Electromyography assessment of chewing induced fatigue in temporomandibular disorders patients – a pilot study

Regiane Cristina Mendonça
Anamaria Siriani de Oliveira
Cristiane Rodrigues Pedroni
Fausto Bérzin
Ada Clarice Gastaldi

1Graduate Program – Master Degree in Physical Therapy - Triângulo Universitary Center (UNIT)
2Department of Biomechanics, Medicine and Rehabilitation of the Locomotor Apparatus, Ribeirão Preto School of Medicine, São Paulo University (USP)
3Department of Morphology, College of Dentistry, State University of Campinas (UNICAMP)

Received for publication: March 07, 2005
Accepted: November 21, 2005

Abstract
The purpose of this study was to evaluate the endurance time, pain and discomfort intensities, the RMS and median frequency (Fmed) in the induced fatigue by prolonged gum mastication in control and temporomandibular disorders (TMD) groups. This study evaluated 8 healthy and 11 TMD patient women (mean age 27±6 years). Each gum (18x17x4mm, weight 245mg) was put on both sides of the dental arc. The metronome set at 80 bpm indicated chewing rate. Endurance time corresponded to time ranging from beginning of mastication to the subject fatigue. Pain and discomfort intensities were evaluated by visual analogue scale (VAS) obtained after and before the prolonged gum mastication. Surface EMG was recorded from the anterior temporalis and masseter muscles using surface differential electrodes (silvers bars 10mm apart, 10mm long, 2mm wide, gain of 100x, input impedance of 10GΩ and CMRR of 130dB). The EMG signals were analogically amplified with gain of 50x, filtered (10-1500Hz band-pass) and sampled by 12 bits A/D covert board with a 2KHz frequency. The signals were digitally band-pass filtered (10-500Hz). The RMS and Fmed (PSD, FFT, 250 ms, 1024 points, Hanning window processing) were obtained from masticatory cycles in 250ms windows determined visually considering the most stable epoch. The maximal clenching RMS values were used to normalize masticatory cycles EMG amplitude. The first masticatory cycle Fmed values were used to normalize EMG frequency of masticatory cycle remains. There were no significant differences among the values of RMS and Fmed during the prolonged gum mastication (p>0.05, Friedman ANOVA). Endurance time was significantly shorter to TDM group (p>0.05, Mann-Whitney test). Pain and discomfort intensities were not different for control and TDM groups after the prolonged mastication (p>0.05, Mann-Whitney test). There was no evidence of change related to prolonged gum mastication in the investigated electromyographic parameters, in these experimental conditions.

Key Words: mastication, chewing, muscle fatigue, electromyography, visual analogue scale

Correspondence to:
Anamaria Siriani de Oliveira
Avenida Bandeirantes, 3900 - 11º andar
Ribeirão Preto – São Paulo – Brasil
E-mail:siriani@fmrp.usp.br
Pain and fatigue are the most commonly related symptoms in temporomandibular disorders (TMD) patients. However, the subjective feature of these symptoms makes the TMD assessment and treatment difficult. According to Von Lindern et al., these symptoms are the result of masticatory hyperactivity muscles produced by bruxism and clenching. It’s stabilizing in many recent scientific reviews that the investigation about median frequency (MDF) of electromyography (EMG) power density spectrum (PDS) is a useful tool to comprising physiological changes in muscular fatigue. The MDF assessment reflects muscle fiber conduction velocity, synchronization and firing rate of motor units changes. These events could occur in isolated or combined form.

The fatigue changes of EMG PDS are usually designated as a spectral shift or compression towards lower frequency that will happen before the subjective related or force decrease.

The decrease in mean frequency of PDS during fatiguing clenching contraction has established in masseter and anterior temporal muscles of the TMD non-patients. Maton et al. found similar results in MDF, but didn’t establish a constant pattern of variation for root mean square (RMS) values.

Lindstrom and Hellsing assessed the localized fatigue in masseter muscle during 10 minutes of clenching. The authors demonstrated a gradual decrease in spectral curve and advocated the EMG analysis as an objective measure to masticatory muscles fatigue in research and clinic practice. Buzzinelli and Bérzin evaluated the EMG changes in the anterior temporalis and masseter muscles after fatigue induced by continuous chewing. The results showed a endurance time about 500 seconds and no significant changes on the average amplitude of muscle activation.

However, the use of dynamic contractions of jaw muscles to elicit fatigue hasn’t been explored in EMG studies. Thus, the aim of this study was to compare the endurance time, pain and discomfort intensities, the RMS and MDF in induced fatigue by prolonged gum mastication in control and TMD volunteers.

Material and Methods
Participating in this study were 19 females volunteers, aged 18 to 33 years, divided into 2 groups: an TMD group composed of 11 subjects (mean aged 21.9 ±3 years), and a control group composed of 8 (mean aged 23.0 ±5 years).

The subjects belonging to the TMD group were patients with myogenous TMD, who had pain to masticatory muscles during functional activities (speaking or eating), occlusal parafunction and/or associates muscle fatigue. The control group was comprised of subjects without dysfunction, oral or facial pain. None of the volunteers was taking analgesic medications, nor was there any treatment to TMD. They were completely informed of experiment and participated voluntarily.

The differential surface electrodes (two pure silvers bars 10mm apart, 10mm long, 2mm wide, gain of 100x, input impedance of 10Ω and CMRR of 130dB) were used in this study. The differential electrodes (Lynx Tecnologia Eletrônica Ltda.) were placed over both masseter and anterior temporalis muscles; the position being determined by muscle palpation. A circular stainless steel electrode (diameter of 3 cm) was also used as a reference electrode for reducing acquisition noise, fixed on sternum bone.

The EMG signals were analogically amplified with gain of 50x, filtered (0.01-1.5KHz band-pass) and sampled by 12 bits A/D covert board with a 2KHz frequency (DataHominis Tecnologia Ltda.). The signals were digitally band-pass filtered (10-500Hz).

The electromyographic signals were captured in two conditions: during maximal clenching (four seconds of EMG record) and chewing gum (Gang Tatuagens). Chewing gum was employed to elicit fatigue in jaw muscles during continuous chewing. Each gum (18x17x4mm, weight 245mg) was put on both sides of the dental arc. The metronome was set at 80 bpm to indicate chewing rate. The volunteers were instructed to chew one gum on each side simultaneously during 40 seconds to reduce its initial hardness. After 80 seconds of rest the subject started chewing the gums continuously until the exact moment of fatigue that they should indicate by a hand movement.

Fatigue was previously defined as the moment of subject sensation of not being able to continue chewing. Endurance time corresponded to time ranging from beginning of mastication to the subject fatigue.

Five seconds of EMG signals were recorded at the beginning of chewing, 30 to 30 seconds, and at the end of chewing (subject fatigue).

Pain and discomfort intensities were evaluated by visual analogue scale (VAS) obtained after and before the prolonged gum mastication.

The maximal clenching amplitude (root mean square - RMS) values were used to normalize masticatory cycles EMG amplitude. The RMS and MDF (PSD, FFT, 250 ms, 1024 points, Hanning window processing) were obtained from masticatory cycles in 250ms windows visually determined, considering the most stable epoch. The first masticatory cycle Fmed values were used to normalize EMG frequency of masticatory cycle remains.

Mann-Whitney tests were performed to detect significant differences in endurance time, pain and discomfort intensities between groups. Wilcoxon tests were used to detect significant difference in these variables in the same group.

The EMG variables (RMS and MDF normalized mean values) were compared between TMD and control groups by...
Friedman test. The significance level was set at p<0.05 for all analyses carried out.

Results

Endurance time

The endurance time to prolonged chewing was closely to 10 minutes to TMD group and 18 minutes to control group (Table 1). Endurance time was significantly shorter to TDM group (p>0.05, Mann-Whitney test).

Pain and Discomfort intensities

The pain (Table 2) and discomfort (Table 3) intensities were greater in the post-chewing assessment in TMD and control groups. However, pain and discomfort intensities were not different for control and TDM groups after the prolonged mastication (p>0.05, Mann-Whitney test).

Electromyography variables

There were no significant differences among the RMS and MDF normalized values (p>0.05, Friedman ANOVA) during the prolonged gum mastication (Tables 4 and 5).

Discussion

The results of this study showed that the subject fatigue perception, corresponded to endurance time, occurred closely to 10 minutes to TMD volunteers and 18 minutes to controls. In this study the discomfort sensation was defined as a subject unpleasant event different from pain and fatigue and

Table 1. Mean and standard deviation values of the elapsing time from beginning chewing to the first discomfort related, endurance time (subjective fatigue) and time between the first discomfort related and fatigue. TMD group n=8; Control group n=11. Values in millimeters (mm).

<table>
<thead>
<tr>
<th>Group</th>
<th>First Discomfort</th>
<th>Endurance</th>
<th>Discomfort-Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMD</td>
<td>4.45± 4.07*</td>
<td>9.95± 6.78</td>
<td>5.50± 6.24</td>
</tr>
</tbody>
</table>

*p significant p value set as 5% (p<0.05).

Table 2. Mean and standard deviation values of pain intensity. TMD group n=8; Control group n=11. Values in millimeters (mm).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>TMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior-Chewing</td>
<td>0.00±0.0</td>
<td>9.82±15.6</td>
</tr>
<tr>
<td>Post-Chewing</td>
<td>15.88±24.1*</td>
<td>32.36±23.6*</td>
</tr>
</tbody>
</table>

*p significant p value set as 5% (p<0.05).

Table 3. Mean and standard deviation values of discomfort intensity. TMD group n=8; Control group n=11. Values in millimeters (mm).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>TMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior-Chewing</td>
<td>3.38±8.4</td>
<td>24.09±21.8</td>
</tr>
<tr>
<td>Post-Chewing</td>
<td>36.88±27.8*</td>
<td>57.91±17.9*</td>
</tr>
</tbody>
</table>

*p significant p value set as 5% (p<0.05), Wilcoxon test.

Table 4. Mean and standard deviation values of normalized RMS from the five step of chewing (beginning, 25, 50, 75 and 100% of the total time of chewing). TMD group n=8; Control group n=11.

<table>
<thead>
<tr>
<th></th>
<th>Beginning</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C TMD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C TMD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT</td>
<td>1.04±0.6</td>
<td>1.13</td>
<td>1.03</td>
<td>1.05</td>
<td>1.44</td>
</tr>
<tr>
<td>RM</td>
<td>0.87±0.3</td>
<td>0.91</td>
<td>1.03</td>
<td>1.15</td>
<td>1.09</td>
</tr>
<tr>
<td>LT</td>
<td>1.04±0.3</td>
<td>1.03</td>
<td>1.03</td>
<td>1.15</td>
<td>1.14</td>
</tr>
<tr>
<td>LM</td>
<td>0.89±0.2</td>
<td>0.91</td>
<td>1.05</td>
<td>1.05</td>
<td>1.05</td>
</tr>
</tbody>
</table>

RM: right masseter; LM: left masseter; RT: right anterior temporalis; LT: left anterior temporalis.

896
that does not enable the volunteers to continue the chewing if they wanted. The time of discomfort perception was shorter to TMD volunteers. Christensen (17) obtained 31 (±11) seconds fatigue threshold in controls volunteers, using clenching to induced fatigue. However, the author defined fatigue as we defined discomfort in this study. The discomfort sensation spread to increase as the activity continues and preceding the pain and fatigue perception, suggesting that discomfort sensation is reached with less stimulus amount 17. Moreover, cognition and emotions aspects modulate the discomfort perceived 18-19. Christensen 20 suggested that the subject fatigue precedes physiological fatigue to alert that the muscle is submitted an overload. The TMD patients present a reduced ability to maintain a long-term dynamic muscle contraction due to biomechanical and physiological changes in masticatory muscles 21. The results of the present study also agreed with this affirmation. Thus, our results indicated that a shorter chewing time must induce an early discomfort perception in TMD patients. Pain and discomfort intensities were higher in post-chewing assessments for both control and TMD volunteers. Dao et al.22 have been relating a decrease in pain intensity in post-chewing for TMD volunteers that had high pain intensity before chewing. Otherwise, the pain intensity became higher in TMD volunteers that had minor pain intensity before chewing.

Muscular pain could affect the rest, static and dynamic contraction myoelectrical activity. The accurate origin of muscular pain during the effort is unknown22. Authors have been suggested different causes to muscular pain, like pH decreasing and inorganic kreatine-phosphate concentration increase23, intramuscular pressure increase and local isquemia24. Farella et al.16 evaluated the post-chewing pain intensity in a control group, using the VAS. The volunteers chewed different density gum. The results demonstrated higher pain intensity to volunteers that chewed the hardest gum. In our study the gum density was not accuracy measured, but it was chosen on account high density. In this way, a constant density was expected during all the chewing time. Thus, the pain intensity increase may be occurred due to the high density of the gum.

Ours results evidenced no changes in both frequencies and electrical activation amplitude of the studied muscles, despite TMD. These results are distinct of Lyons et al.25 research with prolonged clenching contractions. The authors have been relating a strong correlation between PDS frequency characteristic (objective parameter) and subject perception of fatigue. Other, as Clark and Carter26 demonstrated relationship between central fatigue perception (limiting factor in static contraction of masticatory muscles) and visible changes in EMG signals.

Most of the studies induced fatigue in the jaw muscles by continuous clenching and it is a plausible factor to explain the difference in our results from others. Static contractions reduce the blood flow by compression and metabolic products, as lactic acid, accumulate in muscle. The reduced muscular pH is a cause of the conduction velocity decrease, resulting in amplitude increase in PDS lower frequencies. Otherwise, the dynamic contraction, as chewing, produced shortening and stretching in muscle belly, increasing the blood pump. The increase in blood flow increase the temperature and metabolism, improving the subtract removal22,27. According to Stal et al.28 the orofacial muscles, demand a greater blood supply than limbs muscles. This argument reflected the differences in physiological adaptation to functional activity. Thus, pain, fatigue and changes in EMG

<table>
<thead>
<tr>
<th></th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>TMD</td>
<td>C</td>
<td>TMD</td>
</tr>
<tr>
<td>RM</td>
<td>0.83</td>
<td>0.07</td>
<td>0.89</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>±0.2</td>
<td>±0.3</td>
<td>±0.2</td>
<td>±0.5</td>
</tr>
<tr>
<td>LT</td>
<td>0.93</td>
<td>1.07</td>
<td>1.03</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>±0.4</td>
<td>±0.4</td>
<td>±0.3</td>
<td>±0.3</td>
</tr>
<tr>
<td>LM</td>
<td>1.07</td>
<td>1.15</td>
<td>1.08</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>±0.3</td>
<td>±0.5</td>
<td>±0.3</td>
<td>±0.4</td>
</tr>
</tbody>
</table>

RM: right masseter; LM: left masseter; RT: right anterior temporalis; LT: left anterior temporalis
parameters are most probable to be found in continuous clenching fatigue protocols, even being maintained by a short time. The fatigue induced by dynamic contraction, as chewing, probability collaborated to oxidative metabolism, preventing the intramuscular hydrogen ions accumulate, and their changes in EMG parameters.

At last, the force record absence was a limiting factor in this study, because it was not possible to recognize if both sides of the dental arc were working together and with the same effort. Thus, future studies about fatigue induced by chewing, must be considering the force record associated to electromyography.

According to results obtained, in these experimental conditions, we concluded that: 1. The subjective fatigue perception is expected closely to 10 minutes of chewing in TMD patients; 2. The elapsing time from onset chewing to the discomfort perception is shorter to TMD patients; 3. The continuous chewing increases the pain and discomfort intensities for both TMD patients and controls; 4. No changes in both frequencies and electrical activation amplitude of the studied muscles were demonstrated, despite the TMD, probably due to dynamic feature of the study. Future studies must be associated to the force record in the dental arc and the control of gum density.

References