DOI: 10.590/1809-2950/15568322042015

ORIGINAL RESEARCH

Effects of upper cervical manipulation on the electromyographic activity of the masticatory muscles and the opening range of motion of the mouth in women with temporomandibular disorder: randomized and blind clinical trial

Efeitos da manipulação cervical alta sobre a atividade eletromiográfica dos músculos mastigatórios e amplitude de movimento de abertura da boca em mulheres com disfunção temporomandibular: ensaio clínico randomizado e cego

Los efectos de la manipulación cervical en la actividad electromiográfica de los músculos masticatorios y la amplitud del movimiento de apertura de la boca en mujeres con trastorno temporomandibular: un ensayo clínico aleatorizado y ciego

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ABSTRACT | We evaluated the effects of upper cervical manipulation on the surface electromyographic activity (sEMG) of masticatory muscles and range of motion of the opening movement of the mouth in women with temporomandibular disorders (TMD). We evaluated 10 women with myogenic a TMD diagnosis, according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) and divided randomly into an experimental group (EG) n=5, which received upper cervical manipulation, and a placebo group (PG) n=5, which received maneuvers without therapeutic effects. Five interventions were performed in both groups, once a week, with performance of pre-intervention assessments, post-immediate assessments (after 1st intervention) and post-delayed assessments (48 hours after the 5th intervention). The sEMG activity was processed using the root mean square and normalized by the peak value (RMS EMGn). We used for comparison the Student's *t*-test and ANOVA two-way repeated measures, adopting as significance the amount of 5%, and the Cohen *d* for treatment effect size. We found a significant interaction of group vs time ($p<0.05$) in the RMS EMGn of the left and right temporal muscles at rest, as well as for all masticatory muscles during maximal isometric contraction during jaw-elevation and jaw-depression. Treatment effect size, high to moderate, was observed in the EG, especially in the post-delayed assessment. We also observed a significant increase ($p<0.05$) and a high treatment effect during mouth opening in the EG. The upper cervical manipulation demonstrated a balance of the RMS EMGn of the masticatory muscles and increase the opening range of motion of the mouth in women with myogenic TMD.

Keywords | Manipulation, Spinal; Electromyography; Range of Motion, Articular; Temporomandibular Joint Disorders.

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E-mail: drodrigues@unimep.br – Phone: (19) 97872013 – Presentation: Oct. 2015 – Accepted for publication: Dec. 2015 – Approved by the Ethics Research Committee of the Universidade Metodista de Piracicaba (UNIMEP), under protocol number 01/09 and registered in the Brazilian registry of clinical trials (RBR-4j6xfx).

RESUMO | Avaliou-se os efeitos da manipulação cervical alta sobre a atividade eletromiográfica de superfície (sEMG) dos músculos mastigatórios e amplitude do movimento de abertura da boca em mulheres com disfunção temporomandibular (DTM). Foram avaliadas 10 mulheres com diagnóstico de DTM miogênica, segundo o Research Diagnostic Criteria for temporomandibular disorders (RDC/TMD), divididas, aleatoriamente, em grupo experimental (GE) n=5, que recebeu manipulação cervical alta e grupo placebo (GP) n=5, que recebeu manobra sem efeito terapêutico. Cinco intervenções foram aplicadas para ambos os grupos uma vez por semana, e avaliações de pré-intervenção, pós-imediato (após a 1ª intervenção) e pós-tardio (48 horas após a 5ª intervenção) foram realizadas. A atividade sEMG foi processada via raiz quadrada da média e normalizada pelo valor de pico (RMS EMGn). Utilizou-se para comparação os testes *t* de *Student* e *ANOVA two-way* (medidas repetidas), adotando-se como significância o valor de 5%, e o Cohen's d para tamanho de efeito de tratamento. Constatou-se a interação significativa grupo × tempo (p<0,05) no RMS EMGn dos músculos temporal direito e esquerdo, na condição de repouso, assim como para todos os músculos mastigatórios durante contração isométrica máxima de elevação e depressão da mandíbula. Os tamanhos de efeito de tratamento moderado a alto foram observados no GE, destacando-se na avaliação pós-tardia. Foi observado também um aumento significativo (p<0,05) e um alto efeito de tratamento na abertura da boca para o GE. A manipulação cervical alta demonstrou equilibrar o RMS EMGn dos músculos mastigatórios e aumentar a amplitude de movimento de abertura da boca em mulheres com DTM miogênica.
Descritores | Manipulação da Coluna; Eletromiografia; Amplitude de Movimento Articular; Transtornos da Articulação Temporomandibular.

RESUMEN | En este estudio se evaluaron los efectos de la manipulación cervical alta sobre la actividad electromiográfica de superficie (SEMG) de los músculos masticatorios y de amplitud del movimiento de apertura de la boca en mujeres con trastorno temporomandibular (TTM). Se evaluaron 10 mujeres con diagnóstico de TTM miogénico, con base en el Research Diagnostic Criteria for temporomandibular disorders (RDC/TMD), las que fueron aleatoriamente divididas en grupo experimental (GE) n=5, que recibió manipulación cervical alta, y grupo placebo (GP) n=5, que recibió maniobra sin efecto terapéutico. Se aplicaron cinco intervenciones para ambos grupos una vez por semana, y se realizaron evaluaciones preintervención, posintervención inmediata (después de la 1a. intervención) y posintervención tardía (48 horas después de la 5a. intervención). La actividad SEMG fue calculada mediante raíz cuadrada de la media y normalizada por el valor de pico (RMS EMGn). Se empleó para comparación los test t de Student y ANOVA two-way (medidas repetidas), y el nivel de significancia de 5%, y para el efecto del tratamiento el Cohen's d. Se encontró la interacción significativa grupo × tiempo (p<0,05) en el RMS EMGn de los músculos temporales derecho e izquierdo, en reposo, así como para todos los músculos masticatorios durante la contracción isométrica máxima de elevación y depresión de la mandíbula. Se observaron efectos de tratamiento moderado a alto en el GE, destacando en la etapa posevaluación tardía. También se observó un aumento significativo (p<0,05) y un alto resultado del tratamiento en la apertura de la boca en el GE. La manipulación cervical alta demostró equilibrar el RMS EMGn de los músculos masticatorios y aumentar la amplitud del movimiento de la apertura de la boca en mujeres con TTM miogénica.
Palabras clave | Manipulación de la columna; Electromiografía; Amplitud del Movimiento Articular; Trastornos de la Articulación Temporomandibular.

INTRODUCTION

Temporomandibular disorder (TMD) is a term assigned to a subgroup of orofacial pains whose signs and symptoms include limited joint range of motion, pain or discomfort, clicking and noise in the temporomandibular joints (TMJ), which may be accompanied by neck pain, difficulty in chewing and headaches[1].

It is known that there are patterns of coordinated movements between the TMJ, the atlanto-occipital joint and the cervical zygomatic-epiphyseal joints, determined by the intrinsic sensorimotor connection via trigeminocervical complex[2]. Therefore, any change in one of these structures can trigger changes in the other. Several therapeutic modalities have been used for the treatment of TMD, such as massages[3], electrotherapy[4] and spinal manipulation[5].

Spinal manipulation is notable for establishing joint mobility[6-8], promote analgesia[9,10] and change the muscular activity[10,11]. A recent systematic review study found that spinal manipulation techniques can reduce the intensity of pain and improve function in TMJ, however, the authors note that studies with appropriate methodology should be made to provide better clinical evidence regarding the effects of the technique[12].

Generally speaking, studies have shown that manipulation applied to the upper cervical spine (atlas/axis) shows promising effects in clinical practice, such as increased mouth opening range of motion and the pressure pain threshold in individuals with TMD[13], increased joint range of motion of the cervical spine and reduced pain in people with neck pain and atlantoaxial osteoarthritis[7,14,15]. However, some authors warn about the risk of injury to the vertebral artery after application of upper cervical manipulation[16], a risk that, ruled out by Erhardt et al.[17] when faced their recent findings after technical application in asymptomatic individuals.

Thus, for proper use of applied manipulation to the upper cervical spine, we suggest previous performance of specific tests to confirm or not the presence of altered blood flow of vertebral artery and instability of the upper cervical spine, when confirmed, they contraindicate the performance of manipulation[18,19].

Therefore, given the lack of studies that evaluate the effects of upper cervical manipulation on the TMD, especially regarding the electrical activity of the masticatory muscles, taking into account the coordinated movement pattern that exists between the TMJ and the cervical spine and the beneficial results of this technique found in individuals with neck pain and TMD, the aim of this study was to evaluate the effects of upper cervical manipulation on the electrical activity of the masticatory muscles and mouth opening range of motion in patients with myogenic TMD.

Therefore, the hypothesis is that the upper cervical manipulation increases the mouth opening range of motion and balances the electrical activity of masticatory muscles (anterior temporal, masseter and supra-hyoid) of individuals with myogenic TMD, to increase its electric activities during maximal isometric contraction and to reduce their electrical activity at rest.

METHODOLOGY

This research is characterized by a randomized and blind clinical trial.

We selected 10 women aged between 20 and 37 years (25.8±6.8 years) diagnosed with myogenic TMD according to the axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), accompanied by pain and/or fatigue in masticatory muscles during functional activities for a minimum period of one year and a maximum of five years. The volunteers who had no change in vertebral artery flow were included (according to the extension and head rotation test)[18] and instability of the upper cervical spine (according to the Sharp-Purser test)[19].

We excluded from the study: women with tooth loss that used full or partial dental prosthesis, trauma history in the face and TMJ, with subluxation or TMJ dislocation, those with a diagnosis of IIIb (osteoarthritis) or IIIc (osteoarthrosis) according to the RDC/TMD and those that were receiving any kind of treatment for their TMD.

The randomization of this study was performed by a stratified sortition, thus allocating the volunteers into two groups: experimental (EG) n=5, and placebo (PG) n=5. The volunteers were blind regarding the group they belonged to, and the evaluators were also blind regarding the type of intervention.

The study was approved by the Research Ethics Committee of the *Universidade Metodista de Piracicaba* (UNIMEP), under protocol number 01/09 and registered in the Brazilian register of clinical trials (RBR-4j6xfx).

Experimental procedure

We evaluated the electrical activity of the right and left masseter (RM and LM), right and left anterior temporal (RT and LT) and supra-hyoid (SH) using surface electromyography (sEMG). The mouth opening range of motion was assessed by a caliper rule. The sEMG signals were collected in pre intervention period, soon after the 1st intervention (post-immediate) and 48 hours after the 5th intervention (post-late). The opening of the mouth was measured in pre-intervention and post-delayed intervention period.

To measure the range of motion (ROM) of the active mouth opening without pain, we used a caliper ruler (mm). The measures were collected 2 times for each volunteer, we used as the final result, the mean value of the two measurements.

For the sEMG registry, we used an acquisition module of BIO-EMG signals 1000 (Lynx, São Paulo, SP, Brazil) with the same descriptions and parameters described by Berni et al[20].

The electromyographic signal collection of the masticatory muscles was performed at: 1) rest (lips slightly touching and teeth unobstructed), 2) maximal isometric contraction of the jaw-elevation (teeth clenching) and 3) maximal isometric contraction of the jaw-depression (opening mouth against manual resistance provided by the examiner).

For maximum isometric contraction of jaw-elevation, we used the Parafilm® (Chicago) materials, as described by Berni et al[20]. For maximum isometric contraction of jaw-depression, we requested each volunteer to lower their jaw as hard as possible (opening the mouth without bending the head) against the manual resistance provided by the examiner. For each of the situations, three registers of electromyographic signal were taken for 5s, with one-minute intervals between them, and with a randomized sequence of contractions obtained by sortition.

The electromyographic signal was processed in the time domain by means of the root mean square (RMS) and then normalized by RMS peak value (RMS EMGn) via the Matlab® software 2014a (8.3.0.532).

To the EG group, we performed an upper cervical manipulation (occipital, atlas and axis manipulation - OAA), and a right rotation manipulation and another in left rotation. For the manipulative procedure, the volunteers remained in the supine position, and the physical therapist conducted, passively, a slight pull of the head of the volunteers in the upper direction with rotation. After that, a pulse at high speed and short amplitude was accomplished by increasing the rotation parameter[7] (Figure 1). The joints were considered manipulated when noises were produced in one of the three attempts. With lack of cavitation in one of the three attempts, the joints were considered manipulated[7].

Figure 1. Positioning for application of the upper cervical manipulation and placebo maneuver

To the PG, a similar maneuver was performed, however without traction and quick boost in rotation[8,21]. It is important to note that in the PG, the position without rotation was maintained for 15 seconds on each side. In both groups, there were 5 interventions, one per week, by a physical therapist specialized in Osteopathy with 10 years of experience.

Statistical analysis

The data normality was tested by the Shapiro-Wilk test, which showed normal distribution of data ($p>0.05$). After finding the normality assumption, we followed up with the comparison of data using the ANOVA two-way test repeated measures to the RMS EMGn variables. The time factor (pre- and post-immediate and post-delayed) was used as within-subject and the group factor (EG and PG) as between-subject. The hypothesis of interest was the group x time interaction. We also used Student's *t*-test for intra and inter-group comparison for the mouth opening ROM variable.

The level of significance used for the analysis of all statistical tests described was 5%.

The intra-group clinical treatment effect size was assessed using the Cohen *d* test for all the dependent variables of the research. The "*d*" values established were: "low treatment effect" (≤0.2), "moderate treatment effect" (≅0.5) and "high treatment effect" (≥0.8)[22].

RESULTS

This study was conducted in the laboratory of therapeutic resources of the UNIMEP, between the months of February 2009 and December 2010. Figure 2 shows the flowchart of recruitment, distribution and sample analysis, in which 29 volunteers were previously enrolled, 19 excluded for not meeting the eligibility criteria, i.e., 10 had no diagnosis of myogenic TMD using the RDC/TMD, 3 were already receiving dental treatment during enrollment and 2 dropped out of the study. After volunteer exclusion, the remaining 10 were randomly allocated in the EG and the PG for further analysis.

In the analysis using Student's *t*-test (Table 1), we observed a significant increase in the mouth opening range of motion for the EG in the late post-delayed assessment and high clinical treatment effect. There was no significant difference between groups for any of the evaluation periods.

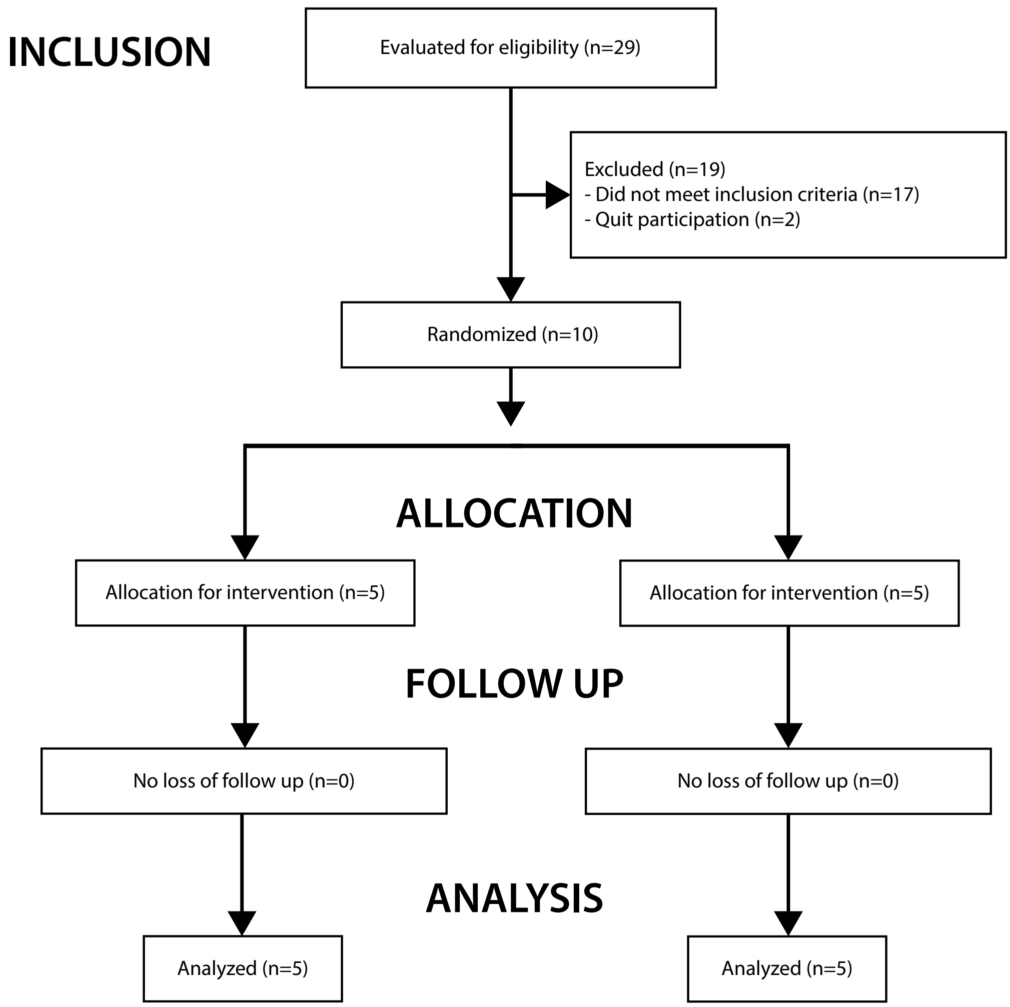

Figure 2. Flowchart for sample distribution

Table 1. Intra- and inter-group comparison of the amplitude of mouth opening

	PRE Mean ± SD	POST Mean ± SD	Δ POST x PRE (95%CI)
Experimental Group	27,60±8,56	37,60±11,15	10,00 (3,35;16,65)*, d=1,00
Placebo Group	40,60±11,76	42,40±14,67	1,80 (-4,85;8,45), d=0,13

PRE: pre-intervention assessment; POST: Post-delayed assessment. Δ: difference between the means
Student t-test
*Significant intra-group difference (p<0.05)
Size of the clinical treatment effect - *Cohen d*

In the ANOVA two-way analysis with repeated measures in mandibular rest (Table 2), we found significant group x time interaction only for the LT muscles (F=5.72; p=0.13) and RT muscles (F=7.17; p=0.006). In the Bonferroni correction, there was a significant reduction of the RMS EMGn of the LT muscles in post-immediate assessment and RT muscles in the post-delayed assessment for EG; as well as in the moderate to high clinical treatment effect in all evaluated muscles. In the intergroup analysis, we observed significantly lower activity of the LT and RT muscles for the EG in the post-delayed period.

In the ANOVA two-way analysis with repeated measures on maximal isometric contraction of jaw-elevation (Table 3), we observed a significant group x time interaction for LT muscles (F=9.28; p=0.002), RT (F=8.61; p=0.003), LM (F=11.99; p=0.001) and RM (F=24.94; p=0.000). In the Bonferroni correction, we observed significant increase in RMS EMGn in all assessments and muscles of the EG (except for LT in the post-immediate); as well as moderate to high clinical treatment effect on the EG for all muscles. We also found a significant increase in the LT muscle activity of the EG in the intergroup post-delayed assessment.

In the ANOVA two-way analysis with repeated measures in maximal isometric contraction of the jaw-depression (Table 3), we observed a significant group x time interaction for the SH muscles (F=34.30, p=0.000). In the Bonferroni correction, we observed a significant increase in RMS EMGn of the SH muscles at all moments of the assessment, and high clinical treatment effect. We also observed significant increase in the muscles activity in the SH of the EG in the intergroup post-delayed assessment.

Table 2. Intra and inter-group comparison of the EMG RMS values of masticatory muscles at rest

	PRE Mean ± SD	POSI Mean ± SD	POST Mean ± SD	Δ POSI x PRE (95%CI)	Δ POST x PRE (95%CI)
Left Temporal Muscle					
Experimental Group	0.76±0.41	0,32±0,12	0,32±0,10**	-0,44(-0,85; -0,02)*, d=-1,45	-0,44(-0,89;0,01), d=-1,49
Placebo Group	0.70±0.37	0,76±0,46	0,79±0,36	0,06(-0,35;0,47), d=0,14	0,09(-0,36;0,54), d=0,24
Left Masseter Muscle					
Experimental Group	0.55±0.42	0,26±0,04	0,27±0,08	-0,29(-0,68;0,10), d=-0,99	-0,28(-0,67;0,11), d=-0,93
Placebo Group	0.54±0.32	0,46±0,28	0,52±0,13	-0,08(-0,47;0,31), d=-0,25	-0,02(-0,41;0,37), d=-0,09
Right Temporal Muscle					
Experimental Group	0.97±0.48	0,71±0,54	0,38±0,17**	-0,26(-0,56;0,05), d=-0,49	-0,59(-1,01;-0,17)*, d=-1,62
Placebo Group	0.91±0.28	0,92±0,25	0,99±0,18	0,02(-0,28;0,32), d=0,07	0,09(-0,33;0,51), d=0,37
Right Masseter Muscle					
Experimental Group	0.42±0.20	0,30±0,10	0,25±0,04	-0,12(-0,28;0,04), d=-0,77	-0,18(-0,40;0,05), d=-1,19
Placebo Group	0.53±0.41	0,51±0,41	0,62±0,48	-0,01(-0,17;0,15), d=-0,03	0,10(-0,13;0,32), d=0,22
Supra-Hyoid Muscles					
Experimental Group	1.96±1.52	1,26±0,58	0,84 ±0,19	-0,70(-1,66;0,26), d=-0,61	-1,11(-2,72;0,49), d=-1,03
Placebo Group	1.89±1.42	1,87±1,42	2,36 ±2,21	-0,02(-0,98;0,94), d=-0,01	0,47(-1,14;2,08), d=0,25

PRE: pre-intervention assessment; POSI: post-immediate assessment; POST: Post-delayed assessment. **Δ**: difference between the means
ANOVA two-way test repeated measures with Bonferroni correction:
*Significant intra-group difference (p<0.05)
** Significant inter-group difference (p<0.05)
Size of the clinical treatment effect - *Cohen d.*

Table 3. Intra and inter-group comparison of the EMG RMS values of masticatory muscles during maximal lifting contraction of the jaw and during maximal isometric depression contraction of the jaw

	PRE Mean ± SD	POSI Mean ± SD	POST Mean ± SD	Δ POSI x PRE (95%CI)	Δ POST x PRE (95%CI)
Left Temporal Muscle - Maximal isometric lifting contraction of the jaw					
Experimental Group	0.61±0.25	0.73±0.31	0.84±0.38**	0.13 (-0.00;0.26), d=0.45	0.24 (0.07;0.40)*, d=0.73
Placebo Group	0.69 ±0.35	0.72±0.34	0.65±0.34	0.03 (-0.10;0.16), d=0.09	-0.04 (-0.21;0.13), d=-0.12
Left Masseter Muscle - Maximal isometric lifting contraction of the jaw					
Experimental Group	0.49±0.25	0.65±0.26	0.68±0.23	0.16 (0.04;0.28)*, d=0.62	0.20 (0.08;0.31)*, d=0.80
Placebo Group	0.51±0.15	0.52±0.17	0.48±0.18	0.01 (-0.10;0.13), d=0.09	-0.04 (-0.15;0.08), d=-0.21
Right Temporal Muscle - Maximal isometric lifting contraction of the jaw					
Experimental Group	0.47±0.16	0.57±0.13	0.59±0.13	0.10 (0.04;0.16)*, d=0.67	0.12 (0.06;0.18)*, d=0.81
Placebo Group	0.52±0.26	0.52±0.23	0.54±0.26	0.01 (-0.05;0.07), d=0.03	0.02 (-0.04;0.08), d=0.08
Right Masseter Muslce - Maximal isometric lifting contraction of the jaw					
Experimental Group	0.51±0.35	0.65±0.39	0.73±0.39	0.14 (0.05;0.23)*, d=0.37	0.22 (0.14;0.30)*, d=0.58
Placebo Group	0.46±0.19	0.45±0.17	0.43±0.18	-0.01 (-0.10;0.08), d=-0.03	-0.03 (-0.11;0.05), d=-0.16
Supra-Hyoid Muscles - Maximal isometric depression contraction of the jaw					
Experimental Group	0.92±0.09	1.38±0.16	1.73±0.23**	0,46 (0.26; 0.66)*, d=3.52	0.81 (0.62;1.01)*, d=4.62
Placebo Group	1.05±0.20	1.13±0.24	1.08±0.15	0,08 (-0.12; 0.28), d=0.37	0.03 (-0.16;0.23), d=0.18

PRE: pre-intervention assessment; POSI: post-immediate assessment; POST: Post-delayed assessment. **Δ**: difference between the means
ANOVA two-way test repeated measures with Bonferroni correction:
*Significant intra-group difference (p<0.05)
** Significant inter-group difference (p<0.05)
Size of the clinical treatment effect - *Cohen d*

DISCUSSION

Individuals with TMD have an increased electrical activity of their masticatory muscles at rest when compared to asymptomatic, and this increase is even more pronounced in the anterior temporal muscle[23]. Given the above, we observed that the upper cervical manipulation technique was able to significantly reduce the RMS EMGn value of the LT and RT muscles in the EG. We believe that the RT and LT muscles had heightened activity and, therefore, more susceptible to the therapeutic effect of the manipulations. However, despite RMS EMGn not having been significantly reduced in the LM and RM muscles, their RMS EMGn values presented themselves much lower in the LG than in the PG after the manipulations.

According to Berni et al.[20], the electrical activity of masticatory muscles at rest is an accurate index for the assessment of individuals with myogenic TMD and without TMD and, therefore, is characterized as an important tool for clinical practice. Thus, the results found in this study help to unravel the initial information of the effects of the high cervical manipulation technique on the electrical activity of masticatory muscles at rest in women with myogenic TMD.

In the task of maximal isometric contraction of the jaw-elevation, research shows that the masticatory muscles (LT, RT, RM and LM) have reduced electrical activity when compared to asymptomatic individuals[20,23]. Based on this assumption, the study demonstrated that upper cervical manipulation significantly increases the RMS EMGn of all masticatory muscles involved in the task, with higher treatment effects in post-delayed assessment to all the muscles in the EG.

In the task of maximal isometric contraction of the jaw-depression, no information was found in the literature that characterizes the difference between TMD and asymptomatic patients. However, Packer et al.[5] found a significant increase in the activity of SH muscles in the same task analyzed in TMD patients after a single manipulation of the upper thoracic spine, which is similar to this study that found significantly increased RMS EMGn and high clinical treatment effect of the SH muscles (in both moments of assessments) in the EG. Which in fact, suggests the possibility of spinal manipulation techniques having potential and promising effects in the evaluated muscles.

According to Pickar[24], spinal manipulation can modulate the influx of sensory signals from the paraspinal muscles that are neuroanatomically connected to the manipulated level, and thereby improve the function of these muscles by changing their myoelectric activity. In this study, we believe that a similar modulation process occured, since there was a manipulation effect in all the masticatory muscles, with these muscles connected to the neuroanatomically with the manipulated level via the trigeminocervical complex.

The event described is confirmed by Bicalho et al.[25] that found a significant increase in the sEMG potentials of the lumbar paraspinal muscles during the isometric task in spinal extension after vertebral manipulation in the lumbar spine in patients with lumbago, and Camargo et al.[26] that observed an increase in non-normalized electromyographic RMS in the deltoid muscle during the task of isometric contraction in shoulder abduction at 90° after manipulation of the 5th/6th cervical vertebra. On the other hand, Pires et al.[27] found no significant changes in the non-normalized electromyographic RMS of the sternocleidomastoid muscles during maximal isometric contraction in shoulder-elevation and head-flexion after high thoracic manipulation, which might be explained by a lack of nerve connection of the evaluated muscles with the segment manipulated.

We also observed that the upper cervical manipulation significantly increased the mouth opening range of motion in the EG with high clinical treatment effect. This result parallels with the work of Mansilla-Ferragut[7] that evaluated the immediate effects of manipulation of the upper cervical spine in patients with chronic neck pain and reduced mouth opening ROM, noting increased ROM after the technique application. La Touche et al.[28] performed 10 sessions of articulate mobilization and stabilization exercises in the cervical region in TMD patients, finding a significant increase in mouth opening ROM (24 hours and 12 weeks after the intervention).

We believe that increased mouth opening ROM in this study occurred due to the higher activation of the depressor muscles and relaxation of the mandible elevator muscles, which can be evidenced by the high sizes of the clinical treatment effects observed in the post-delayed assessment in the EMGn RMS values of the masticatory muscles, especially in the SH muscles.

The limitations found in this study were: 1) conducting assessments only in post-immediate and post-delayed periods (after 48 hours of the last session), since even more satisfactory results could have been observed in long-term assessments due to the chronicity of the TDM evaluated, and the higher clinical effects found in the post-delayed assessment for all tasks and evaluated muscles; 2) assessments of the electrical activity of masticatory muscles only during rest and during maximal isometric contractions, since different information could have been determined in more functional joint tasks; 3) small sample size, justified in part due to the methodological rigor used in this study to evaluate the effects of high cervical manipulation on a sample specifically defined, i.e., with myogenic TMD and 4) lack of assessment of the dominant mastigatoy side of the volunteers, since such information could elucidate different information and interpretations of the results.

However, considering the small "*n*" sample and due care in the interpretation of the results expressed in this study, the same was able to provide novel and positive information about the RMS EMGn values of the masticatory muscles of women with myogenic TMD and, therefore, we suggest that future clinical trials, with a larger sample size, be conducted keeping the methodological rigor used in this study to elucidate the long-term effects of the technique. Finally, regarding the upper cervical manipulation, the study presents relevant information so the clinician physiotherapist may analyze the importance of a potential tool for the treatment of myogenic TMD.

CONCLUSION

We conclude that the hypothesis of this study was confirmed, since manipulation in the upper cervical spine was effective to balance out the RMS EMGn activity of masticatory muscles and increase the mouth opening range of motion in women with myogenic TMD. However, we emphasize the importance of caution in interpreting results due to the small sample size presented in this study.

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