Neck disability is associated with masticatory myofascial pain and regional muscle sensitivity

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A B S T R A C T

Objective: The primary aims of this study are to compare neck disability in masticatory myofascial pain subjects versus asymptomatic controls, and to evaluate the correlation between neck disability and muscle pain.

Design: Two groups composed this case-control study: a symptomatic group comprised of 27 subjects diagnosed with masticatory myofascial pain, as determined by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), and a control group comprised of 28 asymptomatic subjects. The collected variables were pain intensity (visual analogue scale), pressure pain threshold of the temporomandibular joint, anterior temporalis, masseter, sternocleidomastoid muscle, upper trapezius and Achilles tendon (digital dynamometer, kgf/cm²), and neck disability (Neck Disability Index). Statistical analysis included Student’s t-test and the Pearson product-moment correlation coefficient (5% significance level and 95% confidence interval).

Results: The symptomatic group showed greater neck disability with a mean (SD) of 11.8 (7), as compared with 2.8 (2.4) for the asymptomatic group (p < 0.05). A negative correlation was found between neck disability and pressure pain threshold of the anterior temporalis (r = -0.4, 95% CI -0.6 to -0.15, p = 0.002), the sternocleidomastoid (r = -0.35, 95% CI -0.56 to -0.09, p = 0.007) and the upper trapezius (r = -0.37, 95% CI -0.58 to -0.12, p = 0.005).

Conclusion: Our results reinforced the clinical interconnection between masticatory and cervical structures, insofar as subjects with masticatory myofascial pain reported greater neck disability, which, in turn, was correlated with regional muscle sensitivity.

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1. Introduction

Musculoskeletal disorders often affect an individual’s quality of life. A partial explanation for this negative impact could be the co-occurrence of multiple painful conditions in the body. In particular, temporomandibular and cervical pain disorders could be two of the most common examples, since both of these prevalent disorders frequently coexist in the same subject. Temporomandibular disorders (TMD)/TMJ) and cervical disorders encompass a large group of clinical conditions, or signs and symptoms, that affect the masticatory system and the cervical structures, respectively.

Substantial evidence exists for a possible association between the signs and symptoms of TMD and cervical motion impairment or posture differences. At least two systematic reviews were published between 2006 and 2013 regarding this topic, but both drew unclear conclusions, pointing out the need for further research. Whereas the biomechanical and anatomical aspects in reviews of this type are often given the most attention, the relationship between mechanical sensitivity of the masticatory and cervical muscles and presence of TMD and self-reported neck disability, has been underexplored, especially considering that this relationship could be indicative of how pain impacts one’s daily activities. Notably, the first paper to directly address neck disability in patients with TMD was published in 2010, as measured by a well-recognized and validated instrument (Neck Disability Index – NDI). In essence, the paper stated that neck disability was associated with jaw disability and TMD-related disability. A focus on the relationship between neck disability and TMD signs and symptoms may provide a better understanding of how disability related to the cervical region could affect masticatory and cervical muscle pain.

One of the most reliable tests for mechanical muscle sensitivity assessment is the pressure pain threshold (PPT). In particular, PPT data provides a pathophysiological basis to evaluate peripheral or central nervous system abnormalities and alterations in pain perception and modulation. Moreover, muscle tenderness is an explicit criterion for masticatory myofascial pain (MMP), the most common type of TMD. Finally, appraising the correlation between cervical and masticatory muscles with the PPT is paramount for understanding the association between the cervical spine and the trigeminal region. Furthermore, the experimental pain evidenced by healthy volunteers indicated a partial overlap, considering the pain spread and referral patterns observed between the trigeminal and the cervical muscles.

Based on these findings, the primary aims of this study were: (a) to compare the degree of self-reported neck disability between subjects with MMP and asymptomatic controls, and (b) to correlate the degree of self-reported neck disability with (1) pain intensity, (2) PPT of the temporomandibular joint (TMJ), (3) masticatory and cervical muscles and (4) the extracephalic site (Achilles tendon). An additional aim was to correlate the PPT values of masticatory sites, cervical muscles and the extracephalic site. According to these objectives, our hypotheses were: (a) the MMP subjects will have a greater degree of self-reported neck disability than the asymptomatic control patients; (b) there will be a positive correlation among self-reported neck disability and (1) pain intensity, (2) PPT values of masticatory cervical muscles and (3) the extracephalic site; and (c) there will be a positive correlation between the PPT values of the masticatory sites and those of the cervical muscles or the extracephalic site.

2. Methods

2.1. Design

This case-control study was conducted at the Orofacial Pain Laboratory of the Federal University of Sergipe and approved by the Human Research Ethics Committee of the same institution, in May 2011.

2.2. Subjects and recruitment

The study subjects were recruited by advertisements. Eligible participants included university students and local community volunteers of both genders, who underwent a clinical examination for TMD signs and symptoms. They were divided into two groups according to the inclusion and exclusion criteria: symptomatic group (Group 1) and control group (Group 2).

In brief, the inclusion criteria for the symptomatic group (Group 1) were: (a) ages between 18 and 35 years; (b) complaint of pain in the orofacial region for at least 6 months; (c) masticatory myofascial pain diagnosis as determined by the updated Research Diagnostic Criteria (RDC/TMD). The exclusion criteria for the symptomatic group, respectively, were: (a) history of facial or cervical trauma, cervical and/or craniofacial surgical procedures; (b) neurological disorders or fibromyalgia; (c) previous treatments performed in the last three months for TMD; (d) orthodontic treatment in progress or occlusal risk factors for TMD; and (e) use/abuse of substances or medications, such as analgesics, alcohol, anxiolytics, antidepressants or oral contraceptives. The inclusion criterion for eligible participants of the control group (Group 2) was volunteers between 18 and 35 years of age. The exclusion criteria for the control group were: (a) any painful TMD, as determined by the updated Research Diagnostic Criteria (RDC/TMD); (b) history of facial or cervical trauma, cervical and/or craniofacial surgical procedures; (c) neurological disorders or fibromyalgia; (d) orthodontic treatment in progress or occlusal risk factors for TMD; and (e) use/abuse of substances or medications such as analgesics, alcohol, anxiolytics, antidepressants or oral contraception.

Both groups were matched in regard to age and gender. Two experts in orofacial pain and RDC/TMD assessment performed independent and blind evaluations of the eligible subjects, and only those who received the same diagnostic (masticatory myofascial pain or asymptomatic) by both experts were included and assigned to the respective, corresponding group. An alpha level of 0.05 and a beta level of 0.2 (or a power of 0.8) was the least determinant of a small to moderate correlation (r = 0.4), insofar as a total sample size of approximately 47 subjects was required.
2.3. Variables

Facial pain intensity, PPT and self-reported neck disability were assessed.

2.3.1. Self-reported facial pain intensity

Pain intensity was measured by a visual analogue scale (VAS), which consists of a horizontal line 10 cm long, anchored by word descriptors at each end, namely, “no pain” at the far left and “worst pain imaginable” at the far right. Subjects placed a vertical mark along this axis, at the point which they felt best represented their perception of current pain.

2.3.2. Self-reported neck disability

Neck disability was assessed using the Neck Disability Index (NDI). The NDI is a self-reported questionnaire with 10 questions related to pain disability in the neck region. Each item can receive a score from 0 to 5 (0 = no disability and 5 = full disability), and the sum of the scores determines the level of disability. More specifically, higher scores imply greater disability. The scoring disability interpretation was: 0-4 = none; 5-14 = mild; 15-24 = moderate; 25-34 = severe; 35 = complete. Note especially that a validated, published translation of the NDI into Brazilian Portuguese was used. Psychometric properties of the NDI questionnaire have been tested extensively, and well-documented convergent and divergent validity has been published with reliability values between 0.9 and 0.93, and an internal consistency ranging from 0.74 to 0.93.

2.3.3. Pressure pain threshold evaluation

PPT measurements were carried out using a digital dynamometer (Kratos, Cotia, Brazil) to record both sides of the lateral pole of the TMJ, anterior temporalis (AT or Ant Temp), masseter (Mass), sternocleidomastoid (SCM), upper trapezius (TRAP) and left Achilles tendon (Ach T - extracephalic site) (Fig. 1). The dynamometer has a flat circular tip (1 cm²) used to apply pressure on the muscle with an application ratio of 0.5 kg/cm²/s. PPT measurements were performed with the subject seated comfortably in a dental chair, in a state of muscle relaxation. The participants were instructed to verbally express the instant when the increase in pressure brought about a painful sensation. More specifically, the device was positioned perpendicularly to the evaluated site, while the participant’s head was supported by the examiner’s hand. Muscle sites were then measured in a random fashion, and the final PPT value for each site was calculated based on the mean of 2 trials from both the left and the right sides. Additionally, each trial was performed at 2-min intervals for each muscle measured.

Only one experienced examiner, blinded to each group’s allocation, performed all the measurements for the VAS, NDI and PPT tests.

2.4. Statistical analysis

Quantitative variables (age, VAS, NDI and PPT) were expressed as means and standard deviation (SD), along with a description of the gender distribution. Before performing the inferential analysis, all quantitative variables (age, VAS, NDI and PPT) were assessed for normal distribution using the Kolmogorov–Smirnov test.

Student’s t-test was performed to compare the symptomatic and the control groups regarding age, VAS, NDI and PPT; the chi-square test was performed to compare the gender distribution between groups. The significance level was set at 5% (p = 0.05).

The effect size of all significant results was also calculated, according to Cohen’s kappa coefficient (d), which scored the effect as small (d = 0.2) moderate (d = 0.5) and large (d = 0.8).

The Pearson product-moment correlation coefficient was used to correlate NDI with VAS and PPT values in the symptomatic group, as well as to correlate PPT values of the masticatory sites (lateral pole of the TMJ, anterior temporalis and masseter) with those of cervical muscles (sternocleidomastoid and upper trapezius) and the extracephalic site (left Achilles tendon), in relation to the entire sample. The magnitude of each effect measured was based on the r coefficient and was scored as a small (r = 0.3), moderate (r = 0.5) or strong (r = 0.7) correlation. The sample size in this study was considered too small to use regression models that could include all the variables and avert the problem of multiple comparisons. In order to overcome this issue, a Bonferroni correction was applied and the significance level was lowered to 0.7% and 0.5% as the cut-off point to determine the statistical significance, respectively, of the correlation between NDI with VAS and PPT, and the correlation between the PPT values of the masticatory sites with those of the cervical muscles and the extracephalic site.
Table 1 – Baseline characteristics of all study subjects included.

<table>
<thead>
<tr>
<th></th>
<th>Symptomatic group (n = 27)</th>
<th>Control group (n = 28)</th>
<th>p-Value</th>
<th>Cohen’s d (effect size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>24.7 (3.7)</td>
<td>23.2 (3.8)</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>22 (88%)</td>
<td>17 (61%)</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>05 (12%)</td>
<td>11 (39%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure pain threshold (kgf/cm²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior temporalis</td>
<td>2.19 (0.8)</td>
<td>2.8 (1.15)</td>
<td>0.03</td>
<td>0.59</td>
</tr>
<tr>
<td>Maseter</td>
<td>2 (0.7)</td>
<td>2.34 (0.93)</td>
<td>0.04</td>
<td>0.43</td>
</tr>
<tr>
<td>Temporomandibular joint</td>
<td>2.2 (0.7)</td>
<td>2.86 (1.17)</td>
<td>0.01</td>
<td>0.64</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>1.47 (0.6)</td>
<td>1.81 (0.75)</td>
<td>0.06</td>
<td>–</td>
</tr>
<tr>
<td>Upper trapezius</td>
<td>2.95 (1.2)</td>
<td>4.14 (2.16)</td>
<td>0.01</td>
<td>0.64</td>
</tr>
<tr>
<td>Achilles tendon</td>
<td>5.67 (1.5)</td>
<td>6.91 (2.36)</td>
<td>0.02</td>
<td>0.6</td>
</tr>
<tr>
<td>Neck Disability Index</td>
<td>11.8 (7)</td>
<td>2.8 (2.4)</td>
<td>&lt;0.001</td>
<td>1.3</td>
</tr>
</tbody>
</table>

3. Results

3.1. Baseline characteristics

One hundred and nine eligible subjects were evaluated, of which 55 met the criteria. The symptomatic group (Group 1) consisted of 27 subjects diagnosed with Masticatory Muscle Pain (MMP), and the control group (Group 2) consisted of 28 asymptomatic volunteers. The demographic and clinical characteristics are summarized in Table 1. Females made up the majority of each group (88% in the symptomatic group and 61% in the control group). Mean age (SD) was 24.7 years (3.7) and 23.2 years (3.8) for the symptomatic and control groups, respectively. There was no difference between Groups 1 and 2, based on gender or age. However, there were differences related to the NDI, in that the symptomatic group was classified as having mild neck disability and the control group as lacking neck disability, with mean (SD) respective scores of 11.8 (7) and 2.7 (2.4) (<0.001, d = 1.3). Furthermore, PPT values were lower in the symptomatic group for the majority of the evaluated structures (p < 0.05). In particular, the greatest differences occurred in relation to the TMJ, with a mean (SD) of 2.2 (0.13) for the symptomatic group and 2.86 (0.22) for the control group, followed by the anterior temporalis: 2.19 (0.15) and 2.8 (0.21), respectively, the upper trapezius: 2.95 (0.23) and 4.14 (0.41), respectively, and the Achilles tendon: 5.67 (0.28) and 6.9 (0.44), respectively. All between-group comparisons had an effect size greater than 0.4.

3.2. NDI versus VAS and PPT value correlations

After performing the Bonferroni correction, significant negative correlations with magnitudes from small to moderate were found between NDI and PPT values for the anterior temporalis (r = −0.4, 95% CI −0.6 to −0.15, p = 0.002), sternocleidomastoid (r = −0.35, 95% CI −0.56 to −0.09, p = 0.007) and upper trapezius (r = −0.37, 95% CI −0.58 to −0.12, p = 0.005) (Figs. 2–4). However, no significant correlations were observed among the NDI and the facial pain intensity (VAS) and the PPT values for the maseter, TMJ and Achilles tendon.

3.3. Between-PPT value correlations

After performing the Bonferroni correction, positive and significant correlations (p < 0.005) were found among the
PPT values for all masticatory structures (anterior temporalis, masseter and TMJ) and cervical muscles (sternocleidomastoid, and upper trapezius) and the extracephalic site (Achilles tendon) (Table 2). The magnitude of the effect was moderate to strong ($r > 0.4$) for all comparisons.

### 4. Discussion

This study focused on the relationship between symptoms of cervical disorders and the clinical parameters of TMD. Specifically, these results indicated that: (1) subjects with masticatory myofascial pain have greater neck disability than asymptomatic controls; (2) the greater the degree of neck disability, the greater the anterior temporalis, sternocleidomastoid and upper trapezius muscle sensitivity; (3) there exists a strong correlation among TMJ or masticatory muscle sensitivity and cervical muscles and the extracephalic site (Achilles tendon).

Anatomical proximity, neuronal interconnections and convergence inputs between cervical and trigeminal areas have prompted interest in studying the relationship between cervical and temporomandibular disorders. Currently, both conditions are highly prevalent in the world population, and an overlap of signs and symptoms may be present in subjects with TMD and cervical disorders. In fact, our results indicated greater values for neck disability and lower pressure pain thresholds for the upper trapezius in TMD subjects, reinforcing the concept of comorbidity between TMD and cervical disorders. Despite the lack of comprehensive evaluations of cervical structures, disability measurements using the NDI (higher values indicated greater neck disability), associated with the PPT values for cervical muscles, could indicate a dysfunction in the cervical region. Furthermore, our results are similar to a pioneer study by Armijo Olivo et al., who found a significant difference in the NDI between myogenous TMD and healthy controls.

Lower PPT in masticatory muscles could reflect primary hyperalgesia. However, since the PPT is also decreased in cervical muscles, and even in a site far from the trigeminal innervated area, TMD could be associated with a generalized hyperalgesia and brought about by central mechanisms like other chronic facial pain conditions. Other evidence suggests a greater level of cervical muscle tenderness and reported neck pain when comparing TMD subjects with healthy controls. Interestingly, a between-group difference existed in relation to the Achilles tendon, but not to the sternocleidomastoid. Nonetheless, regarding the latter as a muscle without bone support surrounded by conjunctive tissues, the sternocleidomastoid region could be considered normally tender. In fact, our lowest PPT values from both groups were found for this muscle. Moreover, experimental evidence concerning healthy volunteers indicated the sternocleidomastoid as the most tender muscle in relation to other upper cervical muscles like the trapezius and the splenius capitis, thus reinforcing this interpretation. Furthermore, the difference between the symptomatic and control group, in regard to the Achilles tendon, points to the widespread sensitivity as a result of myofascial TMD. Most importantly, the examination of sites far from the trigeminal region may help in assessing these consequences. Finally, the baseline values of the symptomatic group could indicate muscle sensitivity. In relation to the anterior temporalis, Santos Silva et al. found that 2.47 kgf/cm² was a reliable cut-off point to differentiate symptomatic patients from healthy controls. Additionally, Fischer established the PPT values of healthy controls for the trapezius muscle as 3.7 kgf/cm². The mean PPT values of the symptomatic group were below the aforementioned reference values.

The correlation between neck disability and low PPT, regardless of the presence of MMP, suggests greater sensitivity in people with worse self-reported neck disabilities. However, it is difficult to ascertain the underlying mechanisms involved in this correlation, since muscle sensitivity may be understood as a consequence of a widely altered perception or hypervigilant behaviour. Moreover, this sensitivity could be influenced by many factors attributed to central or peripheral

### Table 2 – Significant correlation measures for pressure pain threshold (PPT) of masticatory and cervical and extracephalic sites ($p < 0.005$).

<table>
<thead>
<tr>
<th>PPT (kg/cm²)</th>
<th>SCM</th>
<th>TRAP</th>
<th>Ach T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>CI (95%)</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Ant temp</td>
<td>0.74</td>
<td>0.59–0.84</td>
<td>0.55</td>
</tr>
<tr>
<td>Mass</td>
<td>0.64</td>
<td>0.45–0.77</td>
<td>0.41</td>
</tr>
<tr>
<td>TMJ</td>
<td>0.74</td>
<td>0.59–0.84</td>
<td>0.55</td>
</tr>
</tbody>
</table>
neurons and related to modulated pain pathways, as well as by other factors, such as demography, metabolism and lifestyle.43–46

The involvement of the anterior temporalis, which had a significant correlation with neck disability, reinforces the concept of complex interconnections between masticatory and cervical structures.47 Although this correlation was observed between neck disability and muscle sensitivity, no association with pain intensity was found, indicating that these parameters are a reflection of different aspects of the painful condition. Evidence supporting this idea has shown that there are differences in therapies, indicated on the basis of a pain report versus PPT, and that there seems to be no correlation between these two pain assessment tools.48,49

To the best of our knowledge, this is the first study to show a correlation among the PPT of masticatory structures and cervical muscles and an extracephalic site. Specifically, strong correlations were found in all cases regardless of the presence of MMP, supporting the interpretation that muscle tenderness is driven by factors independent of painful conditions, such as stress and anxiety.50 However, since our aim was not to evaluate psychological and social aspects, any further discussion along these lines would be beyond the scope of this discussion. Notwithstanding, the correlations found in the present study could reinforce the generalized hypersensitivity concept, also implicated in the mechanisms of widespread muscle tenderness.51

Some clinical implications could be highlighted in relation to this study’s overall outcomes. Early recognition of signs and symptoms of cervical disorders, for example, is helpful in performing the prognostic evaluation of TMD patients, since the presence of other pain conditions is associated with greater TMD severity.52 In addition, the assessment of cervical muscle tenderness is important for diagnostic and management purposes, since cervical disorders may be considered a risk factor for TMD,53 and the detection of widespread muscle sensitivity could also have implications regarding therapeutic procedures, since this condition is associated with worse TMD signs and symptoms.54

Some limitations in this study should be noted. First, despite the significance and magnitude of our correlations, the sample was small, considering the observational nature of the study, and causal inferences may not be sustained using the same design. A second limitation is the lack of a physical assessment of cervical structures. Hence, further generalizations inferred from this study should be made with caution.

Finally, we concluded that subjects with masticatory myofascial pain report greater neck disability, which, in turn, is correlated with regional muscle sensitivity, regardless of the presence of pain. Furthermore, this muscle sensitivity could be widespread. All in all, a more comprehensive assessment, e.g., detailed medical history, palpation and/or quantitative sensory testing (QST) of cervical and neck muscles and trigger point screening, along with the evaluation of endogenous pain modulation mechanisms, is recommended and may aid in evaluating peripheral and central factors associated with musculoskeletal pain or neck disability, considering that the presence of these factors has implications for disease prognosis.

### Funding

Not applicable.

### Competing interests

The authors declare no conflicts of interest.

### Ethical approval

The study was approved by Ethics Committee of Federal University of Sergipe – CAAE: 06770912.4.0000.0058.

### Authors contribution

**Conception and design:** Thaïs Alves Barreto Pereira, Ana Paula de Lima Ferreira, Dayse Regina Alves da Costa, Leonardo Rigoldi Bonjardim, Paulo Cesar Rodrigues Conti.

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**Analysis and interpretation of data:** Thaïs Alves Barreto Pereira, Ana Paula de Lima Ferreira, Dayse Regina Alves da Costa, André Luís Porporatti, Yuri Martins Costa.

**Drafting the manuscript:** Yuri Martins Costa, André Luís Porporatti, Thaïs Alves Barreto Pereira, Ana Paula de Lima Ferreira.

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**Final approval and completed manuscript:** Yuri Martins Costa, Leonardo Rigoldi Bonjardim, André Luís Porporatti, Paulo César Rodrigues Conti, Dayse Regina Alves da Costa, Ana Paula de Lima Ferreira, Thaïs Alves Barreto Pereira.

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