Masticatory muscle pain: Causes, consequences, and diagnosis

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Chapter 5

Is myofascial pain in the temporomandibular disorder patients a manifestation of delayed-onset muscle soreness?

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ABSTRACT

In a study to the possible role of overuse of jaw muscles in the pathogenesis of jaw-muscle pain, a protocol involving concentric and eccentric muscle contractions was used to provoke a state of delayed onset of muscle soreness (DOMS) in the jaw muscles of healthy individuals. It was tested whether the accompanying signs and symptoms would yield the temporary diagnosis of myofascial pain according to the research diagnostic criteria for temporomandibular disorders (RDC-TMD) in these individuals. Forty persons (mean age ± SD = 27.7 ± 7.5 years) performed six, 5-min bouts of eccentric and concentric jaw-muscle contractions. Before and immediately after the exercise, and 24 hours, 48 hours, and one week later, self-reported muscle fatigue and pain, pain-free maximum mouth opening, pressure-pain thresholds, and the number of painful jaw-muscle palpation sites were recorded. Significant signs and symptoms of DOMS in the jaw muscles were found, which all had resolved after a week. In 31 (77.5%) of the participants, these signs and symptoms also gave rise to a temporary diagnosis of myofascial pain according to the RDC-TMD. Within the limits of the study it was shown that an experimental protocol involving concentric and eccentric muscle contractions can provoke a DOMS in the jaw muscles and the temporary diagnosis of myofascial pain according to the RDC-TMD. This strengthens the suggestion that the myofascial pain in TMD patients may be a manifestation of DOMS in the jaw muscles.

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INTRODUCTION

Chronic musculoskeletal pain, such as low back and neck pain, is a common symptom in the general population (Wijnhoven et al., 2006), affecting the quality of life of its sufferers. In the orofacial region, the umbrella term "temporomandibular disorders" (TMD) (McNeil, 1993) is often used to denote musculoskeletal disorders in the jaw muscles and/or the temporomandibular joints. TMD pain has a prevalence of about 10% in the general population and affects females the most (LeResche, 1997). Jaw-muscle pain is the most common type of TMD pain in TMD patients (Manfredini et al., 2011). It often has a chronic character and includes the characteristics of pain at rest, and pain which exacerbates during jaw functions such as chewing, biting, and yawning. Moreover, the painful jaw muscles show a tenderness to palpation. The orofacial pain with these signs and symptoms is given the diagnosis of myofascial pain according to the internationally accepted research diagnostic criteria for TMD (RDC-TMD) (Dworkin and LeResche, 1992).

The pathogenesis of jaw-muscle pain in TMD patients is not yet well understood. Epidemiological studies indicate that adverse bruxing habits such as frequent clenching and grinding may play an important role in initiating and perpetuating jaw-muscle pain (Svensson et al., 2008). However, most of the experimental muscle-exercise protocols performed so far have only been successful in provoking a transient jaw-muscle pain that was especially present during the exercise and that resolved quickly after its cessation (Svensson et al., 2008). This may question the role of overuse of the jaw muscles in the pathogenesis of jaw-muscle pain in TMD patients, or it may indicate that the protocols used were not successful in mimicking the overuse of the jaw muscles as present in TMD patients. However, experimental protocols especially involving eccentric jaw muscle contractions were successful in provoking a jaw-muscle pain that did not resolve quickly after the exercise but that lingered on until a few days after the exercise (Svensson and Arendt-Nielsen, 1995; Svensson et al., 1997; Türker et al., 2010; Torisu et al., 2008; Torisu et al., 2010). Muscle pain being present for a few days after the exercise is a well-known phenomenon in limb muscles and is usually called a delayed onset muscle soreness (DOMS) (Cheung et al., 2003). During the oral habit of teeth grinding, the lower jaw performs a high number of consecutive small lateral or protrusive movements, with teeth contact. The jaw muscles, which are tonically active during these grinding movements, then undergo concentric and eccentric contractions (Kato et al., 2003a) and this raises the question whether the jaw-muscle pain experienced by TMD patients is a manifestation of DOMS in the jaw muscles.

Therefore, to further study the possible role of overuse of jaw muscles in the pathogenesis of jaw-muscle pain, a protocol involving concentric and eccentric contractions of the jaw muscles was used to provoke a state of DOMS in the muscles of healthy individuals. It was hypothesized that the accompanying signs and symptoms would yield the temporary diagnosis of myofascial pain according to the RDC-TMD in these individuals. If so, this would strengthen the suggestion that the jaw-muscle pain in TMD patients is a manifestation of DOMS in the jaw muscles.

METHODS

Participants

After receiving detailed information about the experiment, 40 volunteers (20 males, 20 females; mean age±SD=27.7±7.5 years) gave their written informed consent. All participants were healthy, did not use any medication, and had no dental pain pathology (de Leeuw, 2008). Individuals who reported oral parafunctions (i.e., tooth grinding, tooth clenching) were excluded. The experiments were conducted according to the Helsinki declaration, and the protocol was approved by the Clinical Research Ethics Committee of the Medical Faculty at Ege University.

Protocol Overview

The protocol consisted of baseline measurements, a provocation part, and data collection immediately, 24 hours, 48 hours, and 1 week after the provocation part. Data were collected regarding the subjective feelings of fatigue and pain intensity, the pain-free maximum mouth opening (MMO), the pressure-pain thresholds (PPTs) of the major jaw-closing muscles, and the number of painful muscle palpation sites.

Provocation part

During the provocation part, participants performed six sets of eccentric and concentric contractions, each set lasting 5 minutes, and with 1 minute of rest in between. During a set, the participants were continuously biting with their anterior teeth on one end of a custom-made jaw-muscle stretcher (Türker et al., 2010). The stretcher (Figure 1) consisted of two tungsten arms connected by a hinge axis on one end and two small biting plates on the other end. Opposing grooves enabled the placement of a rubber tubing between the two arms. When the compression force of the rubber tubing was gradually released by the experimenter, the participant’s mouth was gently forced open, allowing jaw-closing muscles to contract eccentrically during approximately 3 sec. Subsequently, the experimenter manually closed the apparatus (the concentric contraction) (duration: 1 sec) and the compression force was built up again in the rubber tubing. The “occlusal” phase, i.e. the transition from closing to opening, took about 1 sec and thus, each open-close cycle lasted approximately 5 sec in total. This way, the participants performed about 60 eccentric and concentric contractions during each set. Participants continuously received visual feedback of the root mean square values of the electromyographic (EMG) activity of their right masseter muscle by means of a voltmeter. The EMG activity was recorded by custom-made, bipolar electrodes made of silver amalgam (diameter: 4 mm) that were placed over the belly of the right masseter after thorough cleaning of the skin with alcohol. The electrodes were placed parallel to the muscle fibres and with their centres approximately 15 mm apart. The EMG signals were filtered (bandwidth 5-1000Hz), amplified (1000 times), and sampled (2000 Hz). An isolated metal common electrode held in the palm of the hand served as reference electrode. Participants were instructed to keep the EMG activity as constant as possible during the exercise. For the first 20 participants (10 males, 10 females; mean age±SD=26.9±5.2 years) the EMG level was set at 10% of the maximum voluntary EMG activity recorded at baseline; for the other 20 participants (10 males, 10 females; mean age±SD=28.5±9.3 years), it was set at 30%.

Figure 1. Muscle stretcher (Reprinted from Arc Oral Biol 2010;55:621-626, Kemal S. Türker, Michail Koutris, N. Ceren Sümer, E. Sibel Atis, Ian R. Linke, Frank Lobbezoo, Machiel Naeije, Provocation of delayed-onset muscle soreness in the human jaw-closing muscles, with permission from Elsevier).

Collected Data

All data were collected by three experimenters (MK, ESA, and NS), who followed the same data-collection protocol. The clinical examination was performed by two experienced clinicians (MK and FL), who are calibrated on a yearly basis. Before the start of the present study, an extra calibration session was performed.

Fatigue and pain intensity

The subjective feelings of fatigue and pain intensity were measured with two, 100-mm long visual analogue scales (VAS), with left anchor words “No fatigue/pain at all”, and right anchor words “Fatigue/pain as bad as it could be”. VAS values below 5 mm were set to zero (Ekblom and Hansson, 1988).

Pain-free maximum mouth opening (MMO)

The MMO was recorded while the participants opened their mouth as wide as possible without experiencing any pain. The distance between the incisal edges of the right upper and lower central incisors was measured (in mm) with a plastic ruler and was adjusted for the vertical overbite.

Pressure-pain thresholds (PPTs)

PPTs were recorded from the right and left masseter muscles (RM and LM) and the right and left anterior temporalis muscles (RAT and LAT). A custom-made electronic algometer with a tip of 1 cm in diameter was used. The rate of pressure application was 30 kPa/sec (Svensson et al., 2003), which was visually displayed on a computer screen. While the jaw muscles were relaxed, the experimenter applied the tip of the algometer perpendicular to the skin at the points of the muscles' maximum bulge. These points were marked before the start of the experiment while the participants clenched several times. For each muscle, four PPT recordings were obtained right after each other, with at least 1 minute rest in between. For the data analysis, the mean values of the last three recordings were used (Isselée et al., 1998).

Jaw-muscle palpation

Twenty orofacial muscle sites were palpated according to the guidelines of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD) (Dworkin and LeResche, 1992). Following the algorithm of the RDC-TMD, a diagnosis of myofascial pain was set.

Statistical analysis

Because the VAS scores of fatigue and pain intensities were not normally distributed and had unequal variances at different time points, Friedman's ANOVA's were used to test for possible differences in the VAS scores over time. In case of significance, contrast analyses with Wilcoxon signed-rank tests were performed with the values at baseline as reference. Subsequently, for each participant, the medians of the VAS scores over all time points were calculated. Using Mann-Whitney U tests, these medians were tested for gender and intensity level differences.

ANOVAs for repeated measures were used for the analysis of the MMO, the PPTs, and the number of painful muscle-palpation sites. For the MMOs and the number of painful palpation sites, "time" (with 5 levels: before and immediately after the provocation part, and 24 hours, 48 hours, and one week later) was the within-subject factor; and "gender" (with 2 levels: male and female) and "intensity level" (with 2 levels: 10% and 30%) were the between-subjects factors. For the PPTs, an extra within-subject factor was added, viz., "muscle" (with 4 levels: RM, LM, RAT, and LAT). In case of significance, simple contrast analyses were performed, with the values at baseline as reference.

The number of myofascial pain diagnoses, averaged over three time points (immediately, 24 hours, and 48 hours after the provocation part), was calculated for each participant. A possible difference between men and women in the number of positive diagnoses was tested with a Chi-square test. Differences between the two intensity levels were analyzed similarly.

RESULTS

Significant and long-lasting responses to the eccentric and concentric contractions of the jaw muscles were found in all variables investigated (ANOVA's, $p<0.001$). Contrast analysis demonstrated that the fatigue and pain intensity, and the number of painful muscle-palpation sites showed an immediate (immediately after the provocation part) and a delayed (24 hours and 48 hours after the provocation part) increase with respect to baseline; see figure 2A and 2B. Significant decreases with respect to baseline were found for the MMOs (immediate and delayed) (Fig 2C) and for the PPTs (delayed only) (Fig 2D). All variables had returned to baseline after one week.

The temporalis muscles showed higher PPT values than the masseter muscles (p=0.001) and men showed higher PPT values than women (p=0.003). No gender influence was found for any of the other variables (p>0,05 for all variables tested). No influence of the intensity level was found, except for the reported fatigue levels. These levels were higher for the protocol with the 30% intensity level than for the protocol with the 10% intensity level (p=0.04) and are thus reported in separate boxplots (Fig 2B).

Based on the above provoked clinical signs and symptoms and following the diagnostic algorithm of RDC-TMD, up to thirty-one (77.5%) participants received a myofascial pain diagnosis immediately, or 1 or 2 days after the provocation part (Fig 2F). No significant differences in the number of myofascial pain diagnoses were found between men and women or between the two feedback levels.

DISCUSSION

In this study, a protocol involving concentric and eccentric contractions of the jaw muscles could provoke a state of DOMS in the muscles of healthy individuals. The accompanying signs and symptoms yielded the temporary diagnosis of myofascial pain according to the Research Diagnostic Criteria for TMD in 77.5% of these individuals.

The present study indicates that intense, unaccustomed eccentric and concentric muscle contractions can induce immediate and delayed symptoms of fatigue and pain in the human jaw muscles. The symptoms present immediately after the provocation part were probably the result of an accumulation of metabolites, such as lactic acid, within the muscles due to an obstruction of the muscles' blood flow during the exercise (Graven-Nielsen et al., 2003; Kim et al., 1999; Mills et al., 1982; Rasmussen et al., 1977). The delayed responses resembled the characteristics of a so-called DOMS in the human jaw muscles. In limb muscles, DOMS typically develops 12-48 hours after an intense, unaccustomed, eccentric exercise (Friden, 2002; Proske, 2005) and includes the characteristics that were also found in the present study, viz., decreased range of motion, pain at rest, pain exacerbating during movement, and the muscle being painful to palpation. It is generally assumed that the symptoms of DOMS arise from micro traumata to the muscle fibres due to mechanical overloading and rupture especially during the eccentric contractions. The repair of muscle damage is associated with an inflammatory reaction within the muscles (Proske, 2005), which is responsible for a peripheral sensitization of the primary afferent nerve fibers (Regueme et al., 2005). In this study, peripheral sensitization was present on the days following the provocation part, as revealed by the lower PPTs and the muscles' tenderness to palpation. The differences in PPT values found between the temporalis and the masseter muscles corroborate previous studies (Ohrbach and Gale, 1989), as do the lower PPTs values found for women (Jensen et al., 1992).

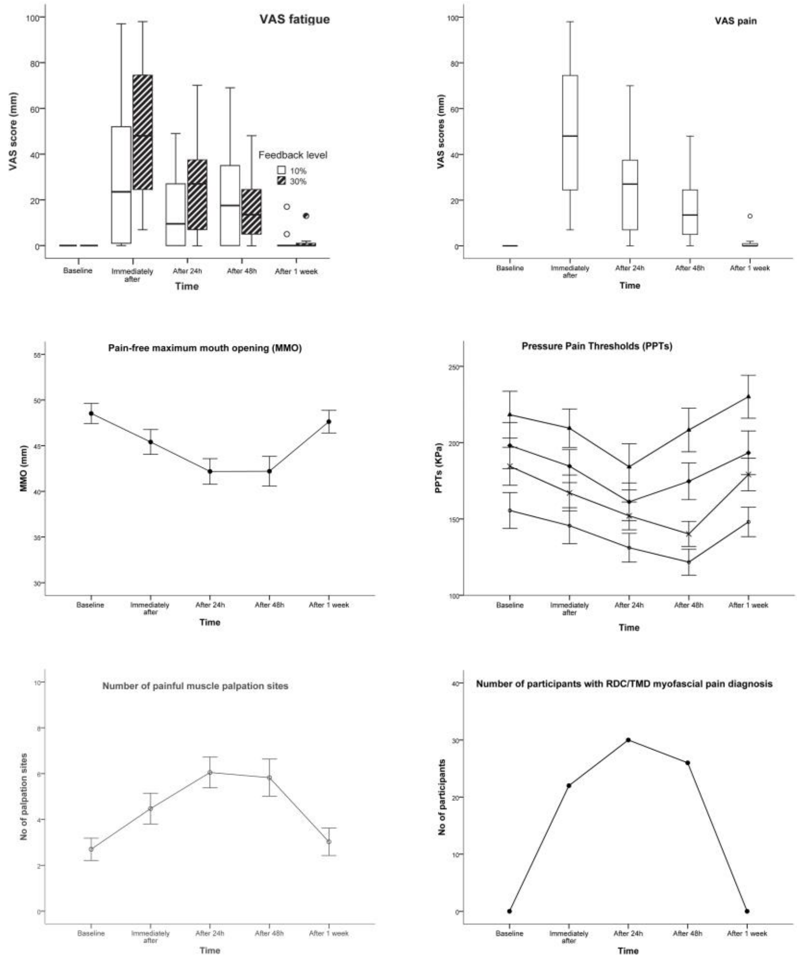

Figure 2. Box plots of the VAS scores of fatigue (for intensity levels at 10% and 30% of the maximum voluntary EMG activity recorded at baseline, since they showed significantly different results) (a) and pain (b), and mean values ± standard errors of the mean of the maximum mouth opening without pain (MMO) (c); the pressure-pain thresholds (PPT) of the masseter (Mas) and the anterior temporalis (Temp) muscles for men (Men) and women (Women) (-♦- Mas_Men, -■- Mas_Women, -▲- Temp_Men, -x- Temp_Women) (d); the number of painful muscle palpation sites (e); and the number of participants with a myofascial pain diagnosis (f). All variables were recorded before and immediately after the provocation part, and after 24 hours, 48 hours, and one week. (*: $p<0.05$; **: $p<0.01$)

The findings of the present study strengthen the suggestion that the myofascial pain in TMD patients may be a manifestation of DOMS in the jaw muscles. In TMD patients associations has been found between self-reported bruxism and TMD pain (Magnusson et al., 2005) and it is well-known that during this parafunctional activity the jaw muscles also perform eccentric contractions (Kato et al., 2003b). In the present study, the myofascial pain was provoked by a single provocation protocol and had subsided after one week indicating that the provoked symptoms were only transient. However, in myofascial TMD patients, the pain complaints are often chronic. This is probably related to the fact that TMD patients usually do not show their bruxing behavior only once in a while, but more on a regular, sometimes even daily basis. It can then be hypothesized that the provoked jaw muscle complaints will run the risk of becoming chronic in case the relaxation periods in between the parafunctional activities are too short for the jaw muscles to recover and to adapt to their overuse. From sports medicine, it is known that when there is an imbalance between training and recovery, exercise and exercise capacity, there is a risk for overtraining the exercised muscles (Lehmann et al., 1993). Thus in TMD patients who brux on a regular basis, the myofascial pain could be the manifestation of a chronic DOMS in their jaw muscles.

The absence of any gender effect in the pain and fatigue scores in this study is in accordance with the results of similar studies in limb muscles (Dannecker, 2008). It may indicate that the higher prevalence of women among jaw muscle-pain patients (Anastassaki and Magnusson, 2004) is not related to a different (patho)physiology of their jaw muscles, which would render these muscles more susceptible to overuse. It may very well be so that the higher prevalence is more related to a higher susceptibility of women to the psychosocial factors, known to be involved in the development of especially chronic pain complaints (Svensson and Sessle, 2004). No standardized experimental protocols exist so far for the provocation of DOMS in skeletal muscles, also not in the human jaw muscles. For this reason two EMG feedback levels were used in this study. More insight into the pathophysiological mechanisms of DOMS is needed to appreciate that the exercise protocol set at a 30% EMG feedback level gives more or less the same results as the feedback level set at 10%.

Though the majority of the participants showed jaw-muscle pain following the provocation protocol, 9 (22.5%) of the participants did not report any pain at all. Apparently, large differences in the jaw muscles’ susceptibility to overuse exist. This can also be observed clinically in patients with severe signs of bruxism (e.g., hypertrophic jaw muscles), who sometimes present themselves without any muscle pain, but only with severe tooth wear as their main complaint. This substantiates the claim that there is no simple one-to-one relationship between muscle overuse on one hand and muscle pain on the other hand (Svensson et al., 2008).

Within the limits of the study it was shown that an experimental protocol involving concentric and eccentric muscle contractions can provoke a delayed onset of muscle soreness (DOMS) in the jaw muscles of healthy individuals. The accompanying signs and symptoms yield the temporary diagnosis of myofascial pain according to the RDC-TMD in these individuals. This strengthens the suggestion that the myofascial pain in TMD patients may be a manifestation of DOMS in the jaw muscles.

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