Effects of transcutaneous electrical nerve stimulation on maximal voluntary contraction in women with temporomandibular dysfunction: randomized clinical trial

Efeitos da estimulação elétrica nervosa transcutânea na contração voluntária máxima de mulheres com disfunção temporomandibular: ensaio clínico randomizado

Guilherme Lemos Monteiro dos Santos[1], Fabiane Miron Stefani[1]

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ABSTRACT

BACKGROUND AND OBJECTIVES: The purpose of this study was to evaluate the effectiveness of Transcutaneous Electrical Nerve Stimulation (TENS) combined with manual therapy in women diagnosed with muscular Temporomandibular Dysfunction (TMD) with or without Reduced Disc Displacement (RDD). The objective was to evaluate the action of manual therapy in conjunction with TENS as a therapeutic tool for treating TMD, analyzing the electromyographic tasks in MVC and in rest, and measuring pain scores with the Visual Analog Scale (VAS).
METHODS: This study has a blinded randomized clinical trial design. In this context, after screening, 11 women with a diagnosis of muscular TMD with or without RDD, aged between 18 and 39 years, were investigated. The 11 women were randomly divided into two intervention groups, one receiving manual therapy alone and the other receiving manual therapy together with TENS. The participants were assessed using the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) and MBGR protocols for inclusion and exclusion, using the VAS to analyze pain, and Surface Electromyography (EMG) to analyze MVC and rest muscle activation.
RESULTS: Lower MVC and rest values were observed after the intervention in both intervention groups. Manual therapy alone was as effective as manual therapy combined with TENS. There was no difference between the manual therapy group (MG) and manual therapy+TENS group (TG) in the VAS scores, however when comparing pre- and post-intervention, lower values were observed in the scores of both groups.
CONCLUSION: Both groups showed a reduction in pain, but the combination of TENS and manual therapy showed a slight improvement in the stability of the masticatory muscles compared to manual therapy alone. With or without TENS, muscle relaxation and analgesia were achieved.

Keywords: Electromyography, Manual therapy, Speech, therapy, Temporomandibular dysfunction, Transculturas electrical nerve stimulation.

RESUMO

JUSTIFICATIVA E OBJETIVOS: Esta pesquisa teve o propósito de avaliar a eficácia da Estimulação Elétrica Nervosa Transcutânea (TENS) combinada com terapia manual em mulheres diagnosticadas com Disfunção Temporomandibular (DTM) muscular com ou sem Deslocamento de Disco com Redução (DDR). O objetivo foi avaliar a ação da terapia manual em conjunto com a TENS como ferramenta terapêutica para tratamentos da DTM, analisando as tarefas eletromiográficas na Contração Voluntária Máxima (CVM) e no repouso, e aferindo os escores da dor com a Escala Analógica Visual (EAV).
MÉTODOS: Este estudo possui um desenho de ensaio clínico randomizado cego. No contexto, após a triagem foram investigadas 11 mulheres com diagnóstico de DTM muscular com ou sem DDR, com idades entre 18 e 39 anos. As 11 mulheres foram divididas randomicamente em dois grupos de intervenção, um deles recebendo somente terapia manual e outro grupo recebendo a terapia manual juntamente com a TENS. As participantes foram avaliadas pelos protocolos Critérios de Diagnóstico para Desordens temporomandibulares (DC/TMD) e MBGR para inclusão e exclusão, por meio da EAV para análise da dor, e da Eletromiografia de Superfície (EMG) para a análise da CVM e do repouso, verificando a ativação muscular.
RESULTADOS: Foram observados menores valores da CVM e de repouso após a intervenção em ambos os grupos de interven-

Guilherme Lemos Monteiro dos Santos – https://orcid.org/0000-0003-4851-6789;
Fabiane Miron Stefani – https://orcid.org/0000-0002-8531-6594.

1. Federal University of Santa Catarina, Department of Speech and Hearing Therapy, Florianópolis, SC, Brazil.

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HIGHLIGHTS
- Manual therapy applied individually is just as effective as its use concomitantly with transcutaneous electrical nerve stimulation.
- Both groups showed lower values of muscle electrical activity.
- A decrease in the pain score was identified in comparison to the pre- and post-intervention periods for both groups.

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https://orcid.org/0000-0002-1238-1707

Correspondence to:
Guilherme Lemos Monteiro dos Santos
E-mail: guilhermejsantos@hotmail.com

ção. A aplicação só de terapia manual é tão eficaz quanto o uso de terapia manual em conjunto com a TENS. Não houve diferença entre o grupo com terapia manual (GM) e o grupo com terapia manual+TENS (GT) nos escores da EAV, entretanto quando comparados pré e pós-intervenção, foram observados menores valores nos escores dos dois grupos.

CONCLUSÃO: Ambos os grupos apresentaram redução da dor, mas a combinação de TENS e terapia manual mostrou ligeira melhora na estabilidade da musculatura mastigatória em comparação com a terapia manual isolada. Com ou sem TENS, o relaxamento muscular e a analgesia foram alcançados.

Descritores: Disfunção temporomandibular, Eletromiografia, Estimulação elétrica nervosa transcutânea, Fonoaudiologia, Terapia Manual.

INTRODUCTION

Temporomandibular Dysfunction (TMD), which is a set of clinical alterations involving the muscles of mastication, the Temporomandibular Joint (TMJ) and other related orofacial structures, triggers an imbalance in the structures of the head and neck[1-4].

There is no single etiology for TMD, which is characterized by a multifactorial origin associated with neuromuscular, biomechanical, biological, psychological and social factors. The etiopathology of TMD remains unclear, which often creates challenges in the therapeutic process. In this sense, it is important to carry out a comprehensive mapping of the dysfunction[5-7].

The prevalence of TMD is higher in adults, especially between the ages of 18 and 45, and the literature indicates that women are the most affected gender[3,8]. To classify TMD, the literature suggests dividing it into two main groups: TMD of muscular origin, which affects the muscles of mastication, predominantly the masseter and temporal muscles, causing tension and pain; and TMD of articular origin, which affects the TMJ, causing limitations and pain in the articular region[9-12].

In TMDs with articular origin, a subtype can be found, classified as Disc Displacement With Reduction (DDR), characterized by a deformation of the articular disc, with modification of its biconcave morphology, and by producing a mechanical overload in the joint, making it painful.

This condition is also associated with clicks, which occur during the translation movement of the mandible, when an articular sound called reduction click is generated, due to the displaced disc returning to a more normal position after the condyle recaptures it. Another click is also produced when an incorrect disc is displaced anteriorly to the condyle. In addition, disc displacement can result in reduced joint space, arthritis, resorption, inflammation, as well as pain and TMD[13].

It is important to correctly diagnose the subtype of TMD so that treatment can be adapted according to the individual's needs, in order to provide a correct diagnosis and therapeutic means[11,12,14].

The telltale signs and symptoms of TMD include reduction in mandibular range of motion, pain in the masticatory muscles, TMJ discomfort, the presence of joint noises associated with functionality, the manifestation of generalized myofascial pain and restriction or functional deviation during jaw opening. The most frequently reported symptom in TMD is pain, predominantly localized in the masticatory muscles, TMJ and/or pre-auricular region, affecting stomatognathic functions. As a result, speech therapy is increasingly looking for alternatives to reduce pain and cause relaxation of the structures that make up the stomatognathic system[4,13,15-18].

To measure pain sensation, it is possible to use the Visual Analog Scale (VAS), which makes it possible to quantify nuances in the intensity of individuals' pain, which is essential for monitoring the response to therapeutic interventions. Thus, VAS application has emerged as a valuable tool in clinical practice and research, contributing to a more comprehensive and accurate approach to understanding and managing orofacial pain associated with TMD[19-21].

One of the procedures used to assess muscle activation is surface electromyography (EMG), which records the electrical activity of the muscles, supporting both diagnosis and therapeutic intervention. In the analysis of electromyographic activities, which are resting, mastication and Maximum Voluntary Contraction (MVC), the assessment of MVC stands out as a method for measuring muscle tension[22,23].

In order to discuss the findings of this study, it is important to briefly explain MVC. It is known that EMG is used to analyze the electrical signals generated by the muscles in different individuals. For these acquisitions, it is necessary to use techniques for normalization, which consists of transforming absolute amplitude values into relative values with reference to an amplitude value characterized as 100%. One of the techniques to do it - the one used in this study - is CVM, which uses the highest value found voluntarily in a maximum muscle contraction as a reference for normalization[24].

In order to reduce the muscle tension and pain associated with TMD, speech therapy employs various strategies, including manual therapy. This approach involves the application of stretching and relaxing movements directed at the muscles affected by TMD[25]. In addition, transcutaneous electrical nerve stimulation (TENS) is used, which consists of the application of low-frequency electrical currents capable of inducing muscle relaxation and analgesia. This therapeutic modality also promotes balance between the stomatognathic system structures[26].

Also with the aim of evaluating the effectiveness of TENS in combination with manual therapy in women diagnosed with muscular TMD, with or without DDR, the main objective of this study was to analyze the electromyographic activity of the masseter and temporal muscles. Specifically, the focus of the analysis was on the resting and MVC periods, and the evolution of pain scores was monitored using VAS.

METHODS

This study was a blind randomized clinical intervention trial. The sample consisted of 11 women, aged between 18

and 39, diagnosed with TMD of muscular origin, with or without RCD.

This study was approved by the Human Research Ethics Committee of the Federal University of Santa Catarina, under the opinion number 5.402.772. In addition, this study was duly registered with the Brazilian Registry of Clinical Trials (*Registro Brasileiro de Ensaios Clínicos* - REBEC) under number RBR-633rr3r. It should be noted that all the participants formalized their agreement to take part by signing the Free and Informed Consent Term (FICT) before the interventions began.

This study included women dentally diagnosed with TMD of muscular origin, with or without DDR, according to the criteria established by the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). The participants ranged in age from 18 to 45 years and their body mass index (BMI) was between 18.5 and 29 points.

The following parameters were established as exclusion criteria: participants who had been diagnosed with TMD of articular origin; those who had more than three missing teeth or two missing occlusion pairs; those who used analgesic, myorelaxant or anti-inflammatory drugs during the research period; participants who had previously received therapy for TMD; those who used occlusal plates during the research period; those who missed any of the intervention days; those who did not follow the prescribed guidelines; and those whose BMI was below or above the specified parameters.

Participants were approached via an online form, which registered 83 entries. Of these, 68 were women and 15 were men. Five registrations were excluded due to age criteria not being met, while nine were discarded due to their BMI not being in line with the established criteria. Thus, 54 women were invited to take part in this study. Of those invited, 22 did not show up or did not respond to the call. After diagnostic assessment by a dental surgeon, eight participants were diagnosed with TMD of joint origin and were subsequently excluded from the sample. Thus, 24 participants were included in the therapeutic interventions. However, during the process, 13 participants dropped out of treatment, resulting in 11 participants who fully completed this study.

All the participants were diagnosed with TMD of muscular origin, with or without DDR, confirmed by a dental surgeon who conducted a clinical assessment using the DC-TMD protocol[27]. After confirming the diagnosis of TMD, the participants underwent an anamnesis and an assessment focused on oromyofunctional aspects, as established by the MBGR protocol[28], with a speech therapist, to identify myofunctional alterations and TMD signs and symptoms. The participants were randomized using the Randomizer® mobile application, resulting in the random selection of five women for the Manual Therapy Group (MG) and six for the Manual Therapy+TENS Group (TG). The participants were assessed using VAS[29], which allowed pain scores to be measured both before and after the intervention.

To assess muscle activity in the temporalis and masseter muscles, the participants underwent EMG. To collect MVC, the participants were instructed to perform the maximum bilateral voluntary contraction of the mandible for 10 seconds, repeated three times, with intervals between cycles to prevent muscle fatigue. In order to eliminate occlusal interference and prevent tooth wear, gauze rollers were positioned between the premolar teeth and the first and second molars, both lower and upper, bilaterally. The initial MVC recording, performed only once and without maintaining the movement, was used to normalize the EMG data.

The EMG recordings were captured by a four-channel Miotec® Miotool 400 electromyograph with Miotec® DoubleTrace LH-ED4020 bipolar electrodes and Kendall® Meditrace 200 Adult ECG Electrode ground electrodes, and recorded on a Samsung® Book 550xda-Kv3, Intel® Corel i3 computer.

The electromyograph was configured with the following specifications: a 14-bit resolution A/D converter for acquiring electromyographic signals; a common signal rejection rate of over 100 dB; a 20 Hz high-pass filter and a 500 Hz low-pass filter; an acquisition capacity of 2000 samples per second per channel; and electrical insulation of 5000 volts. The information was automatically presented in root mean square (RMS) by the Miotecsuite 1.0 software. The analysis data was normalized by MVC and expressed as a percentage. The device was connected to a battery-powered notebook computer, thus eliminating the need for mains power. The recordings were stored both on the notebook's hard disk and on a USB stick for subsequent analysis.

The speech therapy intervention aimed at relieving pain and relaxing the masseter and temporalis muscles consisted of a massage program, with weekly sessions of 30 minutes for MG and 55 minutes for TG, over four weeks.

The manual therapy used in both groups was uniform and consisted of stretches incorporating vertical movements and relaxation exercises with circular movements. The latter were performed in the direction of the masseter and temporalis muscle fibers bilaterally, using the index and middle fingers in a bidigital manner, contrary to the direction of muscle contraction. The stretching exercises involved a series of 10 repetitions for each side, while the relaxation exercise comprised a series of 20 seconds for each side.

The TENS therapy administered to TG used the Fono Stim® device, manufactured by HTM. This portable electrostimulation device has two output channels. To transmit the stimuli to the patient, Medix® unipolar electrodes of the Disposable Neonatal ECG Electrode model were used, which is characterized by: drop shape, flexibility, solid conductive gel, silver sensor and silver chloride; with dimensions of (± 1mm): 25mm x 31mm.

The electrodes were applied after the skin had been prepared with gauze soaked in 70% ethyl alcohol, in order to increase impedance and maximize the electrical impulses generated by TENS. After preparing the skin, the electrodes were positioned bilaterally on the masseter muscles, the mandibular angle and the insertion point, with the aim of inducing relaxation and analgesia.

This study followed a protocol designed by the author to establish a standard, based on a literature review article[30]. The parameters established for TENS were as follows: TENS Burst stimulus, frequency of 130 Hz, duration of 100μs, with the amplitude of the stimulus increased every 2mA after the participant had adapted to the stimulus, with a total duration of 25 minutes.

After the four therapeutic intervention sessions, the participants underwent a reassessment using VAS to measure the post-intervention pain score. In addition, EMG was used to assess the therapeutic effects induced in the stimulated muscles.

Statistical analysis

The quantitative variables were described using the mean, standard deviation (SD), 95% confidence interval (95% CI), median and interquartile range (IQR), following statistical procedures to characterize the samples.

The normality of the quantitative variables was assessed using the Shapiro-Wilk test and histogram analysis. Differences between the intervention groups were analyzed using Student's *t*-test (for parametric data) and the Mann-Whitney test (for non-parametric data).

In addition, to investigate possible differences between EMG measurements in the same participant before and after the intervention, Student's *t*-test was applied for paired groups and Wilcoxon signed-ranks test for non-parametric data.

The data was recorded in Microsoft Excel for Mac (2019) spreadsheets, and then exported for statistical analysis using Stata software version 14.0 (available at https://www.stata.com). A significance level of 5% ($p < 0.05$) was adopted.

RESULTS

Eleven female participants were included in this study, five of whom were assigned to MG and six to TG. Table 1 sho-

Table 1. Comparison of electromyographic activity before and after intervention for each of the muscle areas during maximum voluntary contraction (MVC), between the manual therapy group (MG) and the manual therapy+TENS group (TG)

Variables	MG group	TG group	p-value	p-value median*
Pre-MVC RM			0.152[b]	0.782
Mean (IC95%)	240.28 (112.71-367.86)	163.05 (101.11-224.99)		
Standard deviation	102.75	59.03		
Median (IQR)	297.02 (172.45-298.11)	149.26 (108.80-227.35)		
Pre-MVC RT			0.655[b]	0.782
Mean (IC95%)	229.55 (90.59-368.51)	202.06 (112.34-291.78)		
Standard deviation	111.9126	85.50		
Median (IQR)	278.16 (148.61-306.14)	170.60 (141.20-278.16)		
Pre-MVC LM			0.169[b]	0.782
Mean (IC95%)	205.90 (89.79-322.01)	139.50 (85.33-193.67)		
Standard deviation	93.51	51.62		
Median (IQR)	211.02 (132.55-288.19)	139.64 (101.72-171.74)		
Pre-MVC LT			0.465[a]	0.782
Mean (IC95%)	186.84 (100.09-273.59	174.48 (62.89-286.08)		
Standard deviation	69.87	106.34		
Median (IQR)	194.14 (148.37-224.55)	145.88 (99.23- 183.20)		
Post-MVC RM			0.223[b]	0.136
Mean (IC95%)	163.72 (92.09-235.34)	120.01 (64.28-175.74)		
Standard deviation	57.69	53.10		
Median (IQR)	154.48 (150.94-190.42)	127.42 (83.66-149.42)		
Post-MVC RT			0.383[b]	0.136
Mean (IC95%)	143.29 (59.03-227.55)	105.68 (34.82-176.55)		
Standard deviation	67.86	67.53		
Median (IQR)	121.69 (115.03-174.16)	96.59 (78.50-101.96)		
Post-MVC LM			0.310[b]	0.782
Mean (IC95%)	125.86 (67.65-184.07)	100.85 (69.42-132.27)		
Standard deviation	46.88	29.94		
Median (IQR)	117.04 (100.24-135.76)	100.60 (71.09-127.28)		
Post-MVC LT			0.477[b]	0.782
Mean (IC95%)	130.50 (78.30-182.69)	107.77 (48.49-167.04)		
Standard deviation	42.04	56.48		
Median (IQR)	135.91 (120.26-155.28)	118.12 (52.42-161.98)		

MG = Manual therapy group; TG = Manual therapy with TENS group; 95% CI = 95% Confidence Interval; IQR = Interquartile Range; RM = Right masseter; LM = Left masseter; RT = Right temporal; LT = Left temporal. [a]Mann-Whitney test. [b]Student's t-test.
*Exact p-value for the test of equality of medians.

ws no statistically significant difference between the intervention groups in terms of MVC. The higher means observed in the pre-intervention period (205.90 for the left masseter and 186.84 for the left temporalis), and in the post-intervention period (for all muscles in MG compared to TG), showed that, although there was no statistical significance, the electrical signals decreased regardless of the intervention used.

With regard to the rest EMG results, a higher average electrical activity was observed in the pre-intervention resting phase for the left temporal muscle (4.30). In the post-intervention phase, a higher average was found for the right temporal (2.00) and left temporal (2.74) in MG compared to TG. However, this difference did not reach statistical significance (Table 2).

Figure 1 shows a comparison of the mean electromyographic activity during MVC. In MG, a lower mean electrical activity was observed in the left masseter (125.86; p=0.045) after the implementation of manual therapy. In addition, lower contraction averages were identified in all the muscles assessed in the post-intervention phase, compared to the pre-intervention phase in TG.

When the resting electromyographic activity values were analyzed, a statistically significant difference was found in muscle contraction before and after the intervention for both groups. In MG, the right masseter (1.67; p=0.043) and right temporal (2.00; p=0.043) and left temporal (2.74; p=0.043) muscles showed lower contraction values after the intervention compa-

Table 2. Comparison of electromyographic activity before and after the intervention for each of the muscle areas at rest, between the manual therapy group (MG) and the manual therapy+TENS group (TG)

Variables	MG group	TG group	p-value	p-value median*
Pre-rest RM			0.814[b]	0.545
Mean (95% CI)	2.19 (1.13-3.25)	2.32 (1.36-3.29)		
Standard deviation	0.85	0.92		
Median (IQR)	2.09 (2.06-2.41)	2.48 (1.53-3.18)		
Pre-rest RT			1.000[a]	1.000
Mean (IC95%)	3.19 (0.04-6.34)	3.55 (0.66-6.44)		
Standard deviation	2.54	2.76		
Median (IQR)	2.23 (1.98-2.65)	2.44 (1.56-4.93)		
Pre-rest LM			0.999[b]	0.567
Mean (95% CI)	1.71 (0.59-2.84)	1.71 (1.10-2.32)		
Standard deviation	0.91	0.58		
Median (IQR)	1.82 (1.26-1.94)	1.49 (1.28-2.01)		
Pre-rest LT			0.855[a]	1.000
Mean (95% CI)	4.30 (0.67-7.92)	3.86 (1.64-6.09)		
Standard deviation	2.92	2.12		
Median (IQR)	3.83 (2.24-3.93)	3.82 (2.73-4.56)		
Post-rest RM			0.715[a]	0.567
Mean (95% CI)	1.67 (1.19-2.15)	1.68 (1.05-2.31)		
Standard deviation	0.39	0.60		
Median (IQR)	1.80 (1.77-1.84)	1.54 (1.36- 2.14)		
Post-rest RT			0.954[b]	0.954
Mean (IC95%)	2.00 (0.58-3.42)	1.96 (0.87-3.05)		
Standard deviation	1.15	1.04		
Median (IQR)	1.69 (1.63-2.19)	1.82 (1.15-2.26)		
Post-rest LM			0.707[b]	1.000
Mean (95% CI)	1.24 (0.72-1.75)	1.34 (0.84-1.84)		
Standard deviation	0.42	0.48		
Median (IQR)	1.39 (1.21-1.42)	1.30 (0.99-1.71)		
Post-rest LT			0.715[a]	0.782
Mean (95% CI)	2.74 (0.95-4.53)	2.22 (1.32-3.11)		
Standard deviation	1.44	0.85		
Median (IQR)	2.10 (2.02-2.42)	2.40 (1.42-2.99)		

MG = Manual therapy group; TG = Manual therapy with TENS group; 95% CI = 95% Confidence Interval; IQR =Interquartile Range; RM = Right masseter; LM =Left masseter; RT = Right temporal; LT = Left temporal. [a]Mann-Whitney test. [b]Student's t-test.
*Exact p-value for the test of equality of medians.

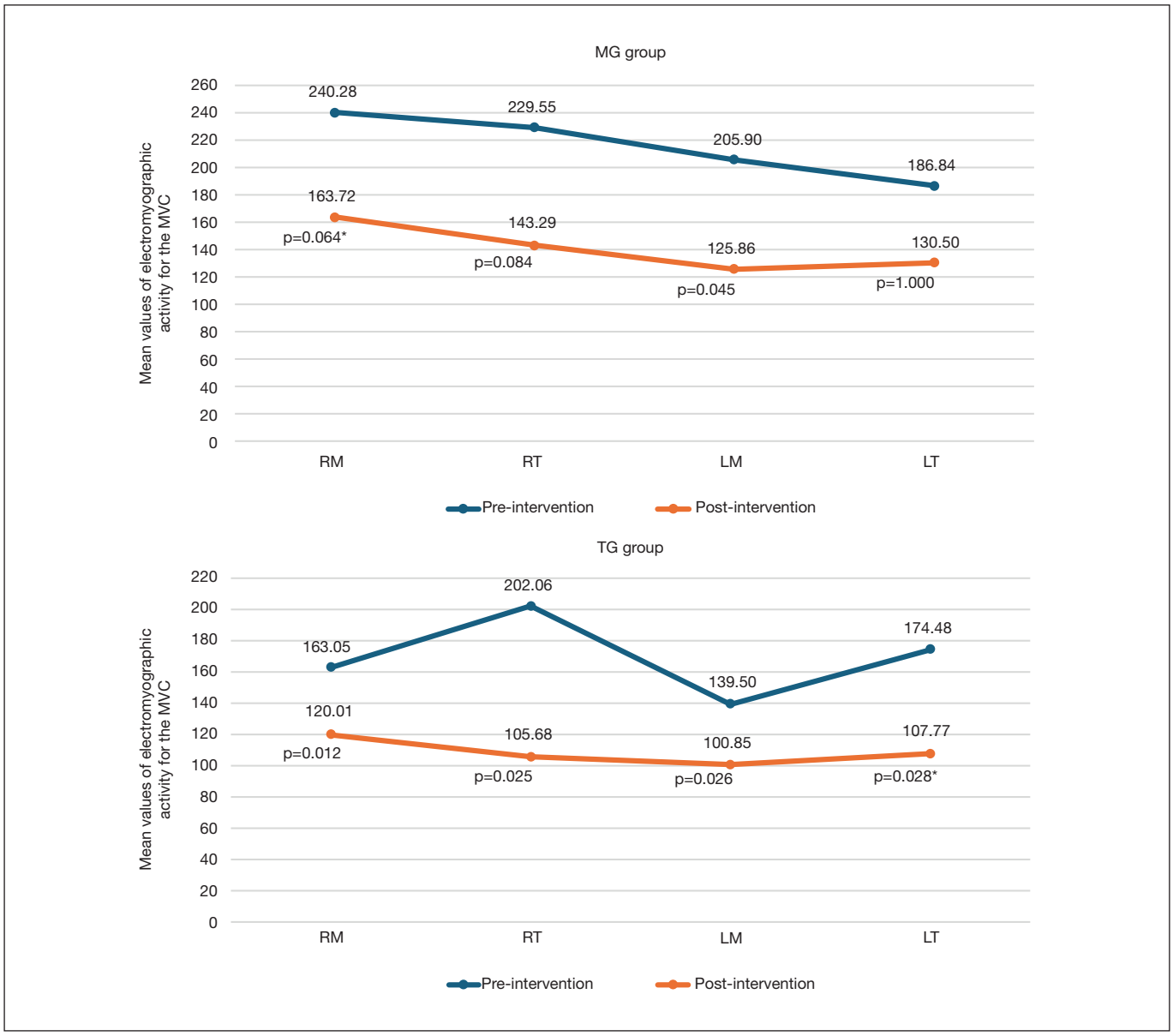

Figure 1. Comparison of the mean values of electromyographic activity for each muscle area in pre- and post-intervention CVM, according to the intervention groups

MG = Manual therapy group; TG = Manual therapy group with TENS; MVC = Maximum Voluntary Contraction; RM = Right masseter; LM = Left masseter; RT = Right temporal; LT = Left temporal. T-test for paired samples. *Wilcoxon test.

red to the pre-intervention values. On the other hand, in TG, lower mean resting electromyographic activity was observed after the intervention for the right masseter (1.68; p=0.046) and left masseter (1.34; p=0.010), as well as for the left temporalis (2.22; p=0.041 - Figure 2).

Figure 3 shows the VAS scores according to the intervention group. There was no statistically significant difference between the initial and final VAS scores between MG and TG groups. However, when comparing the initial and final scores within each intervention group, there was an average VAS score of 0.6 for MG in the post-intervention period, compared to 4.6 in the pre-intervention phase (p=0.002). Similarly, the TG participants had an average VAS score of 5.5 before the intervention, reduced to 0.7 after the intervention (p=0.026).

As a general result of this study, it was found that MVC showed reduced values of muscle electrical activity after the intervention, specifically in the left masseter for MG, and in all the muscles for TG. The findings also indicated that the application of manual therapy alone was as effective as the combination of manual therapy+TENS, since no differences were observed in the measurements before and after the intervention between the two groups. However, after the application of manual therapy+TENS, it was found that the electrical activity values were lower in multiple muscle regions compared to the group that only received manual therapy during MVC. No differences in VAS scores were identified between the two groups before and after the intervention. Nevertheless, a reduction in pain perception was observed in both groups after the intervention.

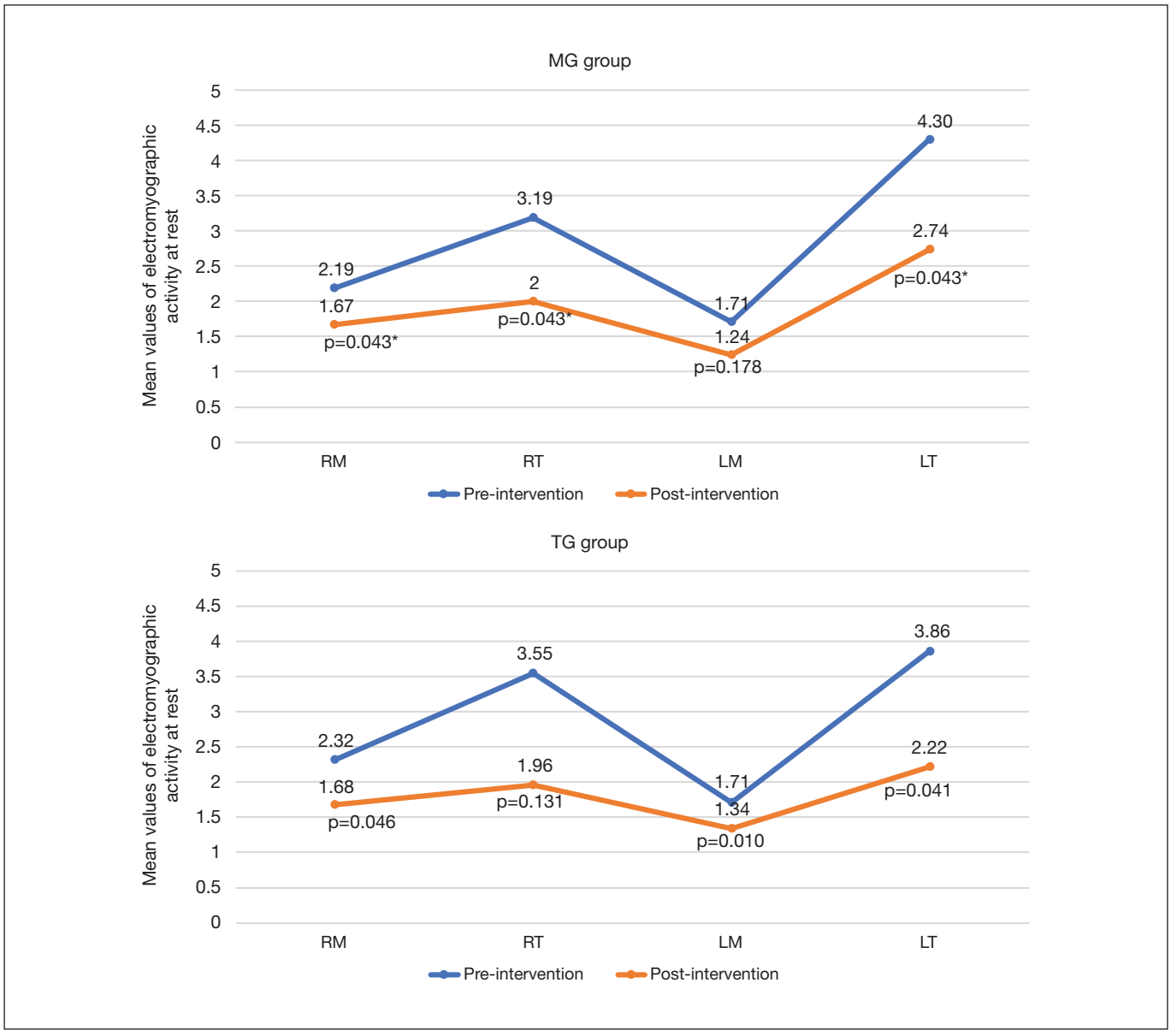

Figure 2. Comparison of the mean values of electromyographic activity for each muscle area at rest, pre- and post-intervention, according to the intervention groups

MG = Manual therapy group; TG = Manual therapy with TENS group; RM = Right masseter; LM = Left masseter; RT = Right temporal; LT = Left temporal. *T*-test for paired samples. *Wilcoxon test.

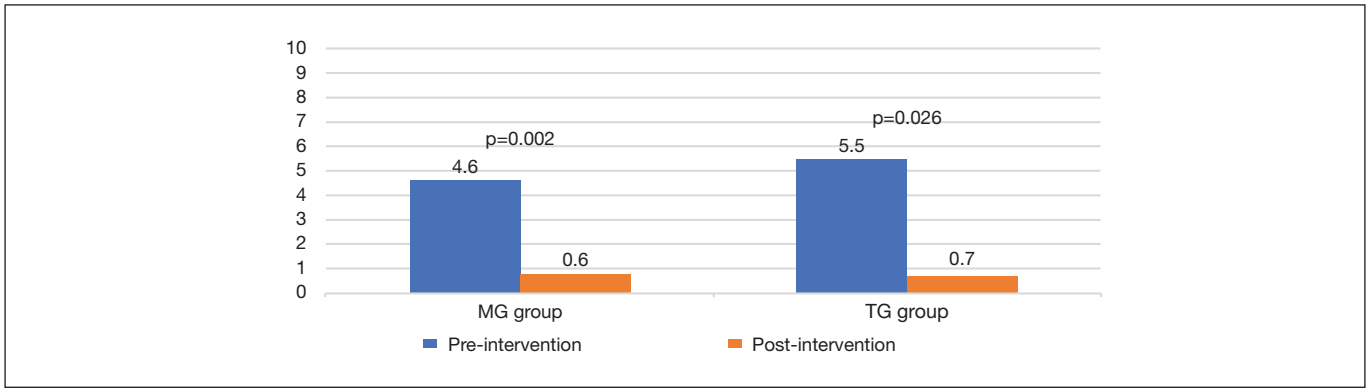

Figure 3. Description of the VAS scores of the manual therapy (MG) and manual therapy+TENS (TG) groups, before and after the intervention

MG = Manual therapy group; TG = Manual therapy with TENS group; VAS = Visual Analog Scale. Mann-Whitney test. Student's *t*-test. Exact p-value for the test of equality of medians. *T*-test for paired samples. Wilcoxon test.

DISCUSSION

This study examined the effectiveness of combining TENS with manual therapy. Although no statistically significant correlation was identified between the groups in relation to MVC and resting electromyographic activity, as well as VAS scores before and after the intervention, a reduction in mean muscle electrical activity and VAS scores was observed when comparing the pre- and post-intervention periods.

In this way, the literature highlights the findings of this research in comparison with other studies, such as this one, which show the relevance of MVC examination, especially in the context of patients diagnosed with TMD. One study compared the MVC capacity of the masseter muscle in individuals with and without TMD to investigate the relationship between pain intensity and MVC. The sample included 50 participants divided into TMD (n=25) and Control (n=25) groups. MVC was measured by bilateral masseter muscle EMG, while the DC/TMD questionnaire assessed the presence of TMD and pain intensity. Results indicated a significantly reduced MVC in TMD group compared to control group ($p<0.05$). In addition, a negative correlation was identified between pain intensity and MVC in the TMD group ($p<0.05$). It is concluded that individuals with TMD have a notable reduction in the masseter muscle's MVC, highlighting the usefulness of MVC assessment to measure the severity of TMD and monitor the effectiveness of therapeutic strategies[31].

The results of this study revealed that MVC showed no statistically significant differences between the intervention groups with and without TENS. However, higher means were observed in the pre-intervention phase for the left masseter (205.9%) and left temporalis (186.84%), while in the post-intervention phase, all means were higher in MG compared to TG. This result suggests a decrease in muscle electrical activity, although without statistical significance. In support of this finding, a study aimed at comparing pre- and post-intervention activity in the masseter and temporal muscles, using myofascial release and post-isometric relaxation in individuals with muscular TMD, selected 60 participants divided into two groups. Group I received post-isometric relaxation treatment, while Group II received myofascial release treatment. Both groups underwent 10 treatment sessions, with the electrical activity of the masseter and temporal muscles monitored using EMG and pain intensity assessed using VAS. After the interventions, there was a significant reduction in muscle electrical activity during MVC and in pain intensity in both groups, with no significant difference between them. These findings highlight the effectiveness of both therapeutic methods for the treatment of TMD[32].

Another study that converges with the results obtained in this study, which involved predominantly women with not only muscular TMD, but also DDR, set out to investigate muscle patterns using EMG in individuals with TMD/DDR. In this study, 64 women with TMD/DDR were compared to a group of 40 women without TMD diagnosis, and the masseter and temporal muscles were assessed using EMG in both groups. The results showed that the women with TMD/DDR showed greater EMG activity compared to those without a TMD diagnosis, showing greater electrical activity in MVC and lower chewing efficiency in the group of women with TMD/DDR compared to control group. The findings of the present study converge directly with the results of this previous study[33].

In the comparative analysis of the mean EMG activity during MVC and at rest, there was a decrease in mean electrical activity in the masseter muscle after therapy in MG. In addition, lower mean contraction values were observed in all the muscles assessed in TG during the post-intervention phase, compared to the pre-intervention phase. This reduction in post-therapy electrical activity is similar to the results of a study involving 40 patients with muscular TMD, divided between active TENS and placebo TENS. The study, which used VAS, EMG and the DC/TMD protocol for assessment, found a significant reduction in VAS immediately after the intervention and 48 hours after treatment in the group receiving active TENS, showing significant balances in muscle electrical activity immediately and 48 hours after the intervention[34].

In order to assess the effectiveness of TENS, a study selected 35 women, 19 of whom had TMD and 16 of whom had no related complaints. TENS treatment was applied once to both groups, lasting 45 minutes. EMG and VAS assessments were carried out immediately before and after TENS application. At rest, the volunteers with TMD showed an increase in EMG activity in the masseter and temporal muscles compared to the group without complaints. However, no differences were identified between the groups during MVC. Notably, in women with TMD, TENS was effective in reducing pain and EMG activity in the masseter and temporal muscles during MVC and mastication. The conclusion is that the TENS application was effective in mitigating pain and balancing the masticatory muscles. Despite the comparison between two groups with TMD and different therapeutic approaches, convergent results were observed in the post-therapeutic effects with the use of TENS[35].

In congruence with the results of this research, an additional study set out to evaluate the effects of TENS on the muscles and pain perception in TMD patients, using EMG and VAS techniques. This investigation involved 80 participants, 58 female and 22 male, aged between 19 and 35, all diagnosed with TMD. During the TENS intervention, there was a significant improvement in VAS scores, accompanied by an optimization in EMG values, indicating a reduction and balance in the electrical signals associated with the muscles of mastication. It was concluded that TENS was effective in attenuating pain symptoms in individuals with TMD, while also promoting a reduction and balance in the electrical signals generated by the masseter and temporal muscles in EMG. This characteristic of muscle balance was also seen in the present study[36].

No statistically significant differences were identified in the initial and final VAS scores between MG and TG groups. However, when comparing the initial and final scores within each intervention group, there was a statistically significant

decrease in pain scores in both groups after the intervention. These findings are in line with the results of a study whose purpose was to evaluate the efficacy of TENS therapy in the treatment of TMD associated with DDR, conducting a randomized clinical trial with 40 patients diagnosed with this condition. Participants were randomly assigned to two groups, one experimental (receiving TENS) and one control (receiving placebo). Pain intensity was assessed using VAS before and after treatment. The results showed that TENS group had a significant reduction in pain compared to placebo group. Thus, it is suggested that TENS therapy may be an effective option in the treatment of TMD associated with DDR, showing a reduction in pain[37,38].

This study had limitations, including the small number of participants due to gradual loss during the therapeutic process, as well as the inclusion and exclusion criteria adopted. Therefore, it is imperative that future research expands the sample, making it possible to generalize the data and obtain statistically significant results between the research groups. Subsequent research is expected to validate the results of this study, corroborating the benefits of manual therapy associated with the use of TENS.

CONCLUSION

The results of this study suggest that both groups showed a reduction in painful sensation. However, the combined approach of TENS with manual therapy provided slightly better benefits in reducing electrical activity and balancing the movements of the masticatory muscles in TMD, compared to using manual therapy alone. Muscle relaxation and analgesia were achieved both with and without the use of TENS.

AUTHORS' CONTRIBUTIONS

Guilherme Lemos Monteiro dos Santos
Data Collection, Project Management, Research, Methodology, Writing - Preparation of the original, Writing - Review and Editing
Fabiane Miron Stefani
Supervision

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