Manual Therapy, Posturology & Rehabilitation Journal
formerly REVISTA TERAPIA MANUAL

RESEARCH ARTICLE

http://dx.doi.org/10.17784/mtprehabjournal.2016.14.317

Biofotogrametric and electromyographic analysis in different position in women with temporomandibular disorder.

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ABSTRACT

Introduction: The relationship established between TMJ (Temporomandibular Joint), cranium and cervical spine requires the synchrony of these structures for the proper performance of stomatognathic functions and muscle balance in this region. **Objective:** Evaluate the craniocervical posture and the electrical activity of masticatory and cervical muscles in sitting and standing positions in patients with TMD, correlating these variables. **Method:** The participants were 21 women, with mean age 28 ± 5.33 years and severe TMD. The participants were evaluated by electromyography of the masseter, anterior temporal and sternocleidomastoid (SCM) and upper trapezius muscles, bilaterally, in standing and sitting position. The body posture was evaluated by biophotogrammetry, with analysis of the Head Horizontal Alignment (HHA) and Acromion Horizontal Alignment (AHA) in frontal view and the Head Vertical Alignment (HVA) and Head Horizontal Alignment related to seventh cervical vertebra (HHAc7) in lateral view. **Results:** The electrical activity of masticatory muscles during resting did not differ between the different evaluated positions. During maximum intercuspation, the electrical activity was significantly lower in the left masseter (p=0.016), higher in the left anterior temporal muscle (p=0.046) and higher in the right (p=0.005) and left (p=0.015) upper trapezius muscles, in standing position when compared to sitting position. The photogrammetric values found were within the normal range. There was a significant and moderate negative correlation between the left SCM muscle and the right (r=0.386) and left (r=0.428) HHAc7 angle. **Conclusions:** Muscular electrical activity was modified with the change between sitting and standing positions, with an increase in cervical muscle recruitment and asynchrony of the masticatory muscles. Thus, it can be inferred that there is a postural destabilization with possible head anteriorization during maximum intercuspation, reinforcing the relation of synergy between the masticatory and cervical muscles.

Keywords: Temporomandibular Joint Disorders; Posture; Electromyography.

INTRODUCTION

Temporomandibular disorders (TMD) is a chronic disease of non-dental origin most prevalent to affect the stomatognathic system, affecting the masticatory muscles, the temporomandibular joint (TMJ), the cervical spine and surrounding structures. Common symptoms of TMD include localized pain over the face and cervical region, movement limitation, joint noises and tenderness to palpation of masticatory structures. (1, 2)

Studies demonstrated the close link between TMD and body posture, (3, 4) however, it is considered scarce conducting research with assessment tools, such as electromyography, in different body positions, supporting the influence of body posture on the electrical activity of masticatory muscles in patients with TMD. Postural changes are frequently observed in patients with TMD, because constant and coherent body adjustments are necessary to maintain the standing position in order to keep properly aligned and oriented the body segments. (2)

Electromyography has been widely used to assess the changes caused by TMD. Such assessments have been conducted in the sitting position with feet on the ground (1, 5) and in standing position. (6) Although only few studies explore different positions of evaluation while acquiring electromyographic recordings, this research is distinguished for comparing the different positions, in addition, correlate these values with the postural evaluation of individuals with TMD. However, there are no studies that compare the masticatory and cervical muscle recruitment pattern in different body positions in patients with TMD.

It is believed that when there is a postural impairment associated with TMD, there will be a greater recruitment of masticatory and cervical muscles in the standing position compared to the sitting position.

The objective of this research was to evaluate the electrical activity of masticatory and cervical muscles in different body positions and the body posture in patients with TMD,

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Financial support: Supported by "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" (CAPES), Brazil.
Submission date 21 May 2016; Acceptance date 5 August 2016; Publication online date 20 August 2016

correlating the electromyographic and biophotogrammetric variables.

METHOD

This study was approved by the Ethics Committee of the Federal University of Santa Maria (UFSM) in the Protocol nº: 0281.0.243.000-08. The study participants were from the Dental Clinic of the UFSM and volunteers who responded to the research dissemination in electronic media. The sample selection process and the description of the inclusion and exclusion criteria are shown in Figure 1.

To detect the presence of TMD, the RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders) was used. [7] This instrument is divided into two axes being Axis I for the physical signs and symptoms of TMD and Axis II for the associated psychological and psychosocial factors. To evaluate the severity of temporomandibular dysfunction was applied the Temporomandibular Index (TMI), which consists of three sub-indices: functional index (FI), muscle index (MI) and articular index (AI). The average value of the indexes can range from zero to 1, with 1 being the highest possible score, indicating greater severity of the dysfunction.

All participants were evaluated by electromyography (EMG) of sternocleidomastoid (SCM) and upper trapezius (UT) cervical muscles, and masseter (MA) and anterior temporal (AT) masticatory muscles, bilaterally. The acquisition was carried out with 400 Miotool equipment (Miotec®, Porto Alegre, RS, Brazil), with eight channels, 14-byte resolution, 2000 Hz sampling frequency, 110 dB common mode rejection, and a 20-500 Hz bandpass filter. The EMG data were recorded by MiotechSuite 1.0 software (Miotec®) and stored on an Asus notebook computer, AR5B125 model. Ag-AgCl bipolar surface electrodes (Hal Indústria Comércio de Metais Ltda, São Paulo, SP, Brazil) were positioned in the assessed muscles, connected to the active sensors (Miotec®). A reference electrode was placed in the sternum bone of each subject, in order to avoid interference and noise. [8] Prior to placement of the electrodes, skin was cleaned with gauze soaked with 70% alcohol (Isek - International Society of Electromyography and Kinesiology).

The electromyographic records of the masseter and temporalis muscles were performed in mandibular rest and maximum intercuspation (MI) conditions with the volunteer in sitting position, with feet parallel to the ground, hands resting on her thighs and looking for a fixed point at eye height. Then the same tests were performed in a standing position, in normal posture, without interference from the examiner, only with guidance to direct the look to a fixed point at eye height.

During MI recording, participants were asked to clench their teeth as much as possible maintaining the contraction for 5 seconds. For the evaluation of mandibular rest, the volunteers were instructed to keep the jaw relaxed, with no occlusal contact, also for 5 seconds.

It was also recorded the maximal voluntary contraction (MVC) of MA and TA muscles during maximal clenching, with Parafilm material positioned between the first and second molars bilaterally. Parafilm was folded 20 times with similar width and thickness of a Trident® gum (3.5 x 1.5 cm) [9] 2010). Using the MiotecSuite 1.0® program, the volunteer, under verbal stimulation of the examiner "*Bite and force, force*", with maximum effort. As the force showed a decrease the

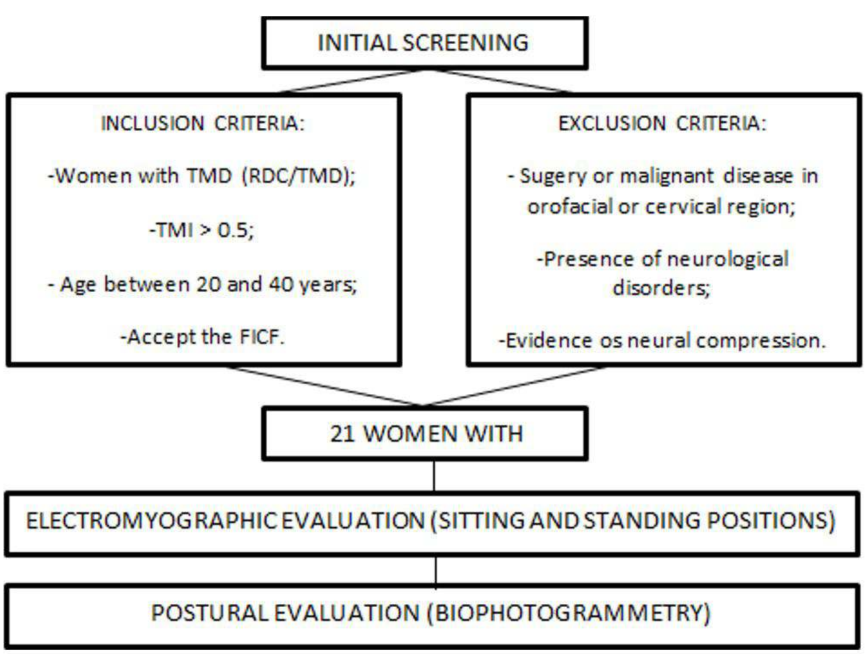

Figure 1. Flow chart of TMD (Temporomandibular Disorders) search; RDC/TMD: Diagnostic Criteria for Temporomandibular Disorders Research; TMI: Temporomandibular Index; FICF: Free and Informed Consent Form.

verbal stimulus was ceased and the MVC was recorded in the program. The same procedure was used for the cervical muscles SCM and UT by verbal commands "*Push the chin down and force, force, force*" and "*Push your shoulders up and force, force, force*", respectively. In these last tests, was used an apparatus to provide resistance under the chin and on the shoulders, respectively.[10]

The electromyographic signal was processed by the Root Mean Square (RMS) and normalized using the MVC values as reference (equation 1).

$$RMS\% = \frac{RMS\ Value\ of\ Activity}{RMS\ Value\ of\ MVC} \times 100 \qquad (1)$$

Body posture was evaluated by computerized biophotogrammetry with photographic records in the frontal and sagittal planes (anterior, right and left side views). [11] The photographs were obtained in the standing position. The participants were dressed in bathing suit and barefoot in a scenario consisting of a black background (3m x 1.5m), a plumb line attached to the ceiling was positioned in a perpendicular plane to the subject evaluated, and subsequent to image calibration was used two polystyrene balls attached to the plumb line and positioned 1 meter away from each other. [12] The camera (Nikon, Coolpix S2500DSC, with resolution of 12 megapixels, 4x zoom) was located three meters away from the subject and supported on a tripod at a height of 1.20 meters. The anatomical points were marked on the body of participants with polystyrene balls and double-sided tape and the analysis were performed by the Postural Assessment Software - PAS v.0.68. Were selected craniocervical posture measures, since this region is often affected in patients with TMD and for the applicability to correlate with the EMG of masticatory and cervical muscles. The anatomical points and their angles used for analysis were (Figure 2):

- Acromion Horizontal Alignment (AHA), angle formed between a line passing through the right and left acromion and a horizontal line;
- Head Vertical Alignment (HVA), angle formed by C7, tragus and a vertical line;
- Head Horizontal Alignment (HHA), angle drawn between the points of the tragus, bilaterally, and a horizontal line;
- Head Horizontal Alignment related to seventh cervical vertebra (HHAc7), angle formed by the tragus line and C7 with the horizontal line; [13]

Data regarding the electromyographic evaluation were expressed as median and quartiles (25-75%), according to the nonparametric distribution presented by them in the *Kolmogorov-Smirnov* test. The comparison between the electromyographic activity of masticatory and cervical muscles during resting and MI in the sitting and standing position situations was analyzed by the *Wilcoxon* test. The significance level considered was $p < 0.05$. To analyze the correlation between the values obtained in EMG records and values of biophotogrammetry was used Spearman correlation coefficient (r), since the sample is not normally distributed. For interpretation of the magnitude of the correlations was adopted the following classification, according the value of r: weak = $0 < r < 0.3$, moderate = $0.3 < r < 0.7$ e strong > 0.7. [14]

RESULTS

The participants were 21 women, with mean age 28 ± 5.33 years and severe TMD (mean score = 0.73), according to the temporomandibular index. [15] Figure 3 shows the data of the evaluated patients regarding the side of masticatory preference and the side affected by TMD.

Table 1 shows the median and quartiles of normalized RMS values regarding the electromyographic activity of the masseter, anterior temporal, sternocleidomastoid and upper

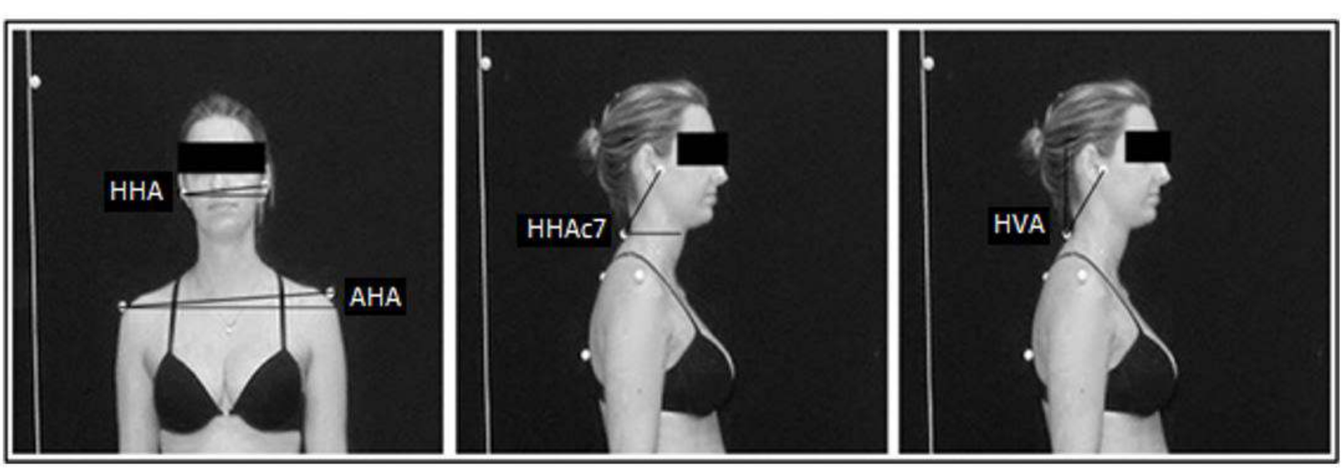

Figure 2. Anatomic points marked for evaluation of the angles: Acromion Horizontal Alignment (AHA); Head Vertical Alignment (HVA); Head Horizontal Alignment (HHA); Head Horizontal Alignment C7 (HHAc7)

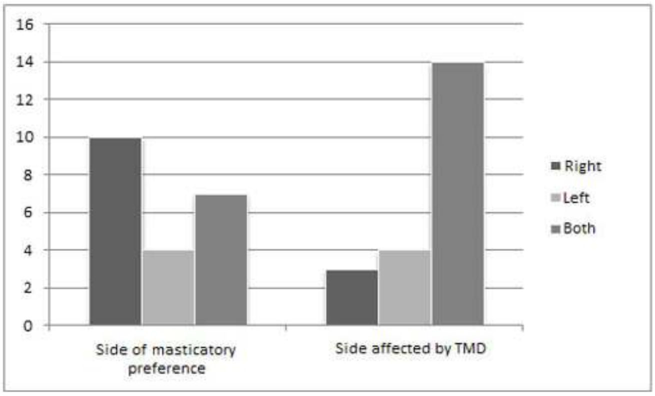

Figure 3. Side of masticatory preference and side affected by TMD.

trapezius bilaterally during conditions of rest and maximum dental intercuspation in sitting and standing position.

There was no statistically significant difference in the electrical activity of masticatory muscles during rest when comparing the different positions. During maximum intercuspation, the electrical activity was significantly lower in the left masseter muscle and higher in the left anterior temporal muscle in standing position when compared to siting position. The right and left upper trapezius muscles presented higher electrical activity in standing compared to sitting position.

The results of biophotogrammetry evaluation showed angular mean values of: 49.94° ± 5.84° to right HHAc7

Table 1. EMG normalized values (%) of masticatory and cervical muscles during mandibular rest and maximum intercuspation in siting and standing positions.

Muscles	Task	Position	Median	Quartiles (25-75%)		*P*
R MA	Rest	Siting	0.98	0.73	1.82	NS
		Standing	0.96	0.63	2.06	
	MI	Siting	72.93	53.30	82.18	NS
		Standing	62.94	45.33	86.36	
L MA	Rest	Siting	0.90	0.45	1.39	NS
		Standing	0.95	0.47	1.26	
	MI	Siting	78.88	63.83	98.62	0.016*
		Standing	70.26	57.46	87.10	
R AT	Rest	Siting	1.57	1.01	2.20	NS
		Standing	1.64	0.94	1.98	
	MI	Siting	79.49	66.72	85.77	NS
		Standing	71.06	65.07	89.75	
L AT	Rest	Siting	1.07	0.55	1.52	NS
		Standing	1.04	0.49	1.83	
	MI	Siting	76.69	68.90	89.10	0.046*
		Standing	79.38	61.02	87.28	
R SCM	Rest	Siting	2.22	1.36	4.65	NS
		Standing	2.01	1.47	4.41	
	MI	Siting	9.62	7.39	18.67	NS
		Standing	9.46	6.59	15.91	
L SCM	Rest	Siting	1.65	1.22	3.47	NS
		Standing	1.64	1.22	3.33	
	MI	Siting	8.34	5.47	13.89	NS
		Standing	7.50	5.50	10.10	
R UT	Rest	Siting	2.29	1.375	4.81	0.001*
		Standing	3.39	2.17	11.925	
	MI	Siting	3.06	2.69	6.26	0.005*
		Standing	6.04	2.75	10.97	
L UT	Rest	Siting	1.78	0.98	4.52	0.008*
		Standing	1.94	1.57	5.48	
	MI	Siting	3.01	1.38	4.14	0.015*
		Standing	4.22	1.46	8.49	

* Significant difference ($p < 0.05$; *Wilcoxon test*). R: Right; L: Left; MA: masseter; AT: anterior temporal; SCM: sternocleidomastoid; UT: upper trapezius; MI: maximum intercuspation; NS: non-significant.

and 50.22° ± 5.34° to left HHAc7; 2,33° ± 2,68° to HVA in right lateral view and 11.02° ± 6,56° to HVA in left lateral view and 2˚ ± 1,57˚ to HHA in anterior view. The angular values of biophotogrammetric measures were similar to those found in the literature for asymptomatic individuals, therefore, considered within the normal range. [13, 16]

Negative and moderate correlation were found between the L SCM muscle and the corresponding angles of R HHAc7 (r= -0.386; p=0.084) and L HHAc7 (r= -0.428; p=0.053) in standing position and maximum intercuspation (Table 2). In the same situation, there was also a moderate positive correlation between the right upper trapezius muscle and the Head Vertical Alignment angle (r=0.463; p=0.034) (Table 2).

DISCUSSION

According to the results of this study, there was a decrease in the activity of the left masseter muscle and an increase in the activity of the left anterior temporal muscle in the standing position during maximum intercuspation in relation to the sitting position. It can be noticed that the temporal muscle may be exerting greater masticatory activity, on demand of the maximum intercuspation and under the influence of orthostatic posture.

There is a tendency to increased activity of the left anterior temporal muscle on the homolateral masseter and lower activity of the right anterior temporal on the homolateral masseter in patients with different degrees of TMD severity when compared to a control group, regardless of the evaluated position. [1,6] This muscular adaptation, which the temporal muscle assumes the additional function to compensate the loss of the masseter muscle strength, may occur to minimize pain in a motor response in individuals with TMD. [17] Alterations in the electrical activity of masticatory muscles in patients with TMD has been related to muscle pain, emotional factors, stress and tension, moreover, greater muscle asymmetry can be observed in this group of patients during the sitting evaluation and MI. [18, 19] As the results of this study, authors demonstrated in their study a greater activity of the left anterior temporal than the masseter in patients with TMD, when evaluated during MI. [20]

The inversion in the pattern of electrical activity in masticatory muscles can also be attributed to possible postural action performed by the anterior temporal muscle and the relation between greater contact of the anterior teeth and relative increase in the activity of this muscle. [8] Such action seems to make the anterior temporal more sensitive to occlusal changes and to increment of the masticatory activity. Thus, there seems to have a recruitment strategy of differentiated motor unit between the masseter and temporal muscles and between individuals with and without TMD. [21] A study demonstrated that there is a greater asymmetry in the activation of the temporal, masseter and sternocleidomastoid muscles of individuals with TMD, i.e., a greater muscle activity of a side to perform mandibular movement and maintain the head upright and there is a greater probability of muscle fatigue and consequent increased pain. [22]

Analyzing the electrical activity of the masticatory muscles, it is observed that the values in the mandibular rest were 0.98 µV in R MA, 0.90 µV in L MA, 1.57 µV in R AT and 1.07 µV in L AT. Similar values of muscle activity were found in women with TMD and mean age 25.69 ± 5.13. [18] Another study found higher values when compared to the results of this research (R MA = 1.71; L MA = 2.35; R AT = 2.55; L AT = 2.47). [2] The authors found that patients with different degrees of severity of TMD evaluated with electromyography in resting showed higher electrical activity of the masseter and temporal muscles, especially when such impairment is considered severe. Although this research group has shown TMI higher than 0.5, the electrical activity of the masticatory muscles in resting showed values similar to individuals with TMD after treatment.

The pattern of chewing on the right side overcame the left and but not the bilateral preference, what may explain the increase in muscle electrical activity in the right side of the four evaluated muscles during the mandibular rest. The tendency towards a pattern of unilateral masticatory preference is

Table 2. Correlation between the biophotogrammetry and electromyographic evaluation in sitting and standing positions.

Muscles	HHA	AHA	R HHAc7	R HVA	L HHAc7	L HVA
L SCM sitting	0.152	0.130	-0.343	0.069	-0.368	0.306
L SCM standing	0.077	-0.007	-0.386*	-0.026	-0.428*	0.267
R SCM sitting	0.124	0.122	-0.243	-0.116	-0.240	0.071
R SCM standing	0.106	-0.064	-0.267	-0.099	-0.297	0.175
L UT sitting	0.023	-0.191	-0.042	-0.110	-0.048	-0.281
L UT standing	-0.095	0.098	-0.267	0.288	-0.240	0.127
R UT sitting	-0.052	-0.036	-0.372	0.346	-0.374	0.103
R UT standing	-0.224	0.264	-0.353	0.463*	-0.358	0.116

SCM: sternocleidomastoid; UT: upper trapezius; L: left; R: right; HHA: Head Horizontal Alignment; AHA: Acromion Horizontal Aligment; HHAc7: Head Horizontal Alignment (C7); HVA: Head Vertical Alignment (acromion); Significance level: *p<0.05; *Spearman* coefficient (r).

a characteristic of patients with TMD. [23, 24] A study that evaluated muscle activity after an acupuncture treatment in patients with TMD, also found increased electromyographic activity on the right side, and this finding was correlated with masticatory preference on the same side, demonstrating a greater electromyographic activity in the work side. [25]

It can be assumed the influence of unilateral pattern of masseter and temporal muscles predominantly on the right than the left (contralateral), with greater activation in standing position than in the sitting position. However, this EMG finding does not seem to be related to the side affected by the dysfunction, since 75% of the evaluated patients had bilateral TMD. Despite being proved the close relation between posture and TMD, this not allows to determine whether postural deviations are the cause or the result of the disorder. [3]

In this research, the right and left upper trapezius muscles showed greater muscular electrical activity during resting and MI, in standing position compared to sitting position. During the evaluation of the upper trapezius muscle in resting, authors observed a tendency of increase in their electrical activity in patients with TMJ dysfunction. [12]

Regarding the craniocervical posture, the mean values of HHAc7 angle were 49.44° and 50.22° in right and left lateral view, respectively. Similar values were observed in asymptomatic individuals [16] indicating that the group evaluated in the current study presented head posture compatible with normal alignment mentioned for this segment. Although using a different angular measurement of this study, another study showed a greater craniocervical extension in TMD individuals compared to a control group, but this difference was of small magnitude, according to the authors. [26] The association between head posture and TMD seems still obscure and controversial, and the methodological quality of the studies is the main factor for acceptance or rejection of this association. [27] Considering the extensive discussion produced on this issue, it seems clear that there is a neural and anatomical relation between the postural and stomatognathic system structures, [12, 20] but postural biomechanics relation remains uncertain.

The head posture was related to a greater electrical activity of the left SCM muscle in standing position and maximum intercuspation in individuals with TMD. In the same situation, there was also a moderate positive correlation between the right upper trapezius muscle and the HVA angle, i.e., the higher the value of this angle, higher the recruitment of the right upper trapezius and greater the head anteriorization. The postural misalignment in individuals with TMD, especially in the segments of the head, hip and calcaneus, seems to be common even considering the variability of body posture in the general population and the influence of various factors that posture may suffer. [16] The change in the behavior of electrical activity in different postures may be related to improper body posture, which interferes with the mandibular position, most often found in patients with TMD. [3, 16] In addition, the posture of the head may be related to the severity of TMD, as demonstrated in a study that correlated the forward head posture and lower cervical spine flexion both measured by cephalometry, and higher rates of the dysfunction severity. [29]

In sum, the relation of the stomatognathic system with the posture has been revealed by several lines of studies. One of them suggests that the tension of the stomatognathic system impairs the neural control, because it generates a bodily imbalance, consequently affecting the signals that reach the central nervous system, directly interfering motor muscle responses. In addition to this, the mandibular position, dental occlusion and periodontal receptors are also factors already studied that prove this correlation. [30]

Analyzing the results obtained, it was found the influence of the postural system on masticatory muscles, since the standing position influence the electrical activity of the masseter and temporal muscles in maximum intercuspation. Another important finding relates to the correlation between the higher head anteriorization and greater muscular activity of the SCM muscle, which exerts postural and stabilizing function for good masticatory function.

CONCLUSION

The patients with TMD of the present study showed craniocervical posture aligned in frontal or lateral views. Despite this, the muscular electrical activity was modified with the change of sitting position to standing position, with an increase in cervical muscle recruitment and asynchrony of the masticatory muscles. It was also found that with the increase in head anteriorization, there was a greater recruitment of the left sternocleidomastoid. Thus, it can be inferred that there is a postural destabilization with possible head anteriorization during maximum intercuspation, reinforcing the relation of synergy between the masticatory and cervical muscles.

AUTHOR'S CONTRIBUTIONS:

MPS – Acquisition of data and drafting of manuscript.
AGA- Acquisition of data.
HVL- Acquisition of data.
JMM – Acquisition of data and article revision.
FP – Statistical analysis and article revision.
ECRC- Guidance of the study and article revision.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest in the research.

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