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Original articles

Masseter muscle surface electromyography in college students with a high degree of anxiety and temporomandibular disorder

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ABSTRACT

Objective: to compare the electrical activity of masseter muscles, bilaterally, according to the presence or absence of Temporomandibular Disorder (TMD) in college students with a high degree of anxiety.

Methods: the study was conducted with a randomized sample of 31 Speech Therapy students aged between 17 and 32 years; 61.3% (n = 19) were females and 38.7% (n = 12) were males. They were divided into two groups, Group 1 (G1), comprising 11 students with TMD, and Group 2 (G2), composed of 20 students without TMD. The college students answered the State-Trait Anxiety Inventory (STAI) for anxiety investigation, and were evaluated by the protocol *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TMD) for TMD diagnosis. The evaluation of muscular electrical activity took into account the records in the conditions of rest, Sustained Maximum Voluntary Activity (SMVA) and habitual chewing (HC). The data were analyzed using the version 22 IBM *Statistical Package for Social Sciences* (SPSS) software. The statistical analysis was performed using Student t test to compare means between groups, considering < 0,05 as the significant p-value.

Results: college students, of both groups, presented high levels of anxiety traits. Significant statistical differences were observed on the percentage of electrical activity of right masseter muscle in chewing function, as well as muscle fibers recruitment during chewing, which were higher on the group without TMD.

Conclusion: college students with TMD and a high degree of anxiety presented lower means of masseter muscle electromyografic activity during chewing, in most conditions assessed, as compared to volunteers without TMD, except for the left masseter muscle in rest and chewing.

Keywords: Temporomandibular Joint Dysfunction Syndrome; Anxiety; Students; Electromyography

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INTRODUCTION

Temporomandibular disorder (TMD) is a term referring to a series of functional changes related to the Temporomandibular Joint (TMJ), chewing muscles and associated structures. It is characterized by a set of signs and symptoms with great variation between subjects, and by negative repercussions on quality of life. In general, the clinical condition consists of pain or discomfort in the masticatory muscle or TMJ, muscle spasm, inadequate occlusion, headache, deviations and joint noises (such as cracking and crackling) during mastication and opening of the oral cavity, restrictions on the performance of mandibular movements and masticatory, vocal and auditory difficulties[1-5].

This dysfunction is more common in individuals aged 20-45 years, with a higher prevalence in females[3]. The American Academy of Orofacial Pain estimates that 40-75% of the US population has some type of TMD signs and that 33% have some symptoms[1]. However, it is estimated that only 3.6% to 7% require or seek some type of intervention[2].

The etiology of TMD is multifactorial, and is associated with anatomical and neuromuscular aspects, deleterious habits, postural deviations, trauma and psychosocial changes[6,7]. The physiological and structural tolerance of the individual is the aspect that will determine whether or not the patient will develop the disorder. Due to a combination of factors, intervention should be performed from a biopsychosocial perspective, which takes into account pathological, physiological, social, cultural and psychological components.

Literature data show evidences of a relationship between TMD and emotional factors such as anxiety[4-6,8-10]. It can be defined as a condition of alertness determined by the presence of an internal conflict in face of a stimulus which may be interpreted as an eminent or threatening danger[11]. It becomes pathological when present at high levels, disproportionate to the circumstance that originated it, remaining persistent even when there is no specific situation to which it is directed[12]. This scenario may be especially worrisome in college students, because it is a population subjected to situations that generate high levels of anxiety, such as intense academic demands, good performance requirements, increased responsibilities and personal, familiar and social pressures[4-8].

It is known that anxiety may be a triggering, precipitating or perpetuating factor of TMD[6,9], and may change the level of tolerance to pain[3], and thus modulate the activity of muscles acting on the TMJ, such as the masseter. Therefore, it can be assumed that in college students exposed to a high degree of anxiety, the electromyographic activity of the masseter is different according to the presence or absence of TMD.

In a study that sought to analyze the electromyographic activity of masseter muscles and the anterior part of the temporal in an anxiety state, The State-Trait Anxiety Inventory was used with 16 volunteers free of signs and symptoms of temporomandibular dysfunction. The activities of simultaneous bilateral mastication, habitual chewing and voluntary contraction were performed in maximum intercuspation at different periods. The authors concluded that trait and state anxiety may influence electromyographic records even in non-experimental situations[13].

Another study, also analyzing the aspects of anxiety (STAI) and temporomandibular dysfunction (RDC/TMD) using electromyographic recordings, found as a result from the evaluation of physical aspects lower mean values for Pressure Pain Threshold and higher means for Pain to Palpation in volunteers with TMD, both indicators of higher levels of pain, and lower mean frenulum values of the left masseter muscle in the group with temporomandibular dysfunction. Regarding psychological aspects, both State-Anxiety and Trait-Anxiety were statistically higher in the Group with TMD[14].

When analyzing 16 volunteers free from signs and symptoms of temporomandibular dysfunction, they were diagnosed according to the Diagnostic Criteria for Research on Temporomandibular Dysfunction (RDC/TMD), but also with anxiety, by the State-Trait Anxiety Inventory (STAI). Regarding anxiety, the results showed an inverse association between the variable activation time and trait-anxiety levels during both activities and a direct association between the variable maximum instant and trait-anxiety levels during simultaneous bilateral chewing activities, habitual chewing and voluntary contraction in maximum intercuspation. Only the anterior part of the temporalis muscle presented a direct relation between the variable maximum instantaneous and state-anxiety during habitual chewing; during simultaneous bilateral chewing, the variable activation time showed an inverse relation for the same muscle. The authors concluded that trait and state anxiety may influence electromyographic records even in non-experimental situations[15].

In light of the above, the evaluation of electromyographic activity may contribute to the diagnosis and to a more precise, early and effective monitoring of muscular, biomechanical and sensorial changes associated with TMD[16-18]. In addition, research addressing the analysis of temporomandibular anxiety and temporomandibular dysfunction using electromyographic recording, also in men, becomes necessary, since the literature contemplates satisfactory investigations on women. Therefore, the objective of this study is to compare the electrical activity of masseter muscles bilaterally according to the presence or absence of TDM in college students with high degree of anxiety.

METHODS

The research follows the recommendations of the criteria and requirements established by the Resolution no. 466/12 of the National Health Council (CNS). It was previously submitted to the Ethics Committee of Research with Human Beings of the Health Sciences Center of the Federal University of Paraíba for assessment, and approved under protocol no. 0144/12, CAAE no. 03117312.1.0000.5188.

The study was conducted with college students of Speech Therapy of a Public University in the Brazilian Northeast region. The sample was composed of 31 random volunteers aged between 17 and 32 years (mean of 22.1±3.62 years); 61.3% (n = 19) were female and 38.7% (n = 12) were male. They were divided into two Group 1 (G1), composed of students with TMD, and Group 2 (G2), composed of students without TMD.

As eligibility criteria for both groups, we considered no diagnosis of neuromuscular and/or degenerative diseases, not having suffered trauma in the temporomandibular region, not having autoimmune disease that could compromise joints, not having received treatment for TMD, and being a student duly enrolled in the Speech-Language Pathology course.

To investigate the presence/absence of anxiety, college students answered the State-Trait Anxiety Inventory (STAI)[19] using a validated version for Brazilian Portuguese[20,21]. The instrument comprises 40 statements about the subject's feelings, divided into two parts. Each part consists of 20 descriptive statements regarding personal feelings, which the subjects rank in relation to the intensity with which they are occurring at that moment (part I - state-anxiety) or in relation to the frequency with which they occur generally (part II - trace-anxiety) using a Likert scale ranging from 1 to 4 points[22]. The cutoff points for the classification of the degree of anxiety are ≤ 40 for low anxiety and ≥ 41 for high anxiety[23]. In this study, only volunteers with high anxiety were included.

For the diagnosis of TMD, all subjects were evaluated using the protocol *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TMD), translated and validated for Brazilian Portuguese [24]. The RDC/TMD contains two axes: Axis I consists of physical diagnosis through standardized clinical examination applied by a trained researcher, and may be used to classify the individual according to the clinical conditions of TMD into three groups: Group I - Muscle dysfunctions (a. Myofascial pain, b. Myofascial pain with opening limitation), Group II - Displacement of the articular disc (a. Disc displacement with reduction, b. Disc displacement without reduction, with limited opening; c. Disc displacement without reduction, without limited opening), and Group III - Arthralgia, arthritis and arthrosis (a. Arthralgia, b. Osteoarthritis of TMD, c. Osteoarthrosis of TMD). To be allocated in Group 1 (with TMD), individuals should belong to at least one of the RDC/TMD axis 1 groups, otherwise they were allocated to Group 2 (Without TMD). Axis II data, which assess the psychosocial profile of the volunteers, were not used for this study.

After completing the questionnaires, the volunteers were submitted to electromyographic evaluation of the surface of the right and left masseter muscles. We used the Miotool 200/400 electromyograph, MIOTEC® (Rio Grande do Sul, Brazil), composed of four channels connected via USB communication cable to a HP Pavilion notebook, 14-V066BR, 8 GB RAM, 1 TB HD, Processor Intel Core i7-4510U and *Microsoft Windows* operating system, version 7. The electromyographic signals were collected by the data acquisition system of the equipment using a windowing of 32 and a gain of 1,000 for each channel. A ground cable (reference) was used to avoid electromagnetic interference during the examination, and two equipment channels were connected to two claw-connected SDS500 sensors. The surface electrodes were *MEDITRACE®* (Kendall, Canada), disposable, children's standard, made of silver-silver chloride (Ag-AgCl), immersed in a conductive gel, responsible for capturing and conducting the electromyographic surface signal. The signal analysis was performed using the software Miograph, MIOTEC® (Rio Grande do Sul, Brazil).

For the collection of electromyographic surface signs, the volunteer was accommodated comfortably in a chair, with the torso erect, feet resting on the floor, and the head oriented along the horizontal plane of

Frankfurt, parallel to the ground, not being able to see the screen of the notebook. Then, the skin was cleaned with cotton soaked in 70° alcohol to remove any material that could promote impedance to signal capturing. The placement of electrodes began by the ground electrode, positioned in the olecranon of the ulna of the right arm of the volunteer. Subsequently, the electrodes were fixed in the right and left masseters. The fixation of electrodes obeyed the bipolar configuration (with a 1.5-centimeter distance) in the region of the muscular belly of the masseters, longitudinally to the muscular fibers. To locate the region in which the electrode would be fixed, a trained investigator instructed the volunteer to keep the teeth in occlusal contact, thus enabling palpating the more robust region of the masseter, corresponding to the neuromuscular junction[25]. The sensors with claws were then fixed, obeying the same order of placement as the electrodes.

The evaluation of muscular electric activity considered records in conditions of rest, Sustained Maximum Voluntary Activity (SMVA) and habitual chewing (HC), according to the protocol used[26], as shown in Figure 1.

FIGURE 1.

For rest analysis and SMVA, three seconds of the electromyographic signal were selected, excluding the first and last seconds of the recording. A time of 5 seconds for the collection of the signal is important to avoid muscular fatigue, since it is a relatively short time of contraction. In addition, it is sufficient to achieve the required maximum electromyographic amplitude[27]. For the analysis of the mastication record, the selection of five masticatory cycles was performed. The signals were initially calculated from the raw signal (Raw) of the mean amplitude value, measured in microvolts (µV), later transformed into Root Mean Square (RMS), representing the calculation of root mean square.

Test 01 - Rest
The participant was instructed to stay in the usual position, without speaking, chewing or swallowing for 5 seconds, while the electromyographic examination was performed.
Test 02 - Sustained Maximum Voluntary Activity (SMVA) (100%)
The participant was instructed to keep occlusal contact (biting forcefully), contracting the masticatory muscles bilaterally and simultaneously, with a maximum habitual intercuspation, maintaining the contraction for 5 seconds[26].
Test 03 - Habitual Chewing (HC)
The patient was instructed to make the usual incision and keep the usual chewing for 10 seconds. The food used was loaves of French bread.

Figure 1. Stages of the electromyographic evaluation protocol of masseter muscles

The task of maximal voluntary isometric contraction applied to the head and neck musculature is now called SMVA[28], and was used for the normalization of electromyographic signals. The normalization of data allows a comparison with some standard value[27]. The choice for this technique is based on the comparisons to be made in the study. In addition, it is possible to convert absolute values into percentages of a reference value[26,28]. In this study, the SMVA represented 100% of the electrical activity of the masseter muscle on each side. For normalization, the proportion of muscular electrical activity of the chewing procedure was calculated bilaterally in relation to the SMVA. At this proportion, it is considered as 100%, and a simple rule of three is performed to obtain the percentage of habitual resting and chewing activities[27].

Data were organized in spreadsheets using the software IBM *Statistical Package for Social Sciences* (SPSS), version 22, trial, in which a descriptive statistical analysis was performed to obtain mean and standard deviation data. In addition, the Student t test was used to compare the means between Groups 1 (with TMD) and 2 (without TMD). The choice for this test followed the statistical principle of normality, verified as positive by the Shapiro-Wilk test. For all statistical tests, the data were considered significant when the p-value was lower than 5%.

RESULTS

From the assessment of TMD by RDC/TMD, Group I was composed of 11 individuals with TMD and Group II was composed of 20 individuals without TMD. The clinical conditions of patients with TMD were myofascial pain, disc displacement with right or left reduction, myofascial pain, displacement of the left disc with reduction, and myofascial pain and arthralgia.

Table 1 shows the values of the State-Trait Anxiety Inventory of voluntary students for the groups with and without TMD.

Table 1. Distribution of State-Trait Anxiety Inventory means for college students with and without Temporomandibular Disorder

Variables	Group	Mean	SD	P value*
STAI I	with TMD	43.73	4.36	0.42
	without TMD	42.20	5.26	
STAI II	with TMD	45.82	4.26	0.94
	without TMD	45.70	4.72	

Caption: SD - Standard deviation; TMD - temporomandibular disorder
* Student t test, $p < 0.05$

In the results of differences in electromyographic activity between Group I and II of masseter muscles under resting conditions, SMVA, chewing and percentage of maximum electrical activity, it can be observed that the mean values were higher in the Group II for all variables studied on the right side. Regarding the left masseter, electromyographic means were higher among the students of the Group II in the SMVA and percentage of recruitment in mastication. In Group I, the greatest means occurred for the remaining and the chewing variables.

However, statistically significant differences were observed for the percentage of maximal electrical activity of the right masseter in mastication and percentage of masticatory muscle recruitment, with higher means in the Group without TMD (Table 2).

Table 2. Descriptive data and comparison of means of the muscular activity of the masseter in the accomplishment of different tasks in college students with and without temporomandibular disorder

Variables		Group	Mean	SD[2]	P value[4]
Right Masseter	S_{MVA}[1]	With TMD[3]	58.99	48.25	0.45
		Without TMD	81.01	89.28	
		Sample	73.19	77.06	
	Rest	With TMD	3.64	1.17	0.28
		Without TMD	5.80	6.02	
		Sample	5.04	5.24	
	Chewing (in microvolts)	With TMD	36.57	30.59	0.04*
		Without TMD	65.46	39.36	
		Sample	55.21	38.61	
	%[5] chewing	With TMD	65.97	24.13	0.04*
		Without TMD	195.91	270.63	
		Sample	149.80	224.89	
Left Masseter	S_{MVA}	With TMD	92.42	44.44	0.57
		Without TMD	114.60	124.93	
		Sample	106.73	103.25	
	Rest	With TMD	7.77	11.27	0.44
		Without TMD	5.55	4.56	
		Sample	6.34	7.53	
	Chewing (in microvolts)	With TMD	88.31	42.22	0.72
		Without TMD	82.59	42.53	
		Sample	84.62	41.80	
	%[5] chewing	With TMD	135.91	121.07	0.94
		Without TMD	138.91	117.63	
			137.85	116.84	

Caption: [1]Sustained Maximum Voluntary Activity; [2] standard deviation; [3] Tempomandibular disorder, [4] Student t test, $p < 0.05$;
* Significant data; [5]Percentage of electrical activity

DISCUSSION

Given the results, the data showed that college students have high levels of anxiety. Several studies[8,22,28-33] have been conducted with these individuals due to a great repercussion of emotional factors on academic performance. Also noteworthy are the maturational transformations experienced by students[19] arising from the transition between adolescence and adulthood. In the data of this research, both Group I and II presented a high level of state and trait anxiety. Several studies report anxiety as a possible etiology for the development of TMD, acting as an important collaborator for the installation and maintenance of this dysfunction[4-6,8,9,13-15]. The prevalence of individuals with TMD and anxiety is significantly higher in individuals with TMD without anxiety[9]. On the other hand, there are studies[34,35] that did not report differences between the anxiety levels of TMD symptomatic subjects and asymptomatic subjects.

Participants with TMD had a lower electrical activity in the right masseter muscle than asymptomatic subjects in all the conditions studied. The maximum electrical activity that the masseter requests in chewing, in relation to the normalization value, shows that individuals with TMD present a potential lag when compared to the control group. These data are close to those reported by other studies, which show a low functional efficiency of the muscles in TMD patients[36], and statistically significant differences among healthy individuals who have a higher mean bite force value in relation to TMD patients[37]. In many individuals, the reduction in strength occurs due to the pain, a limiting factor in the performance of bite force[38].

The electromyographic activity of the left masseter muscle at a resting state presents a pattern of greater muscular electrical activity in relation to the right side, a result of joint disharmony, when compared with healthy individuals, which indicates an increase in the basal musculature tone. This finding is compatible with others found in the literature comparing the electromyographic activity of masticatory muscles of subjects with and without TMD[37]. The mean of SMVA was higher in the control group; therefore, individuals with TMD have a significantly reduced ability to tighten the jaw[37], which could be interpreted as a defense mechanism of the injured system[39]. Subjects with pain in masticatory muscles change their muscle recruitment, corroborating with the concept that the neuromuscular system changes in patients with craniomandibular disorders[40].

However, even when amplitude averages were higher in Group I, in the left masseter at rest and in mastication, the subjects in Group II achieved a greater efficacy regarding the percentage of their maximum electrical activity in relation to the value of normalization.

CONCLUSION

In this study, we observed that there were differences in the electromyographic means of the masseter muscle between subjects with and without TMD, all of which were lower in individuals with TMD, except for the left masseter at rest and chewing. Such data may indicate that subjects with temporomandibular disorders present a changed neuromuscular system when evaluated by surface electromyography.

The high index of trait and state anxiety, as well as temporomandibular dysfunctions, in college students calls attention to the need for interdisciplinary interventions in this population, in order to prevent this change and promote physical and psychic quality of life.

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