

Pattern of Electromyographic Activity in Mastication Muscles of Adolescents with Temporomandibular Disorder

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Abstract. [Purpose] The aim of the present study was to assess the behavior of the mean and median frequencies of the electromyography signal of the mastication muscles of adolescents with different degrees of TMD severity. [Subjects] Forty-two adolescents aged 14 to 18 years. [Methods] The adolescents were classified according to severity using the Helkimo Index. The control group consisted of 14 subjects with no signs or symptoms of TMD. Three readings were taken in during maximum intercuspation and mandibular rest, with each reading lasting 10 seconds. [Results] Significant differences ($p=0.0001$) were found in the mean frequency (Hz) between the control group (CG), mild TMD group (MG) and moderate/severe TMD group (MSG), especially during mandibular rest, for all muscles evaluated: right temporal: CG (137.5), MG (194.2), MSG (291.7); left temporal: CG (106.9), MG (200.6), MSG (294.2); right masseter: CG (155.7), MG (242.8), MSG (278.3); left masseter: CG (125.0), MG (214.6), MSG (316.7). Greater differences among groups were found under the condition of mandibular rest. Conclusions: Adolescents with TMD especially those with more severe symptoms exhibit hyperactivity of the mastication muscles.

Key words: Temporomandibular joint disorders, Electromyography, Adolescent

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INTRODUCTION

Temporomandibular disorder (TMD) is related to clinical conditions that involve the mastication muscles, temporomandibular joint and associated structures¹⁾. Studies indicate a high prevalence rate of this disorder among children and adolescents²⁻⁷⁾. Therefore, multidisciplinary analysis directed toward adequate treatment for such cases is needed.

The occurrence of parafunctional habits, such as bruxism (teeth clenching/grinding), and changes in occlusal contacts are important factors in the development of this disorder^{2, 5, 8, 9)}. Moreover, emotional factors also play an important role in the occurrence of TMD, especially in adolescence¹⁰⁾. These traits demonstrate the multifactorial etiology of this condition¹¹⁾.

Surface electromyography (EMG) is a widely used in the evaluation and follow up of individuals with TMD, and it allows the observation of the electrophysiological behavior of muscles under different physiological conditions¹²⁻¹⁶⁾. The frequency of the EMG signal represents the excitation rate of the muscle cells. This frequency is affected by the composition of the muscle and the characteristics of the action

potential of active nerve fibers¹⁷⁾.

The evaluation of the mean and median frequencies (MNF and MDF, respectively) of the EMG signal enables analysis of the temporal spectrum of the muscle, the content of the muscle fibers and valuable information for the diagnosis and treatment of individuals with TMD^{16, 18)}. Previous reports have demonstrated that individuals with TMD exhibit alterations in the electrical activity of the mastication muscles either as a result of the disorder itself or from a compensatory mechanism associated with the symptoms^{14, 15, 19)}.

Considering the joint occurrence of TMD and stressors commonly found in adolescence, it is reasonable to hypothesize that teenagers develop important alterations in the mastication muscles. The investigation of electromyographic characteristics of adolescents with TMD is essential for the early determination of problems that predispose such individuals to pain and muscle/joint dysfunction in adulthood. Thus, the aim of the present study was to assess the behavior of the mean and median frequencies of the EMG signal of the mastication muscles of adolescents with different degrees of TMD severity with the mandible at rest and during maximum clenching effort.

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SUBJECTS AND METHODS

Eighty-one male and female adolescents between 14 and 18 years of age enrolled at the José de Paiva Neto Education Institute, Sao Paulo, Brazil, were evaluated. The inclusion criteria were having all four permanent first molars erupted and a statement of informed consent signed by the participant or his/her guardian. The exclusion criteria were current medical or psychological treatment, dento-facial anomalies, history of surgery or trauma in the region of the temporomandibular joint and a history of orthopedic or orthodontic treatment of the jaws.

This study was conducted in compliance with the principles of the Declaration of Helsinki and received approval from the Human Research Ethics Committee of Nove de Julho University, protocol number 332780.

Sample size was calculated based on a pilot study using the DIMAN 1.0 sample calculation program and the root mean square (RMS) of the electromyographic signals of the masseter muscles and anterior bundles of the temporal muscles, with $\alpha=0.05$, $\beta=0.20$ and 80% test power. A minimum of 11 participants in each group was determined. To provide a margin of safety, 14 individuals in each group (control, mild TMD and moderate/severe TMD) were evaluated.

The severity of TMD was assessed using the Helkimo Index. While the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is better for the classification of TMD, the Helkimo Index was employed due to the fact that it is more easily understood by individuals of the age group studied in the present investigation. Moreover, the Helkimo Index has been frequently employed for the diagnosis of TMD²⁰⁻²³. This index classifies the individual in severity categories based on clinical signs of TMD, and is divided into five subscales addressing limitations of mandibular range of motion, limitations of temporomandibular joint function, pain in the mastication muscles, pain in the temporomandibular joint and pain during mandibular movements²⁴.

On a specific chart, data were recorded from a clinical examination involving extra-oral and intra-oral inspection of the teeth, type of occlusion and occlusal alterations as well as palpation of the mastication muscles and temporomandibular joint. The analysis of mandibular movements involved observation of the joint noises, headaches, facial pain, difficulty with chewing, breathing pattern and para-functional habits. Based on the criteria of the Helkimo Index, each item received a score of 0, 1 or 5. The sum of the item scores allows classification of the individual into one of four categories: no symptoms of TMD (0 points), mild symptoms of TMD (1 to 4 points), moderate symptoms of TMD (5 to 9 points) and severe symptoms of TMD (10 to 25 points)²⁴. In the present study, the participants were classified into the following three groups: control group (CG – without TMD); mild TMD group (MG); and moderate to severe TMD group (MSG).

EMG signals were obtained using an eight-channel module (EMG System do Brasil Ltda[®]), consisting of a conditioner with a band pass filter with cut-off frequencies of 20 and 1,000 Hz, an amplifier gain of 1,000 and a common

mode rejection ratio > 120 dB. All data were acquired and processed using a 16-bit analog to digital converter (EMG System do Brasil Ltda[®]), with a sampling frequency of 2 kHz. The system was composed of active bipolar electrodes with a pre-amplification gain of $20 \times$.

The participants were instructed to remain seated in a chair, feet apart, shoulders relaxed and hands resting on their thighs, with their heads on the Frankfurt parallel to the ground and no visual feedback of the signals registered on the computer. The attachment sites for the electrodes were cleaned with a cotton ball soaked in alcohol to diminish the impedance between the skin and electrodes. Disposable Ag/AgCl surface electrodes measuring 10 mm in diameter were attached to the belly of the muscle in the region with the greatest tonus after the volunteer performed moderate intercuspation. Bandage tape was used to secure the electrodes further, with care taken to avoid micro movements. The inter-electrode distance was 20 mm from center to center, as suggested by SENIAM (European Recommendations for Surface Electromyography)²⁵. A rectangular metallic electrode measuring 3 cm by 2 cm coated with Lectron II conductive gel (Pharmaceutical Innovations[®]) to increase the conduction capacity and impede interference from external noise was attached to the left wrist of the volunteers for reference.

The muscles recorded with surface EMG were the right and left masseter and right and left anterior temporal bundle. The evaluations were carried out at rest and the maximum clenching effort (MCE). Under each condition, the signals were recorded three times for 10 seconds each. To avoid direct occlusal contact between the dental cusps, a strip of Parafilm M[®] (American National Can TM, Chicago, USA) was folded five times to create a texture and dimensions similar to commercial chewing gum and arranged bilaterally in the molar region²⁶.

Initially, three readings were performed in the rest position with a two-minute interval between readings. After 3 minutes, three readings were performed in MCE, with a ten-minute interval between readings.

In all tests, a five-second period was selected (the two initial and three final seconds of the EMG signal were discarded). In the frequency domain analysis, 2,048-point running Fast Fourier Transforms with a resolution of 10 Hz were computed with a 50% overlap (Hamming window processing). The mean and median frequencies (MNF and MDF, respectively) of the power spectrum were calculated for a one-second window. All EMG signal processing was performed using specific routines carried out in the Matlab program, version 7.1 (The MathWorks Inc., Natick, Massachusetts, USA).

The Shapiro-Wilk test revealed that the MNF and MDF were not normally distributed ($p < 0.05$). Consequently, medians and inter-quartile (25% and 75%) ranges were calculated and the non-parametric Kruskal-Wallis test and Dunn's post hoc test were used to compare differences in the masseter and temporal muscles among the CG, MG and MSG during maximum clenching effort and at rest. Spearman's correlation coefficients (r) were calculated for the determination of correlations between MNF and MDF values.

Table 1. Mean (MNF) and median (MDF) frequency values (Median [25%, 75% quartile]) of right masseter (RM) and temporal (RT) and left masseter (LM) and temporal (LT) muscles recorded at rest and during maximum clenching effort (MCE) in the control group (CG), mild TMD group (MG) and moderate/severe TMD group (MSG).

		Without TMD group	Mild TMD group	Moderate/severe TMD group	
MNF (Hz)					
RT	MCE	195.7 [173.5–229.8]	180.6 [172.1–197.8]	230.2 [192.6–280.8]	*
	REST	137.5 [119.7–163.6]	194.2 [148.0–225.7]	291.7 [231.3–383.8]	*
RM	MCE	174.1 [153.7–202.9]	176.3 [165.7–195.6]	215.0 [176.8–276.4]	*
	REST	155.7 [139.4–230.1]	242.8 [126.8–274.9]	278.3 [253.4–372.0]	
LT	MCE	194.0 [173.1–207.0]	184.6 [177.5–192.6]	262.2 [208.8–305.8]	*
	REST	120.5 [106.9–169.0]	200.6 [160.7–221.6]	294.2 [236.3–396.9]	*
LM	MCE	175.2 [151.6–184.8]	175.8 [162.5–197.3]	230.6 [189.4–297.7]	*
	REST	125.0 [101.6–235.4]	214.6 [195.3–235.9]	316.7 [266.0–401.4]	*
MDF (Hz)					
RT	MCE	182.5 [161.1–216.3]	172.4 [163.2–188.5]	222.3 [179.5–260.0]	*
	REST	67.3 [55.32–95.46]	110.7 [93.46–157.7]	202.3 [149.2–341.7]	*
RM	MCE	158.7 [142.9–191.7]	164.6 [137.9–174.4]	201.4 [160.9–264.7]	*
	REST	64.9 [28.78–149.4]	176.5 [158.5–204.6]	202.9 [136.6–335.9]	*
LT	MCE	182.1 [159.4–195.2]	157.8 [152.4–179.4]	251.7 [138.2–172.0]	*
	REST	66.8 [28.85–96.88]	135.5 [105.8–161.0]	213.4 [142.2–354.7]	*
LM	MCE	157.9 [138.2–172.0]	151.4 [138.4–172.1]	206.1 [177.8–264.6]	*
	REST	41.6 [26.57–108.3]	150.9 [123.0–165.2]	229.6 [186.3–346.6]	*

Asterisks indicates significant differences between groups ($p < 0.05$)

The significance level was chosen as 5% ($p < 0.05$). All data were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 17.

RESULTS

The sample was made up of 14 individuals without TMD (mean age: 14.92 ± 0.95 years), 14 with mild TMD (mean age: 15.28 ± 0.82 years), 12 with moderate TMD (mean age: 15.25 ± 0.62 years) and two with severe TMD (both aged 15 years).

EMG signal

Table 1 displays the MNF and MDF of the temporal and masseter muscles at rest and during maximum clenching in the CG, MG and MSG. Significant differences ($p < 0.05$) were found in all comparisons of the MNF and MDF among the CG, MG and MSG during maximum clenching effort. However, the post hoc test revealed no significant differences in MNF and MDF among groups for the right masseter muscle.

Greater differences among groups were found under the condition of mandibular rest ($p < 0.05$). The highest MNF and MDF values were found in the group with moderate to severe TMD. These differences were confirmed by Dunn's post hoc test.

DISCUSSION

Individuals with TMD exhibit muscle dysfunctions that can be progressive and have a variety of etiological factors^{2, 5, 8, 9}. In adolescence, occlusal interferences can cause a functional deviation in the mandible, which can lead to serious craniocervical disorders^{27, 28}. Frequent harmful oral habits can lead to alterations in the biomechanics of the temporomandibular joint and an increase in tension in the mastication muscles^{2, 5, 8, 9}, with the consequent retention of fluids in the muscle tissue, reduced blood flow and the accumulation of metabolic products²⁹. Thus, the evaluation of electromyographic activity in the mastication muscles and related occlusal factors is of fundamental importance in comparisons among individuals and the evaluation of signs and symptoms of TMD.

Surface EMG is one of the main tools employed in the diagnosis of TMD, the analysis of muscle performance, and the detection of physiopathological conditions. Previous studies of adult individuals have shown that individuals with TMD exhibit greater asymmetry between the masseter and temporal muscles, as well as hyperfunction of the temporal muscle^{12, 16, 18}.

Knowledge of the electromyographic pattern of the mastication muscles of adolescents with TMD helps in the formulation of treatment strategies aimed at normalizing muscle activity and improving the function of the stomatognathic system. Previous studies have demonstrated the benefits of the use of a bite plate and massage therapy^{30–33}. Other treatment options, such as low-level laser therapy,

have also demonstrated satisfactory results^{34, 35}.

In the present study, significant differences were found in the electromyographic characteristics (MDF and MNF) among the GC, MG and MSG. These findings suggest muscle hyperactivity in adolescents with TMD even when the mandible is at rest. This behavior may be explained by the need for greater muscle recruitment in individuals with TMD and orofacial pain when the mandible is at rest^{36, 37}.

Greater differences among groups were found under the condition of mandibular rest ($p < 0.001$). Minimal electromyographic activity of the mastication muscles in the resting position is found in individuals without TMD, indicating a balance between elevator and depressor muscles of the mandible^{38, 39}. In the present study, significant differences in MNF and MDF were found between adolescents with signs and symptoms of TMD and the control group. This finding may be explained by the increase in muscle tension resulting from the frequency of parafunctional habits. Previous studies have indicated that occlusal alterations and different facial pattern influence the electrical activity of the musculature^{40, 41}. The literature also reports that hyperactivity of the mastication muscles may be related to teeth clenching (bruxism), which is a common occurrence in adolescents with TMD^{1, 4}. Future studies addressing fatigue in these muscles among adolescents with TMD, may offer physiological data to explain these findings.

In conclusion, the mastication muscles of adolescents with TMD, especially those with a greater severity of signs and symptoms, exhibit higher MNF and MDF of the electromyographic signal, indicating hyperactivity of these muscles while at rest and during maximum intercuspation.

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