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Observational, cross-sectional, study

Evaluation of integral electromyographic values and median power frequency values in women with myogenous temporomandibular disorder and asymptomatic controls

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ABSTRACT

Background: Surface electromyography (EMG) has been used as a reliable tool for the evaluation of electrical muscle activity.
Objective: The purpose of this study was to evaluate the EMG indices of the masticatory muscles (masseter, anterior temporalis and suprahyoid) in women with temporomandibular disorder (TMD) and asymptomatic controls in the time domain, by the integrated EMG signal (IEMG) and in the frequency domain, using the median power frequency (MPF).
Methods: An observational, cross-sectional study was conducted involving 30 asymptomatic women as the control (mean age: 25.85 ± 2.57 years) and 74 women with myogenous TMD (mean age: 26.54 ± 2.45 years) diagnosed using the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). Three EMG readings were taken during maximum voluntary clenching (MVC) of the molars on parafilm for five seconds with a three-minute rest interval between readings. The mixed-model analysis of variance test followed by the Bonferroni correction or the Student-t test was used for the analyses, with the level of significance set to 5% ($p < 0.05$).
Results: IEMG values were significantly higher in the masseter muscles than the anterior temporalis muscles in the control group ($p < 0.01$). IEMG values were significantly higher in the masseter muscles of the control group than the group with myogenous TMD ($p < 0.05$). MPF values of the suprahyoid muscles were significantly higher in the myogenous TMD group than the control group.
Conclusions: These significant findings show that women with myogenous TMD have reduction of electrical activity of their masseter muscles and increased firing rate of the motor units of the suprahyoid muscles. These findings may help the treatment of myogenous TMD in women.

1. Introduction

Temporomandibular disorder (TMD) is a set of clinical alterations involving the masticatory muscles and temporomandibular joint (TMJ) (Leeuw and Klasser, 2013). Signs and symptoms of this disorder include limited jaw movement, sensitivity of the masticatory muscles and TMJ, joint sounds (clicks and crepitus), ringing in the ears, headache and upper neck pain (Ciancaglini and Radaelli, 2001; Kordass et al., 2012). Moreover, previous studies have demonstrated that TMD is more prevalent in the female gender (Slade et al., 2011; Slade, 2014).

TMD leads to important changes in the electrical activity of the masticatory muscles due to the disorder itself or compensatory mechanisms associated with the symptoms (Santana-Mora et al., 2009), since the main problems in affected individuals are of a muscular origin (Santana-Mora et al., 2009; Douglas et al., 2010). Thus, surface electromyography (EMG) is an adequate tool for the analysis of neuromuscular function in such cases. When used following specific guidelines and in conjunction with an analysis of the clinical history and physical exam of the patient, EMG provides objective, valid, reproducible data on the functional condition of the masticatory muscles in individuals with TMD (Hugger et al., 2012). Moreover, this is a noninvasive, low-cost technique that

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can be used in the clinical setting without the need to send the patient to a specialized diagnostic center (Sforza et al., 2011; Lodetti et al., 2012).

It is known that the electrical activity of a given muscle (EMG) can be processed according to specific calculations using the root mean square (RMS) and integrated EMG signal (IEMG) in the time domain, as the median power frequency (MPF) of power spectral density in the frequency domain (De Luca, 1997). In this context, studies have documented normalized and non-normalized RMS values of the masseter and anterior temporalis muscles with the jaw at rest and/or during maximum voluntary clenching (MVC) of the molars either in intercuspal position (Santana-Mora et al., 2009; Liu et al., 1999) or on cotton rolls (Tartaglia et al., 2011; De Felício et al., 2012) or on parafilm (Berni et al., 2015; Lauriti et al., 2013) in individuals with TMD and asymptomatic individuals. However, only Santana-Mora et al. (2009) and Liu et al. (1999) have reported IEMG values of the masseter and anterior temporalis muscles of this population during MVC with the molars in intercuspal position. Thus, there are no studies in the literature on normalized or non-normalized IEMG values during MVC on cotton rolls or parafilm.

In addition, studies have demonstrated that the MPF offers a lower probability of being influenced by subjective aspects of the individual, such as cooperation, mood and psychological factors, thereby enabling a better interpretation of the specific electrical behavior of masseter and anterior temporalis muscles (Tartaglia et al., 2011; De Felício et al., 2012; Lauriti et al., 2013). It is therefore, important to evaluate IEMG values together with MPF values for the characterization of individuals affected with myogenous TMD and asymptomatic individuals.

Another important point to consider regards the lack of information in the recent literature on the IEMG and MPF of the suprahyoid muscles during MVC in individuals with TMD, despite the fact that these muscles are considered important to the mechanics of the TMJ as agonists of the mouth-opening movement (Standring, 2011). Thus, the present investigation was conducted to test the hypothesis that significant differences occur in the EMG signals of the masticatory muscles (masseter, anterior temporalis and suprahyoid muscles) between individuals with myogenous TMD and asymptomatic individuals during MVC.

The aim of the present study was to evaluate IEMG (normalized and non-normalized) and MPF values of the masticatory muscles in women with myogenous TMD and asymptomatic controls during MVC on parafilm.

2. Methods

2.1. Sample

An observational, cross-sectional study was conducted with women: 74 with a diagnosis of myogenous TMD (mean age: 26.54 ± 2.45 years) allocated to the TMD group and 30 asymptomatic women allocated to the control group (mean age: 25.85 ± 2.57 years). The inclusion criteria for the group with TMD were age 18–40 years, diagnosis of myogenous TMD [myofascial pain (Ia) or myofascial pain with limited mouth opening (Ib) according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TDM)], bilateral TMJ dysfunction, pain and/or fatigue in the masticatory muscles during functional activities for more than six months (Ohrbach et al., 2011) and body mass index (BMI) between 18 and 25 kg/m^2, because the amount of adipose tissue between the surface of the muscle and electrode can affect the capture of the EMG signal (De Luca, 1997). Moreover, women with simultaneous diagnoses of disk displacement or arthralgia (IIa, IIb, IIc and IIIa) were permitted in TMD group, according with the RDC/TMD. The inclusion criteria for the control group were age 18–40 years, the absence of TMD, according with the RDC/TMD and BMI between 18 and 25 kg/m^2.

The following were the exclusion criteria for both groups: tooth loss, body mass index (BMI) greater than 25 kg/m^2, systemic disease (such as arthritis, arthrosis or diabetes), history of trauma to the face or TMJ, history of sub-luxation or luxation of the TMJ, current orthodontic treatment or current medical treatment involving anti-inflammatory agent, analgesic or muscle relaxant and volunteers with a diagnosis of arthrogenous TMD (IIIb and IIIc) according with the RDC/TMD.

Between 2009 and 2013, 102 women with TMD and 50 asymptomatic women (without TMD) were recruited from the university community of the city of Piracicaba (SP, Brazil) at the Methodist University of Piracicaba, through personal invitation, posters, and Internet advertisements. Of the women with TMD, 28 were excluded: twelve had a diagnosis of IIIb or IIIc on the RDC/TMD, eight were in orthodontic treatment, and eight had a body mass index higher than the established cutoff point. Of the asymptomatic women, 20 were excluded, since ten were in orthodontic treatment and ten had a body mass index higher than the established cutoff point.

The procedures received approval from the Human Research Ethics Committee of the Methodist University of Piracicaba (SP, Brazil), under protocol number 25/15. All volunteers signed a statement of informed consent.

2.2. Evaluations

The RDC/TMD was used to screen the volunteers of the groups. Pain in the TMJ was evaluated using the visual analog scale, which is a tool that facilitates the measurement of pain intensity and consists of a straight line 10 cm in length on which the left extremity represents the absence of pain and the right extremity represents the worst possible pain (Ferreira-Valente et al., 2011; Packer et al., 2014). The volunteers were instructed to mark a perpendicular line between the two extremes that represented the pain intensity at rest that they were feeling at the moment of recruitment.

The BIO-EMG 1000 electromyograph (Lynx®, Tecnologia Eletrônica Ltda., São Paulo, SP, Brazil) was used for the surface EMG procedures, with impedance of 109 Ω, an analog-digital converter with 16 bits of resolution, a sampling frequency of 2000 Hz per channel and a range of ±2 V. The specific software program for this equipment was used for the acquisition and storage of the digitized signals.

Five simple differential electrodes were used to capture the action potential of the masseter (right and left), anterior temporalis (right and left) and suprahyoid muscles. The electrodes consisted of two pure silver bars measuring 10 × 2 mm positioned parallel, with a fixed inter-electrode distance of 10 mm, 1000-fold gain, CMRR greater than 130 dB, input impedance of 10 GΩ and noise/signal ratio less than 3 μV RMS. After clearing the site of hair follicles and cleaning with a cotton ball moistened with 70% alcohol, the electrodes were positioned over the belly of the muscles with the silver bars perpendicular to the muscle fibers following the method described by Cram et al. (1998). A reference electrode composed of a metal plate measuring 30 × 40 mm was positioned over the manubrium of the sternum. During the readings, the volunteers remained seated in a chair and performed a maximum voluntary teeth clenching (MVC) on parafilm, in which the subject was invited to clench the molar teeth as hard as possible and to maintain the same level of contraction for 5 s. Three five-second readings were made with a three-minute rest interval between readings (Berni et al., 2015).

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