in the study, the volunteers were required to present complaint of vocal alteration, altered voice evidenced by a perceptual-auditory speech-language pre-evaluation, bilateral vocal nodules, or mucosal thickening and phonatory gap, evidenced by otorhinolaryngological evaluation.

The criteria for exclusion of volunteers from the study were: volunteers who received previous vocal or surgical speech-language treatment in the larynx, those who were in the menopause period, presented changes in the thyroid gland or hormonal changes, presented heart or vascular problems, and were older than 45 years, in order to isolate variables such as changes resulting from the natural aging process or changes in musculature caused by age[25].

Thus, the volunteers who met the inclusion criteria were divided into: LMT Group - underwent LMT according to the description of laryngeal manual therapy (LMT) proposed in the study conducted by Mathieson et al.[5]; TENS Group - underwent TENS according to Guirro et al.[6]. The distribution of the volunteers in each group was performed by manual drawing of 20 pieces of paper with the same appearance containing the names of each treatment (ten pieces of paper for TENS, and ten for TML) that had been placed in a box. The therapist applied the treatment to each patient according to the paper drawn. It is worth noting that the therapist was proficient in both methods performed in the study, and that she did not participate in the analysis of the results.

After taking the inclusion criteria into consideration, ten volunteers were selected for the TENS Group (mean age of 28.7 years) and ten volunteers were selected for the LMT Group (mean age of 30.1 years). Chart 1 shows the distribution of volunteers with regard to age, occupation, and activities involving the use of voice, weight, and height for the TENS and LMT Group. No statistically significant differences were

Chart 1. Distribution of volunteers in the TENS and LMT Group with regard to age, occupation and activities requiring the use of voice, weight, height and BMI

TENS G	Occupation	Activities with voice	Age	Weight (kg)	Height (m)	BMI
1	Gastronomer	No	21	70	1.75	22.9
2	Teacher	Classes	30	72	1.68	25.2
3	Teacher	Teaches and sings in a choral	36	85	1.70	29.1
4	Teacher	Classes	29	54	1.50	24.0
5	Day-care facility assistant	Speaks and sings throughout the day	30	75	1.65	27.5
6	Student	No	22	65	1.56	27.4
7	HR Department assistant	Sings and services clients on the phone	22	64	1.67	22.9
8	Teacher	Classes	31	70	1.67	25.1
9	Physical education teacher	Classes	24	58	1.62	22.1
10	Civil servant	Attendant	42	77	1.65	28.3
LMT G						
1	Teacher	Classes	30	64	1.61	24.7
2	Physical educator	Classes	27	70	1.73	23.4
3	Physiotherapist	Speaks a lot when seeing patients	22	46	1.63	17.3
4	Dentist	Classes	29	48	1.56	19.7
5	Dentist	No	29	64	1.69	22.4
6	Student	No	25	72	1.64	26.8
7	Reporter	Reports and singing	27	74	1.68	26.2
8	Telemarketing operator	Yes	32	64	1.65	23.5
9	Teacher	Classes	47	70	1.65	25.7
10	Call agent	For work	35	70	1.70	24.2
Value of p			**0.607**	**0.108**	**0.745**	**0.110**

Student's t-test ($p<0.05$)
Caption: BMI = body mass index

observed between the two groups for these variables, which indicates that the groups were homogeneous.

Procedures

The study was composed of two phases: the first phase consisted of initial evaluation repeated after six weeks without treatment or any guidance with regard to speech-language therapy; The second phase consisted of a speech-language intervention composed of 12 sessions of TENS or LMT.

The laryngeal DDK was recorded at three moments, according to the phases of the study:

- First recording: performed at the initial phase of the study after otorhinolaryngological diagnosis and definition of the groups;
- Second recording: performed after six weeks without treatment, still during the first phase of the study;
- Third recording: performed after 12 sessions of TENS or LMT, at the second phase of the study.

Diadochokinesis

Voice was recorded in a silent environment with acoustic treatment by means of a computer system consisting of: Intel Pentium (R) 4, CPU 2.040 GHz and 256 MB RAM computer, LG Flatron E7015 17" monitor, and Creative Audigy II sound card. The recordings were performed by professional audio editing software - Sound Forge 10.0 -, at sampling rate of 44,100Hz, Mono channel at 16Bit and AKG microphone model C 444 PP.

To evaluate laryngeal motor control, the recording of laryngeal Diadochokinesis (DDK) was performed by means of interrupted repetition of each of these vowels separately: /a/ and /i/. The volunteers were instructed to "keep production as fast as possible" for the given period of time. Each emission was recorded for eight seconds, where the first and last two seconds were excluded from the sample for analysis.

The vowel analysis was performed using the Motor Speech Profile Advanced (MSP) computer program, model 5141, version 252 of KayPentax. For adjustment of recordings, sampling rates of 11025 Hz were used. The MSP program presents a graphical record of the emissions, showing a horizontal axis (time, in seconds) and a vertical axis (energy, in dB). To perform the DDK counts, the program draws a line at the center point of the vertical axis energy scale in dB. The value used to determine the point was the mean intensity of the DDK sample (DDKava) provided by the MSP program itself during the analysis for each emission[18] - Figure 1. It was determined as standard that the analysis line should be lowered or elevated in order not to compute subpeaks due to possible instabilities in the energy contours produced by the graph[18,20]. The DDK parameters are automatically provided by the MSP program. The following parameters were analyzed: mean DDK rate (DDCavR), repetition rate (DDCavP), standard deviation of DDK period (DDCdpP), DDK period variation coefficient (DDCcvp), DDK period disturbances (DDCjitP), and DDK intensity peak variation coefficient (DDCcvI). The definitions of each parameter are described in Chart 2.

Speech-language therapy intervention

Application of Laryngeal Manual Therapy (LMT)

LMT was applied for 20 minutes, having the volunteer sitting comfortably on a chair. The therapist stood behind the volunteer and initiated the massage of sternocleidomastoid, suprahyoid and laryngeal muscles bilaterally, with circular descending movements, kneading and stretching of each muscle group, as well as displacing the larynx[5]. The volunteers were superficially and delicately touched with different pressure on each hand. Work was more detailed in areas of greater muscular resistance, where there is greater tonus sensation or presence of nodules. During the procedure, the participant was asked to remain silent, without vocal emissions, to breathe calmly, and try to relax their shoulders and jaw without allowing their dental arches to touch. The following steps were performed during the LMT, in an adapted manner[5], in order to follow the same TENS application time (20 minutes):

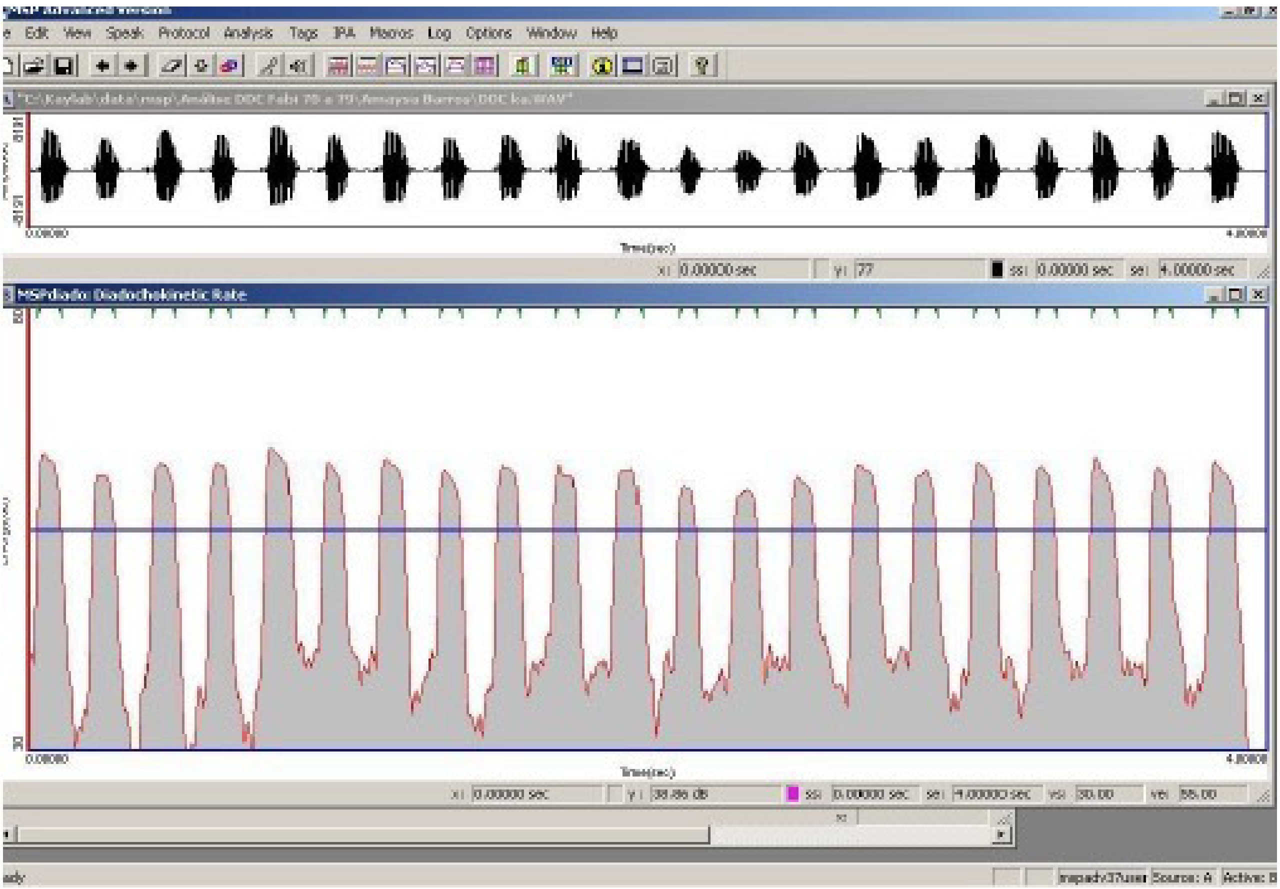

Figure 1. Graphic of program Motor Speech Profile Advanced model 5141, version 252, by KayPentax in which the time (in seconds) is observed on the horizontal axis, and energy (dB) on the vertical axis, the horizontal line of DDK analysis

Chart 2. Parameters analyzed in laryngeal diadochokinesis

Parameters		Unit	Observations
DDCavR	Average DDK rate	/s	Number of vocalizations per second, which represents the DDK speed
DDCavP	Repetition rate	/s	Number of emissions repeated per second, which represents the speed
DDCdpP	Standard deviation of DDK period	Ms	
DDCcvp	DDK period variation coefficient	%	Measures the degree of variation of the period rate, indicating the ability to maintain a constant vocalization rate
DDCjitP	Disturbances of DDK period	%	Measures the degree of variation of the period cycle by cycle, indicating the ability to maintain a constant vocalization rate
DDCcvI	DDK intensity peak variation coefficient	%	Measures the degree of variation of intensity at the peak of each vocalization, indicating the ability to maintain a constant vocalization intensity

✓ Five minutes of massage, with complete circunlaryngeal movements in the sternocleidomastoid muscle (SCM);

✓ Five minutes of massage, with sliding movements throughout the supralaryngeal region;

✓ Repetition of two minutes of massage on the SCM muscle;

✓ Repetition of two minutes of massage on the supralaryngeal region;

✓ One minute of sliding movements, lowering the larynx in the laryngeal region;

✓ Two minutes with movements of thyroid cartilage displacement;

✓ Repetition of one more minute of sliding movements, lowering the larynx;

✓ Repetition of two more minutes of thyroid cartilage displacement.

Twelve sessions of LMT were performed for 20 minutes each, twice a week. Voice recording was performed after each session, as well as investigation of the sensations provided by the technique for later control.

Application of TENS

TENS was performed with the volunteer resting on the dorsal decubitus position, on a stretcher, for 20 minutes. During the procedure, the volunteer was asked to remain silent, without vocal emissions, to breathe calmly, and try to relax their shoulders and jaw. The equipment used for TENS was the two-channel Dualpex 961, by Quark. The parameters used were those of the low frequency TENS, with symmetrical biphasic square wave, 200μs phase, 10Hz frequency, and motor threshold intensity. The electrodes (3.0 cm x 4.0 cm) were positioned in the trapezius muscle region (descending fibers) and submandibular region, bilaterally, amounting to a total of four electrodes[7]. They were fixed to the skin with anti-allergic adhesive tape after being anointed with electroconductive gel.

Twelve sessions of TENS were performed for 20 minutes each, twice a week. Voice recording was performed after each session, as well as investigation of the sensations provided by the technique for later control.

Data analysis

The laryngeal DDK parameter for the three evaluations were compared by means of the paired t-test with a level of significance of 5% ($p \leq 0.05$). The Statistics software 7.0 was used for data analysis.

RESULTS

Fifty-one laryngological exams were performed in this study. After the otorhinolaryngological diagnosis, 24 volunteers initiated vocal treatment, although four volunteers were excluded due to thyroid gland alterations. Thus, 20 volunteers completed the treatment from beginning to end (treatment and final evaluations), where 10 belonged to the TENS Group, and the other 10, to the TML Group. The representation of the sample is shown in Figure 2.

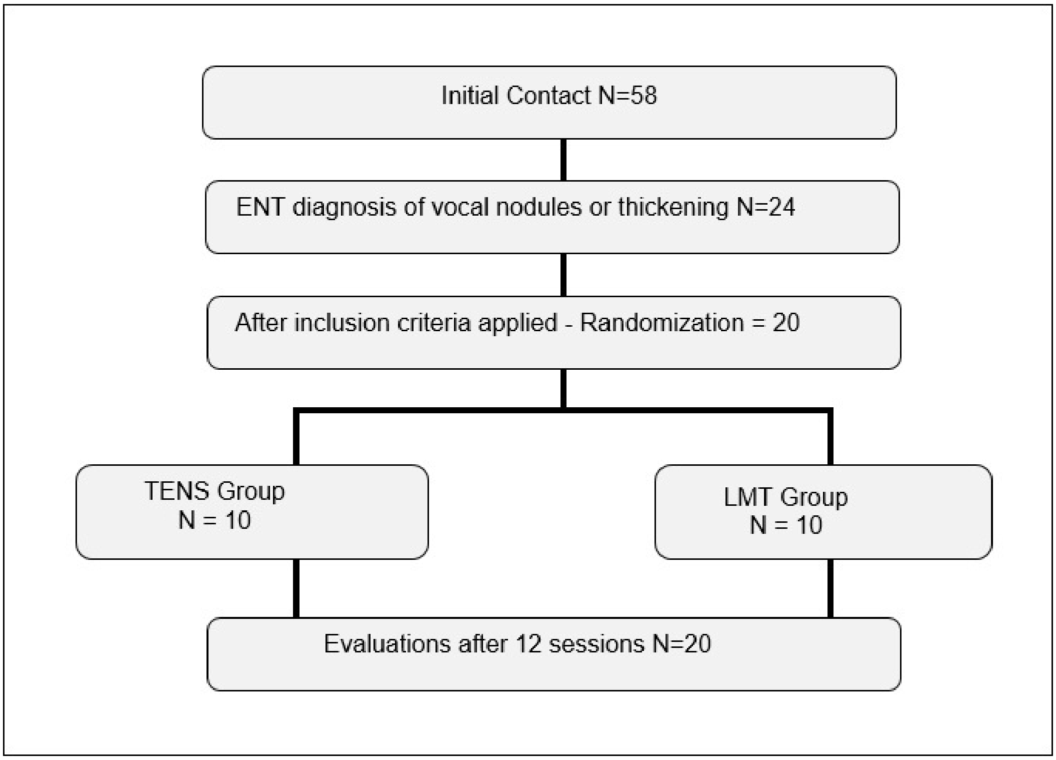

Figure 2. Flowchart referring to the stages of the research in relation to the study sample

Table 1 presents the comparisons between laryngeal DDK recordings: recordings 1 and 2 (without treatment), recordings 2 and 3 (after LMT intervention). No individual variation was verified over time in relation to the phase without treatment. We also observed a decrease in the standard deviation of the period (DDC dpP), the period variation coefficient (DDCcvP), as well as a reduction of the intensity peak variation coefficient (DDCcvI) after treatment, indicating improvement of the stability of the /i/ vowel emission after LMT.

Table 2 shows the comparisons between laryngeal DDK recordings: recordings 1 and 2 (without treatment), recordings 2 and 3 (after TENS intervention). There was a statistically significant difference between the first and second recording of DDK only for the variation of the DDCcvI parameter, which shows variability of the individual in relation to this parameter over time. It was observed that, after TENS, there was no change in the laryngeal diadochokinetic parameters.

DISCUSSION

Assessment of laryngeal diadochokinesis (DDK) identifies the velocity of vocal fold opening and closing movements, as well as their regularity. In addition to intact neuromotor conditions and central nervous system control, this ability depends on morphological and behavioral aspects, such as the balance of muscular strength, which is worked on in vocal therapy for behavioral dysphonias.

For this reason, the DDK test may contribute to the understanding of the effects of treatments in these cases, since imbalances in the extrinsic musculature of the larynx directly

Table 1. Values of laryngeal DDK in the LMT Group in relation to the phases of the study: phase 1 - without treatment (1st and 2nd recordings), phase 2 - with treatment (2nd and 3rd recordings)

	LMT					
DDK Parameters	1st recording	2nd recording	p	2nd recording	3rd recording	p
	Mean (sd)	Mean (sd)		Mean (sd)	Mean (sd)	
DDK /a/						
DDCavR	206.99(33.25)	195.48(23.72)	0.320	195.48(23.72)	201.38(46.50)	0.743
DDCavP	4.95(0.81)	5.18(0.61)	0.419	5.18(0.61)	5.15(0.91)	0.938
DDCdpP	38.02(16.74)	40.06(22.12)	0.735	40.06(22.12)	47.26(24.12)	0.580
DDCcvP	19.47(10.51)	20.66(11.37)	0.708	20.66(11.37)	23.91(11.96)	0.617
DDCjiitP	4.18(2.14)	4.63(2.32)	0.461	4.63(2.32)	5.68(3.60)	0.471
DDCcvI	2.94(0.73)	3.43(1.60)	0.346	3.43(1.60)	3.16(2.18)	0.768
DDK /i/						
DDCavR	213,36(27,97)	210.02(29.43)	0.553	210.02(29.43)	231.25(59.86)	0.335
DDCavP	4.76(0.58)	4.84(0.61)	0.523	4.84(0.61)	4.55(1.00)	0.449
DDCdpP	44.62(33.71)	53.26(32.50)	0.557	53.26(32.50)	37.41(20.10)	**0.041***
DDCcvP	20.64(14.54)	24.63(12.61)	0.494	24.63(12.61)	16.93(9.87)	**0.040***
DDCjiitP	5.35(4.46)	6.58(3.82)	0.353	6.58(3.82)	4.41(2.55)	0.060
DDCcvI	2.86(1.10)	3.11(1.13)	0.649	3.11(1.13)	2.05(0.70)	**0.032***

*Paired t-test (p<0.05)

Table 2. Values of laryngeal DDK in the TENS Group in relation to the phases of the study: phase 1 - without treatment (1st and 2nd recordings), phase 2 - with treatment (2nd and 3rd recordings)

	TENS					
DDK Parameters	1st recording	2nd recording	p	2nd recording	3rd recording	p
	Mean (sd)	Mean (sd)		Mean (sd)	Mean (sd)	
DDK /a/						
DDCavR	208,34(39,37)	204.28(33.71)	0.745	204.28(33.71)	190.96(22.28)	0.203
DDCavP	4.95(0.92)	5.01(0.81)	0.835	5.01(0.81)	5.29(0.57)	0.225
DDCdpP	39.63(19.23)	37.08(20.45)	0.781	37.08(20.45)	30.25(17.37)	0.478
DDCcvp	19.07(9.79)	18.10(9.96)	0.827	18.10(9.96)	15.47(8.11)	0.572
DDCjiitP	4.86(2.30)	4.38(2.70)	0.642	4.38(2.70)	3.42(1.69)	0.398
DDCcvI	2.90(1.09)	2.75(1.68)	0.816	2.75(1.68)	2.62(1.27)	0.859
DDK /i/						
DDavR	222.73(55.40)	214.11(28.66)	0.587	214.11(28.66)	200.35(18.97)	0.156
DDCavP	7.72(1.06)	4.75(0.70)	0.880	4.75(0.70)	5.03(0.44)	0.221
DDCdpP	51.27(21.55)	40.82(9.56)	0.375	40.82(9.56)	36.21(25.61)	0.765
DDCcvP	23.52(9.74)	19.45(14.03)	0.509	19.45(14.03)	18.27(13.06)	0.875
DDCjiitP	4.87(1.94)	4.46(2.87)	0.740	4.46(2.87)	3.45(2.13)	0.458
DDCcvI	3.30(1.62)	2.08(0.62)	**0.048***	2.08(0.62)	1.99(1.09)	0.768

*Paired t-test (p<0.05)

affect the functionality of the intrinsic musculature, which may lead to changes in the diadochokinetic abilities of vocal folds. In addition, authors[22] have confirmed in a study with women without neurological and with vocal alterations that vocal intensity can influence DDK speed. Other studies in different populations[22,26-28] show that when there are morphological and/or functional alterations in structures responsible for speech, including the larynx, impairment in speed and accuracy of their diadochokinetic movements is observed. Thus, we decided to verify the effects of two techniques, laryngeal manual therapy (LMT) and transcutaneous electrical nerve stimulation (TENS), on laryngeal diadochokinesis of dysphonic women, since these therapeutic techniques have been used for vocal treatment of patients with behavioral dysphonia in order to relax the musculature of the laryngeal and perilaryngeal region[5,6,8], which can maximize DDK ability.

This study was composed of three recordings of laryngeal DDK. The first two recordings correspond to the phase without treatment and were conducted with the aim to observe variations inherent to individuals, considered as sample control. The phase without treatment had the same duration as the phase without treatment - six weeks. The measurements of laryngeal DDK parameters were similar at the first two moments - phase without treatment (Tables 1 and 2), which indicates that there was no significant individual variability over time and allows for better observation of the effects of treatment with LMT and TENS. Only the intensity peak variation coefficient (DDKcvl) of the TENS group presented a significant difference at the phase without treatment, which may indicate individual variability, since one of the participants in the TENS group presented a higher rate of this parameter on the second execution of DDK than the other volunteers.

Repetition of vowels /a/ and /i/ evaluate the same vocal fold opening and closing behavior, although authors report that evaluation of laryngeal DDK by means of two vowels presents different results[18], as found in this study. However, the literature fails to reveal the reason for these differences, stating only that these vowels are used for this evaluation. Only the laryngeal DDK of vowel /i/ provided a significant difference following LMT intervention (Table 1), which points to the importance of using both vowels for assessment of laryngeal diadochokinesis. That is because, according to Ludlow et al.[29], there are differences in the use of laryngeal muscles among individuals during sound production that would lead to changes in supraglottal structures that cause changes in subglottal tension, opening, and pressure of vocal folds. In addition, a possible difference in the use of suprahyoid and articulatory musculature during the production of the vowels is assumed, which would lead to different diadochokinetic findings for each vowel.

The results of the laryngeal DDK of both interventions showed that there was no change in the speed of DDK following LMT and TENS (Tables 1 and 2), since there was no significant variation of the average repetition rate (DDCavR) and average duration of the emissions period (DDCavP) for both vowels. However, it was verified that only laryngeal DDK of vowel /i/ was more stable with respect to the duration of the emission period, observed by the decrease of the standard deviation of the period (DDC dpP) and of the period variation coefficient (DDCcvP) - Table 1. Additionally, the DDK of vowel /i/ was more stable with respect to the intensity of repeated emissions, detected by the reduction of the intensity peak variation coefficient (DDCcvI) following treatment (Table 1).

LMT is a type of massage that begins in the sternocleidomastoid muscles, advancing with sliding movements to the suprahyoid muscles, followed by lowering and lateral displacements on the larynx[6]. Therefore, there is an intense action on the extrinsic musculature that is strongly associated with the intrinsic musculature and configuration of the vocal tract[5]. Authors[2,5] have observed that, after intervention with some type of manual therapy, phonatory function improved, which can be observed in the present study since the possible relaxation of the extrinsic musculature provided by the LMT led to better regularity of opening and closing movements of the vocal folds, with improved parameters of standard deviation of the period (DDCdpP) and period variation coefficient (DDCcvP). Likewise, more relaxed adjustments in the laryngeal musculature can influence changes in sub- and supraglottal pressure[30], which also leads to improvement in DDK values associated with the regularity of the emission intensity. The muscle relaxation provided by LMT may have led to a better balance between aerodynamic and myeloelastic forces of the larynx, with improved airflow, decreasing the values of the DDK intensity peak variation coefficient. Therefore, the results demonstrate that LMT can improve coordination of vocal fold movements during phonation.

As for TENS, it was verified that there were no changes in the diadochokinetic parameters (Table 2). The TENS used in this study is a low frequency and strong intensity current, which causes strong contractions in the muscles. The selected setting for each channel of the current generator defines how the muscle will be stimulated. In this study, two electrodes belonging to the same channel were used: one in the submandibular region and the other in the descending fibers of the trapezius muscle, forming an electrostimulation field in a way that all submandibular muscles, sternocleidomastoid muscle and trapezius descending fibers, as well as the larynx, were stimulated. Configuration of the electric current, therefore, generated by the two channels, led to the bilateral electrostimulation of this muscular group, providing strong passive mechanical vibration of the larynx and trapezius muscle, in addition to relaxation of the muscle group mentioned above. Although there have been reports of patients who experienced good laryngeal comfort after TENS[6,8], in the present study, this type of electrostimulation was not able to alter diadochokinetic parameters. That is, the TENS did not influence the opening and closing movement control behavior of the vocal folds.

From these data and the literature findings[5,6,8], it is possible to infer that LMT and TENS, although providing muscle relaxation, act differently and have different effects, and can be used separately or in combination for vocal treatment of dysphonic patients.

It is worth noting that there is a shortage of studies that have investigated the opening and closing behavior of the vocal folds of individuals with behavioral dysphonia.

Most of the works on laryngeal DDK was performed in neurological[13,15], elderly patients[17], or children[18]. Only two studies evaluated oral and laryngeal DDK in individuals with behavioral dysphonia with several types of vocal affections, comparing the diadochokinetic parameters between dysphonic and non-dysphonic individuals[20], and investigated vocal folds behavior by age groups of men and women with vocal alterations[21]. Thus, it is necessary to conduct further studies in order to verify and characterize the neuromotor behavior of vocal folds in the different mass lesions, as well as the effect of different types of exercises and therapeutic techniques. In addition, studies must be carried out to verify the long-term effects of vocal therapy on laryngeal behavior.

CONCLUSION

The greater regularity of diadochokinetic movements of the vocal folds after intervention with LMT in dysphonic women broadens knowledge about the effect of rebalancing the larynx musculature on phonatory function. The same was not found after application of TENS, which did not modify any parameters of the laryngeal DDK.

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Author contributions

LTDS participated in the evaluations, data interpretation and preparation of the manuscript; KCAS participated in the study design, performance of evaluations, data interpretation and preparation of the manuscript; AGB participated in the study design, data interpretation and critical review of the study; RRJG participated in the critical review of the study; CGC participated in the implementation of otolaryngological evaluations and critical review of the study; MB participated in data interpretation and critical review of the study. All of the authors have read approved the final manuscript.