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Original Article

Artigo Original

Influence of craniomandibular and cervical pain on the activity of masticatory muscles in individuals with Temporomandibular Disorder

Influência da dor craniomandibular e cervical na atividade dos músculos mastigatórios em indivíduos com Disfunção Temporomandibular

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Keywords

Mastication
Craniomandibular Disorders
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Electromyography
Pain

ABSTRACT

Purpose: This study aimed to establish the prevalence of pain in the craniomandibular and cervical spine region in individuals with Temporomandibular Disorders (TMD) and to analyze the effects of these disorders on the bilateral activation of anterior temporalis (AT) and masseter (MA) muscles during the masticatory cycle. **Methods:** The participants were 55 female volunteers aged 18–30 years. The presence of TMD and craniomandibular and cervical spine pain was evaluated by applying the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) questionnaire and using a combination of tests for the cervical region. The muscle activity of AT and MA during the masticatory cycle was assessed using the symmetry and antero-posterior coefficient indices. **Results:** The AT activity during the masticatory cycle is more asymmetric in individuals with TMD. The craniomandibular pain, more prevalent in these individuals, influenced these results. **Conclusion:** Individuals with TMD showed changes in the pattern activity of AT. The craniomandibular nociceptive inputs can influence the increase in asymmetry of the activation of this muscle.

Descritores

Mastigação
Transtornos Craniomandibulares
Síndrome da Disfunção da Articulação Temporomandibular
Eletromiografia
Dor

RESUMO

Objetivo: O objetivo deste estudo foi determinar a prevalência de dor nas regiões craniomandibular e cervical em indivíduos com Disfunção Temporomandibular (DTM) e analisar o efeito dessas desordens na ativação bilateral dos músculos temporal anterior (TA) e masseter (MA) durante o ciclo mastigatório. **Métodos:** Participaram deste estudo 55 voluntários do sexo feminino com idade de 18 a 30 anos. A presença de DTM e de dor craniomandibular e cervical foi avaliada por meio do questionário *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TMD) e uma combinação de testes para a região cervical. A análise da ativação muscular do TA e MA durante o ciclo mastigatório foi realizada através dos índices de simetria e do coeficiente anteroposterior. **Resultados:** A atividade dos músculos TA, durante o ciclo mastigatório, é mais assimétrica em indivíduos com DTM. A dor craniomandibular, mais prevalente nesses indivíduos, influencia nesses resultados. **Conclusão:** Indivíduos com DTM apresentam alteração no padrão mastigatório do músculo TA e estímulos nociceptivos da região craniomandibular podem influenciar no aumento da assimetria de ativação dessa musculatura.

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INTRODUCTION

Temporomandibular disorder (TMD) and cervical spine dysfunction include clinical problems in the musculoskeletal structures of the masticatory system and the cervical spine[1]. Clinical manifestations such as pain, joint noises, and irregular or impaired mandibular function are frequent. The association between signs and symptoms of the stomatognathic system muscles and the cervical system[2] or other areas[3] is also common.

The main symptom reported by patients with TMD is bilateral or unilateral pain, usually triggered by jaw movements or palpation, and pain sometimes radiates to the neck[4]. The relationship between the stomatognathic and craniocervical systems was shown by the interplay between the masticatory and cervical muscles[5,6].

Patients with TMD, besides having pain in the craniomandibular region, also present more neck pain[7]. The diseases of one system can induce pain and/or dysfunction in another system through the central command or by reflex connectivity between the two anatomical areas[8]. Then, the evaluation of TMD should not be based solely on the analysis of the musculoskeletal system directly involved. The cervical region should also be evaluated.

Some studies[5,7,9,10] have shown that patients with TMD, compared to asymptomatic patients, showed alterations in the activity of the masticatory muscles during chewing. However, the cited studies are not conclusive. There are disagreements as to the results of bilateral muscle activation and the type of activity under consideration. The differences between studies may be related to the large variability of signs and symptoms of TMD. Another factor that may have influenced the results is the coexistence of signs and symptoms of cervical spine dysfunction, aside from TMD.

If patients with TMD have a greater chance of presenting pain in craniomandibular and cervical regions, these disorders can influence the motor behavior of the muscles involved in chewing. Thus, the aim of this study was to determine the prevalence of pain in the craniomandibular and cervical regions in individuals with TMD and to analyze the effect of these disorders on the bilateral activation of the anterior temporal (AT) and masseter (MA) muscles during the masticatory cycle.

METHODS

Subjects

This is a cross-sectional study in which 60 subjects were evaluated. However, five were excluded due to problems in data processing. Thus, the sample comprised 55 female volunteers aged 18–30 years and was divided into two groups: group with signs and symptoms of TMD (TMD present, n=28, mean age 23.50±3.83 years) and asymptomatic group (TMD absent, n=27, mean age 21.41±2.66 years). The TMD present group comprised volunteers who had one or more diagnoses of TMD based on history and clinical signs according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[11]. In the TMD absent group, volunteers who showed no signs and symptoms according to the RDC/TMD were included.

Exclusion criteria for the volunteers included: history of trauma to the face, temporomandibular joint, pectoral and cervical girdle; changes in the vestibular system; dental flaws; malocclusion classes II and III malocclusion; dislocation; systemic diseases such as arthritis and osteoarthritis; use of orthodontic and/or orthopedic functional retainer and use of analgesics and anti-inflammatory drugs..

Instruments

A clinical examination was used to differentiate groups of volunteers with respect to TMD and the presence of pain in the craniomandibular and cervical regions. This examination consisted of two steps, which, in turn, included a combination of tests for the cervical region[1] and an RDC/TMD diagnostics system[11]. Morphological features of the dental occlusion were also evaluated using the Angle's malocclusion classification, based on visual inspection of the antero-posterior relationship between maxilla and mandible[12].

Through the RDC/TMD, diagnoses of TMD can be classified into three groups: 1) Muscle diagnosis (myofascial pain only or myofascial pain with limited opening); 2) disk displacement (with or without reduction and with limited opening or without reduction and without limited opening); and 3) arthralgia, osteoarthritis, and osteoarthrosis (TMJ). The history and clinical criteria served as the basis for these analyses. In the TMD group, volunteers who had one or more diagnoses according to RDC/TMD were included. In the presence of pain in the craniomandibular region, the individual was classified as "craniomandibular pain present".

The clinical examination for evaluation of the presence of pain in the cervical region consisted of palpation of muscles, active and passive movements, and dynamic and static testing of the cervical regions. Volunteers who reported any pain at the time of clinical examination were classified as "cervical pain present."

In the assessment of muscle activity, one USB Miotool EMG was used with a 14-bit analog/digital converter board for an acquisition rate of 2,000 Hz, minimum common mode rejection ratio of 110 dB, and band pass filter of 20–500 Hz. Electrodes manufactured by Medi-Trace Kendall-LTP (Chicopee, MA) were also used.

Procedures for data acquisition

The research project was approved by the Research Ethics Committee of Universidade do Estado de Santa Catarina (UDESC) under protocol number 149.333/2012. The participants were informed about the procedures and objectives of the research and signed a free and informed consent form.

Then, the evaluation record of the subject was filled, which included questions regarding the clinical examination of the volunteer.

After filling the records, the electromyographic evaluation was performed. The subjects remained seated in a chair, with the head in the Frankfurt position (parallel to the ground), with the back of the seat at the height of the shoulder blades, hands aligned with the shoulder and resting on the thighs and knees and hips to 90°.

For the arrangement of the electrodes on the skin, to reduce the electrical impedance, the area was cleaned with hydrophilic cotton soaked in a 70% alcohol solution and was shaved if necessary[13]. The reference electrode was fixed on the manubrium of the sternum. The other electrodes were aligned along the muscle fibers and fixed to the skin of the AT and MA muscles. The best location of the electrodes was determined by a test of muscle function. The participant was asked to perform an isometric contraction of the mandible elevator muscles for the location of the MA (2 cm above the angle of the jaw) and AT (vertically from the anterior margin of the muscle)[14,15].

Before the start of the electromyographic data collection, a training program was conducted. These data were obtained during mastication (10 s) and during clenching in maximum intercuspal position (5 s), repeated three times with a 1-min interval. During the procedure, Parafilm M bars were used between the occlusal phase of the first and second upper and lower molars, on both sides, folded 15 times at the size of 1.5x3.5 cm each.

Data analysis and processing

The raw signals were filtered through a high-pass filter of 20 Hz and a low-pass filter of 500 Hz. Normalization of data of each masticatory muscle was performed as a percentage of maximum voluntary contraction during clenching in intercuspal position (for 1 s). The muscle activation of AT and MA during the masticatory cycle was analyzed through the indices of symmetry (ATS and MAS) and the antero-posterior coefficient (APC). The masticatory cycle was divided into two phases: the active period (AP, jaw elevation) and the inactive period (IP, jaw depression).

To detect the start (onset) and the end (offset) of mastication's AP and IP, a calculation routine was used in Microsoft Excel. This detection method iterates through the electromyographic signal (EMG) using a fixed size window of 20 ms and seeks the lowest value of the root mean square and its standard deviation (SD). Thus, the reference value to differentiate AP and IP is set.

The ATS, MAS, and APC rates during mastication's AP and IP were obtained through linear envelopment. In ATS and MAS, the percentage of overlapping coefficient (OVL%) of the areas of the curves of the linear envelopment of homologous muscles was calculated[16,17]. The APC compares muscle activity between MA and AT muscles. In this index, the EMG areas are overlapped and the ratio of the areas that do not overlap and those that do overlap is calculated for both sides. The activity of the analyzed muscles is balanced, both in the symmetry index and in the antero-posterior coefficient (APC), when the value obtained is 100%. The MATLAB R2009a software was used for this processing.

Statistical analysis

For the treatment of data, descriptive statistics (mean and standard deviation) was used. To verify the existence of an association between TMD and control groups and craniomandibular and cervical pain, a bivariate logistic regression was applied. The incidence rate and the effect of the explanatory factors in the TMD occurrence were assessed by calculating the odds ratio (OR) and its confidence interval of 95% (95%CI).

After checking the normality of the data through the Kolmogorov–Smirnov test, the *t*-test for independent data was used to verify the difference between the mean rates of MAS, ATS, and APC between the TMD present and TMD absent groups. The effect of craniomandibular and cervical pain in the response variables was analyzed using analysis of variance with two fixed factors. The program used for statistical analysis was the Statistical Package for Social Sciences (SPSS) version 20.0 for Windows, and for all procedures, a significance level of 5% ($p>0.05$) was adopted, with two-tailed distribution.

RESULTS

According to the RDC, 28 subjects had TMD and 27 were asymptomatic. Most subjects with TMD presented pain in the craniomandibular region, but the cervical pain was less frequent. In the asymptomatic group, the pain in the craniomandibular and cervical regions was present, but was not prevalent.

The bivariate logistic regression analysis (Table 1) showed the existence of an association between the presence of TMD and the presence of craniomandibular pain ($p>0.05$). The patients with TMD are 45.50 times more likely to have pain in the craniomandibular region than an individual without TMD. The association between TMD and the presence of cervical pain was not statistically significant ($p>0.05$).

Comparison of the mean scores obtained in the evaluation of muscle activity between the TMD absent and the TMD present groups showed statistical significance only in the symmetry of the AT muscle (Table 2). Patients with TMD had lower symmetry of the AT muscle in the AP of mastication.

Only the effect of craniomandibular pain in masticatory muscle activity was observed (Table 3). Individuals with craniomandibular pain had lower symmetry of the AT muscle during mastication's AP and IP.

Table 1. Distribution of frequencies of 55 asymptomatic volunteers with temporomandibular disorders according to associated risk factors

	TDM		OR	95%CI	p-value
	Absent (n=27) n (%)	Present (n=28) n (%)			
Craniomandibular pain					
Absent (n=23)	21 (77.78)	2 (7.14)	1		
Present (n=32)	6 (22.22)	26 (92.86)	45.50	8.31–249.18	0.00*
Cervical pain					
Absent (n=38)	22 (81.48)	16 (57.14)	1		
Present (n=17)	5 (18.52)	12 (42.86)	3.30	0.97–11.24	NS

*Statistically significant.

Caption: NS = not significant; OR = odds ratio; 95%CI = 95% confidence interval.

Table 2. Comparison between the means of surface electromyographic indices obtained in the evaluation of the active and inactive period of mastication in individuals with temporomandibular disorders present and absent

	TDM		p-value
	Absent (n=27) n (%)	Present (n=28) n (%)	
Masseter symmetry			
AP	82.77 (10.83)	88.32 (9.75)	NS
IP	79.02 (13.74)	84.51 (8.57)	NS
Temporal symmetry			
AP	93.38 (5.17)	90.33 (5.83)	0.04*
IP	88.71 (8.64)	87.03 (6.38)	NS
Antero-posterior coefficient			
AP	85.92 (7.04)	85.62 (7.06)	NS
IP	82.01 (9.62)	82.11 (8.19)	NS

t-Test for independent data; *statistically significant.

Caption: TMD = temporomandibular disorders; AP = active period; NS = not significant; IP = inactive period.

Table 3. Mean and standard deviation (%) of surface electromyographic indices during the active and inactive period of mastication according to the presence of craniomandibular and cervical pain and analysis of variance with two fixed factors

	Craniomandibular pain absent		Craniomandibular pain present		ANOVA		
	Cervical pain absent (n=18)	Cervical pain present (n=5)	Cervical pain absent (n=20)	Cervical pain present (n=12)	Cervical pain	Craniomandibular pain	Interaction
Masseter symmetry							
AP	83.29 (11.61)	85.31 (6.57)	87.85 (8.41)	85.41 (13.60)	NS	NS	NS
IP	81.29 (12.03)	86.35 (10.95)	82.13 (12.19)	80.20 (11.28)	NS	NS	NS
Symmetry of the anterior temporal							
AP	93.90 (2.03)	96.08 (2.37)	90.27 (6.93)	89.54 (6.45)	NS	0,00*	NS
IP	90.89 (4.85)	92.52 (1.37)	85.01 (9.39)	86.07 (6.88)	NS	0,01*	NS
Antero-posterior coefficient							
AP	85.82 (8.38)	85.72 (2.55)	86.26 (5.96)	84.87 (8.14)	NS	NS	NS
IP	80.66 (10.44)	84.76 (8.15)	83.57 (5.70)	80.51 (11.01)	NS	NS	NS

*Statistically significant.

Caption: ANOVA = analysis of variance; AP = active period; NS = not significant; IP = inactive period.

DISCUSSION

This study provides evidence on the prevalence of pain in the craniomandibular and cervical regions in patients with TMD and the effect of these disorders on motor behavior of the MA and AT muscles during the masticatory cycle. The main result of this study was that the AT muscle activity during the masticatory cycle is more asymmetric in patients with TMD, and that craniomandibular pain, more prevalent in these individuals, affects these results. These findings are important for clinicians who work with individuals with TMD. The presence of craniomandibular pain may be related to reduced capacity to symmetrically activate the masticatory muscles.

The stomatognathic system and the cervical spine are interconnected anatomically, biomechanically, and neurologically[18]. However, only the association between the presence of TMD and the presence of craniomandibular pain was observed. Craniomandibular pain was observed in the majority of individuals who had TMD, but cervical pain could be both present and absent in this group.

Although the association between TMD and the presence of cervical pain lacks statistical significance, there was a significant number of individuals (43%) of this group with pain in the cervical region. This result is possibly explained by a lower degree of severity and shorter duration of craniomandibular and cervical pain in the study sample. These factors were not controlled and seem to be the main limitation of this study. Other studies have found a higher prevalence of cervical pain in patients with TMD with moderate or severe intensity[19].

In contrast, in the absence of association between TMD and the presence of cervical pain, it was observed that the majority (70.6%) of individuals who had cervical pain also presented TMD. The higher prevalence of TMD in subjects with cervical pain shows a relationship that should be further investigated. Nociceptive impulses from the head and neck muscles can produce a continuous afferent bombardment for the caudal trigeminal nucleus[20] and generate pain in the orofacial region[21]. The nociceptive input can be adjusted to a condition of pathological hyperexcitability and contribute to the development or maintenance of chronic pain, but also increase the likelihood of other pain disorders[22].

The results of this study showed that individuals with TMD showed greater asymmetry in the activation of the AT muscle during mastication's AP . Corroborating these findings, other studies[7,10] have observed greater asymmetry in the masticatory activity in patients with TMD. However, the study period was not the same. The entire cycle of mastication was more asymmetric during activation of the AT[10], MA[7,10], and sternocleidomastoid muscles[7]. The asymmetry in the activation of masticatory muscles is interpreted as a compensatory strategy to find stability for the mandibular and cervical regions during mastication[7,23].

When the presence of craniomandibular myofascial and cervical pain was considered, there was a higher asymmetric muscular activity of the AT muscle during mastication, both during AP and IP, in the group with craniomandibular pain. Cervical pain showed no effect on the symmetry of the activation of the muscles. The results show that the presence of craniomandibular pain can modify the EMGsignal more than the presence of TMD. Craniomandibular pain showed an increasing effect of this asymmetry. This effect may be related to a compensatory mechanism to alleviate the intensity of pain[24]. It is believed that long-term nociceptive stimuli of the masticatory muscles can change the chewing pattern and thus perpetuate the cycle, causing more pain.

Therapists who work with patients with TMD should be able to differentiate the disorders in the craniomandibular region from those of the cervical region. If the combination of nociceptive stimuli of the cervical region and TMD is confirmed, a therapeutic approach based on the coexistence of cervical and craniomandibular disorders could be assessed in other studies.

CONCLUSION

The patients with TMD have changes in the masticatory pattern of the AT muscle, and nociceptive stimuli of the craniomandibular region can influence the increase of asymmetric activation of these muscles. The influence of the severity and duration of the craniomandibular and cervical pain in TMD and activity of the masticatory muscles remains to be investigated.

**LGKR and VVD were responsible for the study design and overall direction of the stages of implementation and preparation of the manuscript; MDG was responsible for the recruitment of study participants and data collection; CEF, BCFG, DLM, and SCSP were responsible for the processing and analysis of data and drafting of the manuscript.*

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