Cervical spine range of motion, posture and electromyographic activity of masticatory muscles in temporomandibular disorders

Amplitude de movimento articular cervical, postura e atividade eletromiográfica da musculatura mastigatória na disfunção temporomandibular

Rango del movimiento articular de la columna cervical, postura y actividad electromiográfica de la musculatura masticatoria en la disfunción temporomandibular

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Abstract

Introduction: Temporomandibular joint disorders (TMD or TMJD) involve clinical problems and symptoms affecting the temporomandibular joint (TMJ) and associated structures. The temporomandibular joints are anatomically connected to the cervical region, where cervical spine movements occur simultaneously to masticatory muscle activation and jaw movements. **Objective:** Our study sought to assess the relationship between the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), surface electromyography (sEMG) of the masticatory muscles, posture and cervical flexibility in women with TMD. **Method:** Fifty women with an

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average age of 27.0 ± 6.37 years, diagnosed with TMD according to RDC/TMD, were assessed for craniocervical posture, cervical flexibility and sEMG of the masticatory muscles. **Results:** There were no differences in jaw function limitations, depression, pain level and its interference in work ability and daily activities, posture and sEMG between TMD diagnoses or between muscle classification ($p > 0.05$). Depression scores were higher among participants with biarticular dysfunction ($p = 0.023$). The group with bruxism exhibited a higher pain level at assessment ($p = 0.001$) and a greater reduction in work ability ($p = 0.039$). Subjects with muscular and mixed TMD showed less cervical rotation to the right when compared with those with articular TMD. **Conclusion:** There was no difference in posture or sEMG values for TMD diagnoses, joint and muscle dysfunctions and the presence of bruxism. Muscle dysfunction is associated with reduced cervical rotation to the right. Jaw function limitations did not interfere in posture or sEMG and depression was associated with pain.

Keywords: Temporomandibular Joint. Joint Range of Motion. Electromyography. Posture.

Resumo

Introdução: *A disfunção temporomandibular (DTM) compreende alterações clínicas e sintomas que envolvem a articulação temporomandibular (ATM) e estruturas associadas. A ATM possui conexões anatômicas com a região cervical, onde os movimentos das vértebras cervicais ocorrem simultaneamente com a ativação dos músculos mastigatórios e dos movimentos da mandíbula.* ***Objetivo:*** *O objetivo foi verificar a relação entre achados do Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) com a eletromiografia de superfície (EMGs) da musculatura mastigatória, postura e flexibilidade cervical em mulheres com DTM.* ***Método:*** *Cinquenta mulheres com DTM, pelo RDC/TMD, com idade média de 27,0 ± 6,37 anos foram avaliadas quanto à postura craniocervical, flexibilidade cervical e EMGs da musculatura mastigatória.* ***Resultados:*** *Não houve diferença quanto às limitações relacionadas à função mandibular (LRFM), depressão, grau de dor e interferência no trabalho e atividades diárias, postura e EMGs entre os diagnósticos de DTM e entre a classificação muscular (p > 0,05). O comprometimento biarticular apresentou maior depressão (p = 0,023). O grupo com bruxismo apresentou maior grau de dor no momento (p = 0,001), e maior comprometimento na capacidade de trabalhar (p = 0,039). A DTM muscular e mista tiveram menor rotação à direita em comparação ao diagnóstico articular.* ***Conclusão:*** *Os diagnósticos de DTM, os variados comprometimentos articulares e musculares e a presença de bruxismo não apresentaram diferença quanto à postura e a EMGs. O comprometimento muscular está associado a uma menor rotação cervical à direita. As LRFM não interferiram na postura e na EMGs. A depressão tem associação com a dor.*

Palavras-chave*: Articulação Temporomandibular. Amplitude de Movimento Articular. Eletromiografia. Postura.*

Resumen

Introducción: *La disfunción temporomandibular (DTM) incluye alteraciones clínicas y síntomas que involucran la articulación temporomandibular (ATM) y estructuras asociadas. La ATM posee conexiones anatómicas con la región cervical donde los movimientos de las vértebras cervicales ocurren simultáneamente con la activación de los músculos masticatorios y de los movimientos de la mandíbula.* ***Objetivo:*** *Verificar la relación entre la presencia de hallazgos de Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) con la electromiografía superficial (EMG) de la musculatura masticatoria, postura y flexibilidad cervical en mujeres con DTM.* ***Método:*** *Cincuenta mujeres con DTM, por el RDC/TMD, con edad promedio de 27,0 ± 6,37 años fueron evaluadas en cuanto a la postura craniocervical, flexibilidad cervical y EMG de la musculatura masticatoria.* ***Resultados:*** *No hubo diferencia en las limitaciones relacionadas con la función mandibular (LRFM), depresión, grado de dolor e interferencia en el trabajo y actividades diarias, postura y EMG entre los diagnósticos de DTM y entre la clasificación muscular (p > 0,05). La disfunción biarticular presentó mayores puntuaciones de depresión (p = 0,023). El grupo con bruxismo presentó mayor grado de dolor (p = 0,001), y mayor reducción en la capacidad de trabajo (p = 0,039). La DTM muscular y mixta tuvieron menor rotación a la*

derecha en comparación con el diagnóstico articular. **Conclusión:** *Los diagnósticos de DTM con los variados comprometimientos articulares y musculares y la presencia de bruxismo no presentaron diferencias en cuanto a la postura y la EMG. El comprometimiento muscular está asociado a una menor rotación a la derecha de la cervical. Las LRFM no interfirieron en la postura y la EMG, y la depresión estuvo asociada con el dolor.*

Palabras clave: *Articulación Temporomandibular. Rango del Movimiento Articular. Electromiografía. Postura.*

Introduction

Temporomandibular disorder (TMD) is an umbrella term that covers a set of clinical signs and symptoms involving the temporomandibular joint (TMJ), masticatory (chewing) muscles and associated structures [1-6].

The prevalence of this disorder ranges between 5 and 12% in the general population and 65% of patients experience associated pain [6]. Women aged between 20 and 40 years are 4 to 6 times more likely to be affected than men, also exhibiting more pain, muscle sensitivity and other symptoms than their male counterparts. Despite the scarce data on the economic impact of TMD, it is expected to have an impact given the set of symptoms and presence of pain [6,7].

The physiopathology of this disorder is unclear and its etiology multifactorial, including joint trauma, occlusal discrepancies, joint hypermobility, skeletal problems, bruxism (teeth grinding), internal TMJ disorders, parafunctional habits, psychosocial factors and emotional stress [4,6]. It often overlaps with other pain disorders [5] and, except for dental pain, is the most common cause of orofacial pain [1,3].

The Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD) is considered the most comprehensive tool for diagnosing and classifying TMD in myofascial pain, joint disc alterations, arthralgia, arthritis and osteoarthritis [8,9]. Surface electromyography (sEMG) can contribute to knowledge of muscle physiology as a complementary instrument in TMD assessment, as well as differential diagnosis and TMD monitoring[10].

Body posture has been described as a causal or risk factor. Temporomandibular disorder is not only related to the position of the jaw and skull, but also involves the cervical spine, suprahyoid and infrahyoid muscles, shoulders and thoracolumbar spine. Several studies have described greater prevalence of TMD signs and symptoms in patients with poor body posture when compared with those with no postural impairments [11].

Likewise, cervical flexibility and the electrical activity of chewing muscles may also affect or be influenced by the function of the stomatognathic system. Patients with TMD report areas significantly more tense on palpations of the neck and shoulder muscles [12].

Given the complexity of TMD, its multifactorial etiology, repercussions, varied and complex associated factors and different clinical pictures, no single field is capable of developing comprehensive knowledge regarding TMD. Thus, interdisciplinary studies and shared knowledge are vital to ensure a better understanding of this phenomenon. Considering the aforementioned information and the scarce studies that address joint range of motion, posture and electromyographic activity, this study sought to determine if there is a relationship between the presence of RDC/TMD, surface electromyography of the masseter and anterior temporalis muscles, posture and cervical flexibility in women with TMD.

Methods

This is an observational cross-sectional prospective study with an applied quantitative approach whose objectives are based on explanatory research. The study was conducted at the Guairacá Integrated Clinic belonging to Faculdade Guairacá in Guarapuava, state of Paraná, Brazil.

It was approved by the Research Ethics Committee of the State University of Ponta Grossa (UEPG) on August 17, 2016 under protocol number 1.682.504 and registered on the Brazilian Clinical Trials Registry database under RBR-5F6ZW4.

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Volunteers were selected by advertising the study at Faculdade Guairacá, Guairacá Integrated Clinic, and on printed and electronic media. Sixty-two participants accepted the established conditions and signed an informed consent form.

Inclusion criteria were: women aged between 18 and 40 years, diagnosed with TMD according to RDC/TMD Axes I and II. Exclusion criteria were: history of trauma, neoplasms or facial surgery, cognitive and neurological alterations, use of mobility aids, the presence of rheumatic disease, physical disability and pregnancy.

Participants were advised of study objectives and procedures in accordance with ordinance 466/2012 of the National Health Council, which regulates studies with human beings.

Sample size was determined based on the number of individuals who agreed to participate between January and May 2017. The final sample consisted of 50 women aged between 18 and 40 years, diagnosed with TMD according to Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), translated into Brazilian Portuguese and considered the gold standard for diagnosing TMD [13]. This version was selected because a new updated translation currently underway was not yet available when data were collected.

The RDC/TMD is a dual-axis classification system covering the physical (Axis I) and psychosocial components (Axis II) of TMD [14]. Axis I classifies muscle disorders (muscular TMD), disc displacement, arthralgia, osteoarthritis and osteoarthrosis (articular TMD) and a combination of both (mixed TMD) [15]; and Axis II provides information on the psychosocial aspect of TMD such as chronic pain, depressive symptoms, nonspecific physical symptoms including and excluding pain items, and jaw functional limitations [16].

Range of motion (ROM) of the cervical spine was assessed using a Sanny® pendulum fleximeter (American Medical do Brasil, São José dos Campos, state of São Paulo, Brazil). The fleximeter is a gravity-dependent goniometer that provides more reliable measurements because the angle is produced by the effect of gravity, minimizing errors in the interpretation of the corresponding longitudinal axis. Except for cervical rotations performed in dorsal decubitus, all movements were analyzed with participants seated on a chair with

their back straight, head positioned according to the Frankfurt plane, knees flexed at 90° and feet flat on the floor [17]. Movements were actively executed [18] with three repetitions each, considering the average of the three measurements.

Biophotogrammetry is a safe, accurate, reliable and reproducible method that detects postural symmetry, asymmetry, deviations and/or abnormalities between body segments. For postural assessment, participants were photographed using a 14.1 mega pixel SONY® Cyber-Shot DCS- w350 digital camera with 4× optical zoom (SONY BRASIL, São Paulo, state of São Paulo, Brazil). Head and neck posture were evaluated in the orthostatic position, with anterior and left lateral views. The camera was positioned one meter from the participants, with the height adjusted to the level of their left tragus using a professional universal tripod with bubble level [19].

A plumb bob was suspended from the ceiling running anteriorly to the lateral malleolus and defining the true vertical line in the digital images. Points were marked on the participant's left side using 16 mm-wide Styrofoam spheres according to the following anatomical points: the spinous process of the seventh cervical vertebra [C7], outer corner of the left eye, tragus of the left and right ears, suprasternal notch, and center of the chin [19].

Posture was assessed based on the position of the participant's head and neck in relation to the plumb bob. The following angles were analyzed for the left lateral view: 1. craniovertebral angle, based on the intersection of a straight line passing through the C7 spinous process and a horizontal line intercepting C7 in the sagittal plane; 2. head position angle, defined as the angle between the tragus manubrium line and the line extending from the center of the chin to the tragus; 3. Forward head posture angle, formed between the line connecting the tragus of the ear to the canthus of the eye and the horizontal line passing through the tragus [19].

Angles assessed for the anterior view were: 4. the forward head posture angle, defined by the intersection of the straight line formed by the two tragi (left and right) and the horizontal line, and 5. the cervical rotation angle formed by the line between the chin and manubrium and true vertical line. Posture was assessed using Corel DrawX8® software (Corel Corporation, Ottawa, Ontario,

Canada). The different points were marked with a mouse to form the body planes and analyzed based on the true vertical line, to determine possible body inclination or asymmetry of body structures [20].

Surface electromyography (sEMG) is a noninvasive technique that can be used to assess muscle behavior and hyperactivity in TMD [21]. Participants remain seated on a chair with a backrest, their feet apart, shoulders relaxed, hands resting on their thighs and head positioned in the Frankfurt plane [22]. The masseter and anterior temporalis muscles were assessed bilaterally [23].

Prior to sEMG signal collection, the skin was cleaned with a soft sponge and cotton wool soaked in 70% alcohol [24]. The electrodes were placed on the muscle belly of each muscle, according to the direction of the muscle fibers and palpation of the muscle mass during contraction [25]. Disposable LH-ED4020 double trace bipolar electrodes (Shanghai Litu Medical Appliances Co. Ltd.) were

used. These electrodes measure 44 mm long, 21 mm wide and 20 mm from center to center and are registered with ANVISA under 80351690008.

A square (30 mm) Maxicor reference electrode (Shanghai Intco Electrode Manufacturing Co. Ltd.) was used to reduce noise during acquisition (ANVISA registration no. 10299800009).

After a three-minute rest, sEMG activity was recorded for 15 seconds, three times consecutively under the following conditions: 1. resting position, 2. maximum voluntary clenching (MVC, isometric), with two strips of Parafilm M® (American National CanTM, Chicago, USA) folded into 4 parts and positioned bilaterally on the first and second lower molars [10, 23, 26], 3. while chewing two Parafilm strips positioned bilaterally in time with a metronome calibrated to 60 beats a minute [10]. The rest interval between chewing and isometric clenching readings was three minutes and one minute in the resting position.
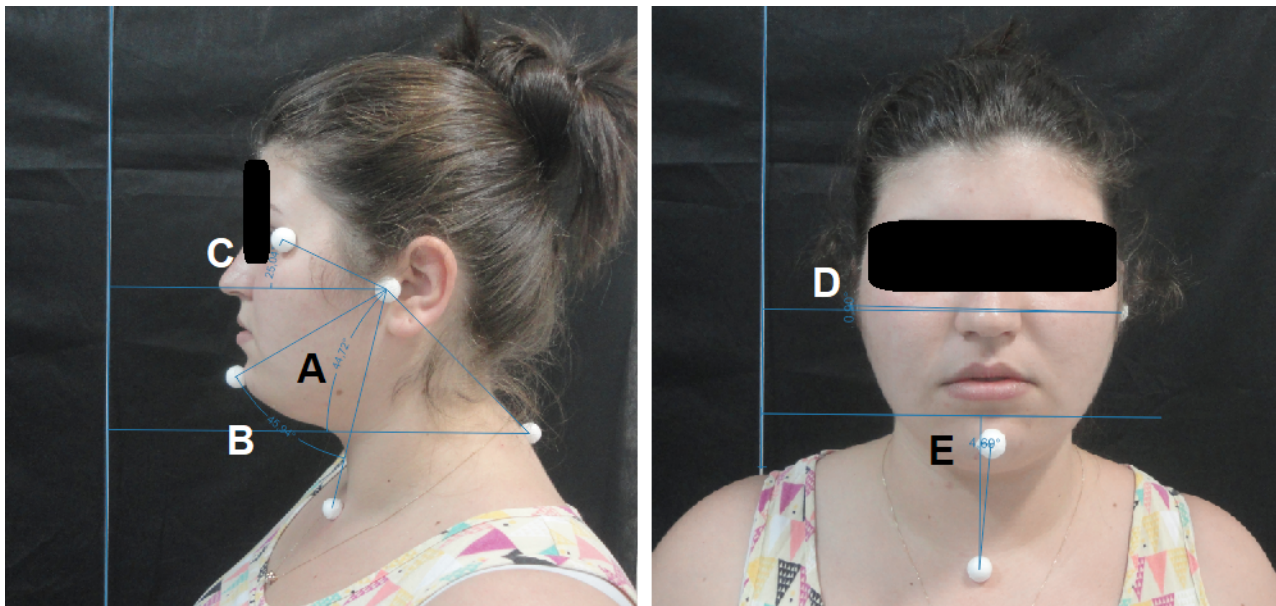
Note: (A) craniovertebral angle; (B) head position angle; (C) head tilt angle; (D) forward head posture angle; (E) cervical rotation angle.

Figure 1 – Rotation angle.

An eight-channel signal acquisition module was used (EMG 830C, EMG System do Brasil Ltda®, S. J. Campos, São Paulo state, Brazil), with a sampling frequency of 2 kHz per channel, 16-bit resolution, amplifier gain of 2000, common mode rejection ratio > 100 dB and 20–500 Hz filters. The system was connected via a USB port to a Lenovo B40-70

laptop computer (Lenovo Group LTD, Morrisville, North Carolina, USA), with a 1.7 GHz Intel Core i3 4005U processor, 3 MB cache, 4 GB DDR3 1600 MHz memory RAM and Microsoft Windows 8.1 operating system (64 bits) on which the data were saved for subsequent analysis in EMGLab 2.0 software.

Ten seconds of the signal were used to estimate the root mean square (RMS) amplitude, with the first three and last two seconds of the 15-second reading disregarded for the recorded data. Signal amplitude in all three conditions was expressed as a percentage of the maximum potential RMS recorded in the three MVC readings (MVC%).

The variables were estimated based on the MVC% for the resting position:

$MVC\%_{rest} = (RMS_{rest} \times 100) / RMS_{MVC}$
and chewing:
$\%MVC_{chewing} = (RMS_{chewing} \times 100) / RMS_{MVC}$ [10].

All the assessments (RDC/TMD, cervical range of motion, postural assessment and sEMG of the chewing muscles) were performed by a trained physical therapist.

The results were analyzed using IBM SPSS 20 software. The mean, standard deviation, median, interquartile range, minimum and maximum value, frequency and percentages were used for descriptive results and nonparametric tests for inferential statistics, namely the Kruskal Wallis and Mann-Whitney test for comparisons and Spearman test for correlations. Significance was set at less than or equal to 0.05.

Results

The sample consisted of 50 women with an average age of 27.0 ± 6.37 years. Participants exhibited complete dentition, with 24 to 32 teeth, and most reported (76%) clenching and bruxism.

The sample was divided into muscle disorders (muscular TMD), disc displacement, arthralgia, osteoarthritis and osteoarthrosis (articular TMD) and a combination of the two (mixed TMD), as well as muscle dysfunction and joint impairment, as shown in Table 1.

Jaw function limitations, depression and pain assessed by RDC/TMD Axis II showed no differences regarding TMD diagnoses and muscle dysfunction. Depression differed considering joint impairment and pain for the presence of bruxism, as shown in Table 2. Women with no joint impairment exhibited higher depression scores (0.90; 0.55 – 1.50) than those with monoarticular dysfunction (0.37; 0.15 – 0.83), (p = 0.008), while those with biarticular impairment (0.80; 0.45 – 1.60) had better scores than those with only one compromised joint (0.37; 0.15 – 0.83), (p = 0.023). The group with bruxism experienced more pain at assessment (3.0; 2.0 – 6.0) than those without the condition (0; 0 – 2.0), (p = 0.001), as well as reduced work ability due to pain (1.5; 0 – 3.0) when compared with the bruxism-free group (0; 0 – 0.75), (p = 0.039).

The muscular and mixed TMD groups showed reduced cervical ROM in right rotation (69.00; 64.5 – 79.3 and 78.60; 71.6 – 85.0, respectively) when compared with those with articular TMD (93.15; 91.3 – 95.0, p = 0.037 and p = 0.033), as shown in Table 3.

For the sample divided according to muscle dysfunction, the myofascial pain (82.95; 66.0 – 88.0) and myofascial pain with limited mouth opening groups (77.00; 67.8 – 79.6) exhibited less cervical ROM in right rotation when compared with the group with no muscle dysfunction (93.15; 91.3 – 95.0, p = 0.049 and p = 0.028, respectively), also shown in Table 3.

Participants without bruxism had decreased ROM in left cervical rotation (75.95; 68.35 – 80.90) when compared with those without the condition (81.95; 77.22 – 87.15, p = 0.023), also shown in Table 3.

Table 1 – Participant characterization in terms of temporomandibular disorder diagnosis, side of the joint impairment and muscle dysfunction classification

Oral condition / Diagnosis		n – %
General diagnosis	Muscular	15 – 30
	Articular	2 – 4
	Mixed	33 – 66
Side of the joint impairment	No joint dysfunction	15 – 30
	Both joints	19 – 38
	Right joint	7 – 14
	Left joint	9 – 18
	No diagnosis	2 – 4
Muscle dysfunction classification	Muscular	16 – 32
	Muscular with limited mouth opening	32 – 64

Table 2 – Comparison of limitation, depression and pain assessed by RDC/TMD Axis II between groups with TMD diagnoses, muscle and joint dysfunction and the presence of bruxism (Kruskal Wallis Test)

	A	B	C	D
	p	p	p	p
Jaw function limitations	0.451	0.682	0.171	0.069
Depression	0.222	0.547	0.017*	0.440
Pain level at assessment	0.147	0.148	0.928	0.001*
Worst pain level over the last six months	0.086	0.072	0.891	0.138
Average pain level over the last six months	0.120	0.123	0.639	0.076
Sick days taken due to pain in the last six months	0.479	0.824	0.121	0.510
Extent to which pain interfered in daily activities	0.209	0.191	0.604	0.452
Extent to which pain interfered in leisure, social and family activities	0.265	0.203	0.239	0.495
Extent to which pain affected work ability	0.307	0.390	0.359	0.039*

Note: A: muscular, articular and mixed TMD; B: muscle dysfunction (no dysfunction, muscle dysfunction, muscle dysfunction with limited mouth opening); C: joint impairment (no impairment, monoarticular, biarticular); D: reported presence or not of bruxism/clenching.

The muscular and mixed TMD groups showed reduced cervical ROM in right rotation (69.00; 64.5 – 79.3 and 78.60; 71.6 – 85.0, respectively) when compared with those with articular TMD (93.15; 91.3 – 95.0, p = 0.037 and p = 0.033), as shown in Table 3.

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For variables related to posture, sEMG showed no correlation with jaw function limitations. There was a weak negative correlation between the ROM of right lateral cervical inclination and jaw function limitations, as shown in Table 4.

Table 3 – Comparison of postural angles, cervical flexibility and surface electromyography between groups with TMD diagnoses, muscle and joint dysfunction and the presence of bruxism (Kruskal- Wallis Test)

	A	B	C	D
Posture	p	p	p	p
Craniovertebral	0.611	0.428	0.879	0.803
Head position	0.433	0.990	0.420	0.166
Head tilt	0.820	0.800	0.370	0.928
Forward head posture	0.980	0.237	0.865	0.937
Cervical rotation	0.473	0.393	0.742	0.084
Cervical ROM				
Cervical flexion	0.163	0.181	0.623	0.883
Cervical extension	0.290	0.538	0.058	0.510
Right lateral cervical inclination	0.283	0.107	0.258	0.964
Left lateral cervical inclination	0.490	0.825	0.260	0.847
Right cervical rotation	0.021*	0.047*	0.075	0.937
Left cervical rotation	0.948	0.732	0.184	0.023*

(To be continued)

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(Conclusion)

	A	B	C	D
Posture	p	p	p	p
Surface electromyography				
Isometric RMS				
Right masseter muscle	0.809	0.721	0.997	0.928
Left masseter muscle	0.828	0.584	0.630	0.666
Right temporalis muscle	0.408	0.154	0.848	0.733
Left temporalis muscle	0.692	0.266	0.382	0.683
Chewing RMS				
Right masseter muscle	0.819	0.785	0.926	0.617
Left masseter muscle	0.909	0.690	0.661	0.803
Right temporalis muscle	0.757	0.245	0.981	0.964
Left temporalis muscle	0.755	0.412	0.468	0.803
Resting RMS				
Right masseter muscle	0.706	0.201	0.482	0.076
Left masseter muscle	0.489	0.642	0.425	0.229
Right temporalis muscle	0.324	0.355	0.650	0.140
Left temporalis muscle	0.151	0.323	0.323	0.650
Chewing MVC%				
Right masseter muscle	0.257	0.995	0.199	0.134
Left masseter muscle	0.172	0.862	0.141	0.166
Right temporalis muscle	0.668	0.481	0.885	0.716
Left temporalis muscle	0.231	0.903	0.222	0.318
Resting MVC%				
Right masseter muscle	0.891	0.932	0.902	0.481
Left masseter muscle	0.975	0.775	0.937	0.097
Right temporalis muscle	0.682	0.562	0.857	0.066
Left temporalis muscle	0.499	0.119	0.329	0.146

Note: A: muscular, articular and mixed TDM; B: muscle dysfunction (no dysfunction, muscle dysfunction, muscle dysfunction with limited mouth opening); C: joint impairment (no impairment, monoarticular, biarticular); D: reported presence or not of bruxism/clenching.

Table 4 – Correlation between jaw function limitations and postural angles, cervical flexibility and surface electromyography (Spearman Test)

	Jaw function limitations	
Posture	ρ	P
Craniovertebral	0.170	0.237
Head position	0.104	0.472
Head tilt	0.127	0.379
Forward head posture	−0.064	0.661
Cervical rotation	0.021	0.883
Cervical ROM		
Cervical flexion	0.205	0.153
Cervical extension	−0.243	0.089
Right lateral cervical inclination	−0.315	0.026*

(To be continued)

(Conclusion)

Jaw function limitations		
Posture	ρ	P
Left lateral cervical inclination	−0.099	0.496
Right cervical rotation	−0.266	0.062
Left cervical rotation	−0.098	0.499
Surface electromyography		
Isometric RMS		
Right masseter muscle	−0.115	0.427
Left masseter muscle	−0.027	0.850
Right temporalis muscle	−0.051	0.723
Left temporalis muscle	0.064	0.661
Chewing RMS		
Right masseter muscle	0.023	0.876
Left masseter muscle	−0.154	0.285
Right temporalis muscle	−0.215	0.134
Left temporalis muscle	0.128	0.376
Resting RMS		
Right masseter muscle	−0.048	0.741
Left masseter muscle	0.060	0.681
Right temporalis muscle	0.065	0.653
Left temporalis muscle	0.082	0.569
Chewing MVC%		
Right masseter muscle	−0.115	0.427
Left masseter muscle	−0.027	0.850
Right temporalis muscle	−0.051	0.723
Left temporalis muscle	0.064	0.661
Resting MVC%		
Right masseter muscle	0.023	0.876
Left masseter muscle	−0.154	0.285
Right temporalis muscle	−0.215	0.134
Left temporalis muscle	0.128	0.376

Note: ρ: Spearman's correlation coefficient.

Table 5 – Correlation between jaw function limitations, depression and pain assessed by RDC/DTM Axis II (Spearman test)

	Jaw function limitations	
	ρ	p
Depression	0.343	0.015*
Pain level at assessment	0.173	0.230
Worst pain level in the last six months	0.246	0.085
Average pain level over the last six months	0.187	0.193
Sick days taken due to pain in the last six months	0.252	0.077
Extent to which pain interfered in daily activities	0.298	0.036*
Extent to which pain interfered in leisure, social and family activities	0.333	0.018*
Extent to which pain affected work ability	0.341	0.015*

Note: ρ: Spearman's correlation coefficient.

There was a positive correlation between depression, pain interference in daily activities, leisure and work ability and jaw function limitations, as shown in Table 5.

Discussion

Almost 5% of the global population has some form of temporomandibular disorder (TMD) and one third exhibit at least one TMD symptom [27]. Epidemiological studies suggest that TMD-related symptoms are more prevalent in 20 to 40-year-old women [5,10,28].

This has been attributed to inflammatory responses to stress, sociocultural behavior in response to pain and effects related to hormonal characteristics. One hypothesis is that endogenous reproductive hormones play a role in TMD-related pain, but the exact mechanism of these hormonal effects remains unknown [28]. Given the distribution of TMD in the population, our study opted for a sample consisting primarily of women aged 18 to 40 years. The average age of participants was 27.48 ± 6.37 years.

According to Berger et al. [29] and Magalhães et al. [30], bruxism compromises the masticatory system and is considered a major etiological factor in TMD. A common condition in patients with TMD, it is predominantly associated with muscle disorders, but can also be attributed to temporomandibular joint (TMJ) dysfunction. Reissmann et al. [31] found that bruxism is associated with a greater incidence of painful TMD. Huhtela et al. [32] also related the presence of bruxism to pain and TMJ dysfunction, with women who reported bruxism experiencing a higher pain level and reduced work ability due to pain.

Magalhães et al. [30] reported that 52% of individuals with TMD exhibited bruxism and those with bruxism were twice as likely to develop TMD. These studies corroborate our findings, in which 76% of women with TMD reported suffering from bruxism.

Our study showed a correlation between jaw function limitations and high depression scores, interference of pain in daily and leisure activities and the extent to which pain affected work ability. Similarly, Graciola and Silveira [33] found a correlation between TMD and stress. Patients with high stress levels exhibited a greater incidence of

mild and moderate TMD and were the only group to display severe TMD. Al-Khotani et al. [34] found that children with TMD and pain experienced greater anxiety, depression and somatic complaints than the group without TMD. In a study by Lei et al. [35], the muscular TMD group displayed significantly higher anxiety levels than the control group. By contrast, Martins et al. [36] found no association between TMD and stress.

According to Rocha, Croci and Caria [37], several authors have reported that postural problems involving the cervical spine and skull can also cause TMD. The TMJ is connected to the neck region via muscles and ligaments, forming a functional complex, in which movements of the atlanto-occipital joint and cervical vertebrae occur simultaneously to activation of the chewing muscles and jaw movements [38].

Although the association between TMD and craniocervical posture has been studied, questions remain. Several studies have shown that individuals with TMD exhibit cervical spine and head posture changes and that body posture is related to dysfunctions of the stomatognathic system [39-43]; however, other investigations have not established this correlation [44-46].

In our study, there was a significant difference in postural angles between muscular, articular and mixed TMD diagnoses. A similar result was reported by Faulin et al. [45] and Câmara-Souza et al. [46], who demonstrated a relation between cervical posture in the sagittal and frontal planes and TMD. Andrade [47] found no significant differences in head posture between patients with muscular TMD and Rocha et al. [44] studied the postural characteristics of individuals without pain exhibiting disc displacement compared with those without TMD and observed no significant intergroup differences.

According to Rocha et al. [44] and Munhoz et al. [48], studies on the relationship between postural deviations and the functional health of the temporomandibular system are controversial and inconclusive. This is because authors use to consider TMD as a whole without considering the specific signs and symptoms of individuals.

Azato [41] and Castillo et al. [42] reported that postural deviations can interfere in the function and organization of the TMJ. The authors observed a significant improvement in the vertical alignment

of the head and less pain in the treatment group. This may be because the neck muscles and those of the stomatognathic system play an important role in maintaining head balance, and interventions at any level can result in changes in this complex. As such, manipulating the jaw muscles changes typical head posture [49]. Despite this anatomical, muscular and neural proximity, there was no difference in postural angles among those with and without bruxism/clenching.

According to Munhoz [50], age, gender and dental malocclusion are directly related to specific postural changes in the cervical spine and shoulders, as well as postural deviations in the anterior-interior chain of the hip. These factors can interfere in the results and conclusions of studies aimed at analyzing the correlation between body posture and TMD, which may be the reason for the lack of consensus between studies.

The results obtained by Baldini et al. [51] combined with previous data indicated that jaw position does not influence active cervical mobility in healthy patients. In our study, the muscular and mixed TMD groups showed significantly less cervical rotation to the right than those with articular TMD. In the muscular TMD subgroups, the myofascial pain group with limited mouth opening exhibited less cervical rotation to the right, followed by the myofascial group, with no significant differences.

The group with no muscular diagnosis displayed the greatest rotation, with significant differences when compared with the other groups, suggesting that masticatory muscle dysfunction most influenced cervical mobility. Similar findings were reported by Ballenberger, et al. [52], who reported reduced cervical mobility in subjects with mixed TMD, followed by muscular TMD. Extension mobility was most affected in the mixed and muscular TMD groups and flexion mobility the least compromised. In our study, those with bruxism/clenching had significantly larger angles in left cervical rotation, with no statistical difference for the remaining movements.

The decline in cervical mobility may be due to changes in the TMJ. Costa [53] found that neck disability was significantly greater in patients with muscular TMD when compared with the control group without the disorder and observed a negative correlation between neck

disability and the pressure pain threshold of stomatognathic structures.

However, study results are still contradictory. Greenbaum et al. [54] observed a significant limitation in upper cervical rotation in patients with myogenic TMD. On the other hand, pure physiological cervical movements in these patients did not differ from those recorded in individuals without TMD. In contrast, in our study, the greater the jaw function limitations, the smaller the angle of right lateral cervical inclination. According to Von Piekartz et al. [38], the more severe the TMD, the greater the cervical musculoskeletal dysfunction and the greater the dysfunction and pain in the temporomandibular region, the higher the levels of cervical musculoskeletal impairment.

Guarda-Nardini et al. [55], Grondin and Hall [56] and Walczyńska-Dragon et al. [57] showed that TMJ interventions improved cervical ROM and reduced cervical pain. However, there is no record in the literature on whether cervical mobility is influenced differently by the various types of TMD. In our study, comparison of cervical fleximetry values between the articular, monoarticular and biarticular involvement groups showed no intergroup differences. There is evidence that TMD influences cervical mobility.

Masticatory muscle activity may be a risk indicator in TMD due to the association between hyperactivity of these muscles and pain-related diagnoses [58]. Individuals with TMD were more susceptible to fatigue than healthy controls [59,60]. In a study by Woźniak et al. [61], masticatory muscle fatigue increased in direct proportion to the severity of TMD symptoms in the patients studied. In our study, RMS values in raw and normalized sEMG signals did not differ between women with and without bruxism/clenching.

Several studies address the influence of TMD severity with surface electromyography of the chewing muscles. In TMD, especially with more severe symptoms, the masticatory muscles exhibited hyperactivity [22]. De Paiva Tosato al. [9], Lauriti et al. [10] and Mazzetto et al. [62] showed that EMG activity of the chewing muscles was positively correlated with the severity of TMD. Regarding TMD severity, our study found no correlation between jaw function limitations and raw and normalized EMG values.

In a study by Santana-Mora et al. [63], the RMS values of resting anterior temporal and masseter

muscles and maximum voluntary clenching were greater in individuals with TMD when compared with the control group, with no significant differences. Dos Santos Berni et al. [23] obtained the same results, but with significant differences. In a study by Rodrigues et al. [64], the TMD group displayed significantly higher RMS in the masticatory muscles during chewing than the control group, who showed more symmetrical muscle activity than those with TMD. Li et al. [65] reported similar findings, with electrical activity differing between the TMD and control groups.

Bortolazzo et al. corroborate these results [26]. Upper cervical manipulation in women with muscular TDM stabilized the electrical activity of chewing muscles. The RMS of the anterior temporal and masseter muscles declined at rest but increased during isometric contraction (clenching).

Strini et al. [66] and Chaves et al. [67] compared healthy individuals and patients with TMD and observed different results from those of other studies. Individuals with TMD obtained similar electrical activity values (raw and normalized RMS) for masticatory muscles when compared with the control group. There was no control group without TMD in our study, which may justify the results. The sample was divided into muscular, articular and mixed TMD, with no significant intergroup differences in RMS values for raw and normalized sEMG.

The results obtained partially corroborate the findings of other studies. There is still no consensus or clear parameter regarding the influence of TMD on chewing muscle EMG activity, body posture and cervical mobility. This disparity may be due to the different TMD diagnoses, which go beyond the muscular, articular and mixed classifications, the various assessment methods for muscle electrical activity and body posture, multi-causality and the different aggravating factors of this complex group of functional alterations involved in TMD.

Thus, the results of our study indicate the need for further studies regarding possible changes in electromyographic activity in the different types of TMD and if they are a cause or consequence of TMD. The limitations of our study are the different number of subjects in the muscular, articular and mixed TMD groups, as well as the complexity and diversity of signs and symptoms in the different forms of the disorder.

Conclusion

The predominant diagnosis was mixed TMD, with no difference in posture or masticatory muscle electrical activity between TMD diagnoses, the different types of muscle and joint dysfunction and the presence or not of bruxism.

Cervical ROM in right rotation was smaller in the muscular and mixed TMD groups when compared with those with articular TMD. For the sample divided according to muscle dysfunction, the myofascial pain and myofascial pain with limited mouth opening groups exhibited smaller ROM for cervical rotation to the right when compared with the control group with no muscular diagnosis. Participants without bruxism had decreased ROM in left cervical rotation when compared with those without the condition. For variables related to posture, sEMG showed no correlation with jaw function limitations.

High depression scores were accompanied by greater pain interference in daily activities, leisure and work ability, with jaw function limitations.

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