Masticatory and Cervical Muscle Tenderness and Pain Sensitivity in a Remote Area in Subjects with a Temporomandibular Disorder and Neck Disability

Anelise Silveira, MS
Physical Therapist
Alberta Health Services
University of Alberta Hospital
Edmonton, Alberta, Canada

Susan Armijo-Olivo, PhD
Physical Therapist
Faculty of Rehabilitation Medicine
University of Alberta
Edmonton, Alberta, Canada

Inae C. Gadotti, PhD
Physical Therapist
Florida International University
Physical Therapy
Miami, Florida, USA

David Magee, PhD
Physical Therapist
Faculty of Rehabilitation Medicine
University of Alberta
Edmonton, Alberta, Canada

Correspondence to:
Anelise Silveira
Alberta Health Services
University of Alberta Hospital
1F1.52 WMC, 8440–112 Street
Edmonton, Alberta T6G 2B7
Canada
Fax: (780) 407-7534
Email: asilveir@ualberta.ca

Aims: To compare the masticatory and cervical muscle tenderness and pain sensitivity in the hand (remote region) between patients with temporomandibular disorders (TMD) and healthy controls. **Methods:** Twenty female subjects were diagnosed with chronic TMD, and 20 were considered healthy. Subjects completed the Neck Disability Index and Limitations of Daily Functions in a TMD questionnaire. Tenderness of the masticatory and cervical muscles and pain sensitivity in the hand were measured using an algometer. Three-way mixed analysis of variance (ANOVA) evaluated differences in muscle tenderness between groups. One-way ANOVA compared pain sensitivity in the hand between groups. Effect sizes were assessed using Cohen guidelines. **Results:** Significantly increased masticatory and cervical muscle tenderness and pain sensitivity in the hand were found in subjects with TMD when compared with healthy subjects. Moderate to high effect sizes showed the clinical relevance of the findings. **Conclusion:** The results of this study have highlighted the importance of assessing TMD patients not only in the craniofacial region but also in the neck and other parts of the body. Future studies should focus on testing the effectiveness of treatments addressing the neck and the pain sensitivity in the hand in patients with TMD. *J Oral Facial Pain Headache 2014;28:138–146. doi: 10.11607/ofph.1112*

Key words: *masticatory muscles, muscle pain sensitivity, neck disability, neck muscles, temporomandibular disorders*

Temporomandibular disorders (TMD) represent one of the most common chronic orofacial pain conditions,[1] accounting for 40% of all chronic pain problems.[2] TMD is a general term that refers to painful and/or dysfunctional conditions of the masticatory muscles, temporomandibular joints, and/or related structures.[3] Symptoms affecting head and neck regions, such as headache, earache, cervical spine dysfunction, and altered head and cervical posture are also commonly associated with TMD.[4]

The connection between TMD and neck dysfunction remains a focus of discussion.[5,6] It is believed that there may be an interdependence between the temporomandibular and neck structures, since there are data supporting the concept that disease or injury in one area may induce pain and/or dysfunction in another area.[7] Ciancaglini et al[6] found a significant relationship between neck pain and TMD, and this association became stronger as the severity of the dysfunction increased. Another study indicated that subjects with myogenous TMD and with combined myogenous/arthrogenous TMD had more neck complaints than subjects with only arthrogenous TMD and control subjects.[7]

Muscle tenderness and muscle pain are common complaints of patients with TMD and/or neck dysfunction, and their evaluation is of particular interest to clinicians treating orofacial pain patients.[5,8–10] Most of the studies that have investigated muscle pain and tenderness in TMD subjects have used palpation techniques, which are difficult to quantify and standardize. Even with extensive examiner training, manual palpation can only achieve marginal levels of reliability.[11] Pressure algometry, on the other hand, is an investigative tool used to apply a uniform rate of pressure for the measurement of muscle tenderness and for the quantification of pain intensity.[3,12–14] The tenderness and pain intensity are expressed quantitatively by the pain pressure threshold (PPT), which is characterized by the first reported pain when increasing levels of pressure are applied.[3,9,12–15] The use of an algometer can improve the reliability of muscle tenderness and pain intensity assessment, since it provides a constant area of skin contact as well as the ability to control the rate and the direction of pressure.[3,9,12–15] In several studies,[8,16,17] the intratester repeatability of the PPT measurements has been proven to be satisfactory or good, presenting intraclass correlation coefficients (ICC) between 0.78 and 0.93, showing that PPT measures are highly reliable for measuring facial and cervical muscle tenderness. In addition, PPT measurements have been shown to achieve acceptable values of sensitivity (0.67 to 0.85), ie, the fraction of all those with the disease who will have a positive test result, and specificity (0.77 to 0.87), ie, the fraction of those without the disease who will have a negative test result.[11] Studies have indicated[11–15,18] that the reproducibility of applied pressure by using an algometer is considered fair to excellent. However, the evaluator should take into consideration that the PPT level and muscle tenderness as well as pain intensity may vary greatly with the rate of pressure and the site being tested.[11–15,18]

Since most of the previous studies evaluating muscle pain and tenderness have used a palpation technique and because the evaluation has been limited primarily to the masticatory muscles, further studies investigating muscle tenderness of the neck and orofacial muscles as well as pain sensitivity in the hand in subjects with TMD are needed to understand the underlying mechanisms of TMD as well as to provide further evidence of a possible relationship between the craniomandibular system and cervical spine.[3] Therefore, the objectives of this study were to compare the masticatory and cervical muscle tenderness and pain sensitivity in the hand (remote region) between TMD patients and healthy controls. It was hypothesized that subjects with TMD and concurrent neck disability would present increased masticatory and cervical muscle tenderness and increased pain sensitivity in the hand when compared to healthy subjects.

Materials and Methods

Subjects

Since TMD are more common among women,[11,19–22] 40 female subjects between the ages of 18 and 50 years were included in the study. Twenty were classified as having TMD with concurrent neck disability, and 20 were considered healthy controls. Women with TMD were recruited from the TMD/Orofacial Pain Clinic at the University of Alberta, through advertisements on television and in different faculties at the University of Alberta and surrounding area. Age-matched healthy subjects were sought from across the university campus. Initially, it was planned to have a third group of participants who had TMD without neck disability. This study's intention was to collect the data by separating the TMD groups into those with and those without neck pain (stratification). After 1 year of data collection, only two subjects had jaw pain without neck pain/disability, which was too small a sample size to have sufficient power to make any group comparisons.

Sample size calculation was based on repeated measures analysis of variance (ANOVA) with one dependent variable and two groups, and on guidelines proposed by Stevens (using $\alpha = .05$, $\beta = .20$, power = 80%, and an effect size d = 0.75).[23] Approximately 34 subjects were needed for each group.

This study was approved by the Ethics Committee of the University of Alberta, and the participating subjects were required to sign a consent form prior to the beginning of the experiment.

Group Classification

Subjects were classified in two groups based on a clinical examination using the guidelines established by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[24–26] and performed by a physical therapist specializing in TMD, and on the results of the Neck Disability Index (NDI).[27–31]

TMD with Concurrent Neck Disability Group. Participants in this group were diagnosed according to the RDC/TMD with either myogeneous TMD or mixed TMD (myogeneous/arthrogeneous TMD). They also presented with chronic orofacial pain of at least 3 months duration, and this pain was not attributed to recent acute trauma, previous infection, or an inflammatory cause. These subjects had to score more than four points on the NDI to be considered as presenting with a neck disability.[27] In addition, they were required to complete the Limitations of Daily Functions in a TMD questionnaire (LDF-TMDQ)[24] to measure their level of jaw disability, referred to herein as the Jaw Disability Index (JDI).[32]

Subjects were excluded if they presented with arthrogenic TMD only; a medical history of neurologic, bone, or systemic diseases; cancer; acute pain or dental problems other than TMD; a history of trauma or surgery to the upper quarter within the last year; or if they had taken any pain medication or muscle relaxants less than 4 hours before the diagnostic session.

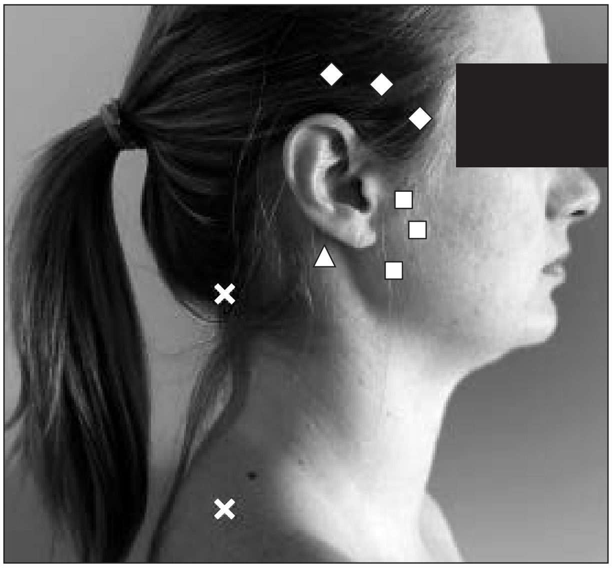

Fig 1 PPT points evaluated (◆ = points of temporalis muscle, ■ = points of the masseter muscle, ▲ = points of the sternocleidomastoid muscle, ✕ = points of the upper trapezius muscle).

Healthy Subjects. The healthy control group included subjects with no chronic pain, clinical pathology, or previous surgery related to the masticatory system or cervical spine. They also had to score less than four points on the NDI to be considered as having no neck dysfunction. In addition, all subjects had to complete the LDF-TMDQ.

Exclusion criteria for the healthy group were neurologic problems, any acute or chronic musculoskeletal injury, or any systemic diseases that could interfere with the procedure and the outcomes. Their history could not include acute or chronic pain or symptom complaints in the masticatory system or cervical spine for at least 1 year prior to the start of the study. Finally, subjects taking any medication, such as pain-relieving drugs, muscle relaxants, or anti-inflammatory drugs, were also excluded.

Procedures

One investigator used a calibrated manual pressure algometer (Force Dial, Wagner Instruments) to measure the pain sensitivity in the hand and the muscle tenderness in both groups. Pain in the hand was measured at the hypothenar region of the left hand as described by Etoz and Ataoglu.[3] The hypothenar region of the left hand is believed to represent the general pain sensitivity of subjects with TMD,[3] and this is the reason that this specific point was chosen. Muscle tenderness was then measured bilaterally in the following muscles: masseter (ie, deep masseter, anterior and inferior portions of the superficial masseter), temporalis (ie, anterior temporalis, medial temporalis, and posterior temporalis), sternocleidomastoid, and upper trapezius (ie, the occipital region and halfway between C7 and the acromium) (Fig 1).[1,2] These muscles were selected for investigation because previous studies have reported that patients with TMD tend to develop tenderness in these muscles.[1,2]

The PPT was defined in this study as the point at which a sensation of pressure changed to pain. At this moment, the subject said "yes" and the algometer was immediately removed and the PPT noted.[33] Before the test was performed, the procedure was demonstrated on the investigator's hand and a practice trial was performed on the subject's right hand.[33] During the test, the algometer was held perpendicular to the hypothenar region of the left hand, the masticatory muscles (ie, masseter and temporalis), and neck muscles (ie, sternocleidomastoid and upper trapezius), and the PPT at each site was measured. This procedure was repeated three times at each site, at 30-second intervals. Since the first PPT of a session is usually higher than consecutive measurements, the first PPT value was discarded and the mean values of the other two PPT measurements were considered to be the final PPTs of the sites tested.[3] An applied pressure rate of 1 kg/s was used for the hypothenar region of the left hand and neck muscles,[3,16] and a pressure rate of 0.5 kg/s was used for the more richly innervated masticatory muscles.[3,34] According to several studies[11–13,35] that investigated the validity and reliability of algometry in both healthy subjects and subjects with pain, different rates of pressure need to be followed depending on the region being tested.

To minimize the algometry limitations, the following possible confounders were controlled:

- The investigator who collected the outcomes was blind to the group status of the participant (ie, TMD or healthy control).
- The assessor was trained in the use of the algometer until consistent measurements were achieved before starting data collection.
- The algometer and the area of application were the same for all subjects. (Landmarking was used to allow easy recognition of the points of the algometer application.)
- The algometer was calibrated each week for the duration of the experimental procedure to make sure that the rate of force application was consistent.
- The instructions were the same for all subjects.

Statistical Analyses

Muscle tenderness data for all analyzed muscles, jaw and neck disability indices, as well as pain sensitivity in the hand values for both groups were descriptively analyzed. An independent *t* test was used to determine age differences between groups. A paired *t* test was performed to verify whether there were any differences between the right and left sides in each pair of muscles. Since significant differences were found between the right and left sides in two muscle pairs (ie, deep masseter and occipital region of upper trapezius), sides were included in all further analyses.

A three-way mixed design ANOVA with repeated measures (ie, muscles, sides, and groups) test was used to evaluate the differences in muscle tenderness between groups as evaluated by the PPT for all selected muscles. Also, a Bonferroni post-hoc test was used to determine where the PPT differences in the analyzed muscles were statistically different between subjects who had TMD with concurrent neck disability and healthy controls.

A one-way ANOVA was used in this study to determine if subjects who had TMD with concurrent neck disability were significantly different statistically compared to the healthy subjects for pain sensitivity in the hand. Also, a Bonferroni post-hoc test was used to determine whether the pain sensitivity in the hand of the TMD group with concurrent neck disability was different than that of the healthy control group.

Effect sizes of the results were calculated according to Cohen guidelines. The magnitude of the effect size has been interpreted as an index of clinical relevance.[36,37] The interpretation of the effect sizes of this study was based on Cohen's guidelines: An effect size of 0.2 or less represents a small change, 0.5 means a moderate change, and 0.8 or more shows a large change.[38]

The level of significance for all statistical analyses was set at α = .05. The SPSS Statistical Program version 18.0 (Statistical Package for the Social Sciences, SPSS Inc, Chicago) was used to perform the statistical analysis.

Results

Demographics of Subjects

The age demographic for each group is shown in Table 1. An independent *t* test showed that there were no significant differences between the study groups for age ($t_{df=38}$ = –0.562, *P* = .578). The TMD group with concurrent neck disability had significantly higher disability scores for NDI and JDI when compared with the healthy control group (*P* < .05) (Table 1).

PPTs in Patients with TMD and Healthy Controls

The mean PPT values for patients who had TMD with concurrent neck disability and healthy control subjects are presented in Table 2. PPT values of the TMD group with concurrent neck disability were statistically significantly lower at almost all sites tested when compared with the healthy control group (Table 3). The only sites that did not show statistically significant differences for PPT values were the right inferior masseter (*P* = .071) and the right sternocleidomastoid (*P* = .107). Effect sizes obtained from these comparisons were moderate to high (Table 3).

Table 1 Means of Age, Neck Disability Index, and Jaw Disability Index for Subjects with TMD and Concurrent Neck Disability and Healthy Controls

	Mean	SD
Age (years)		
TMD with concurrent neck disability	31.05	6.90
Healthy controls	32.30	7.17
Neck Disability Index (0–50)		
TMD with concurrent neck disability	13.05*	6.98
Healthy controls	2.05	1.28
Jaw Disability Index (10–50 points)		
TMD with concurrent neck disability	24.55*	10.86
Healthy controls	10.35	0.99

*The mean difference is significant at the .05 level.

Pain Sensitivity in the Hand

The mean values for pain sensitivity in the hand for subjects who had TMD with concurrent neck disability and healthy subjects were 5.91 (SD = 1.51) and 6.96 (SD = 1.58), respectively. Pain sensitivity in the hand of the subjects who had TMD with concurrent neck disability was significantly lower than that of the healthy control group (mean difference = 1.04 kg/cm^2/s; SD = 0.49; *P* = .04). In addition, the calculated effect size was 0.67, indicating a clinically relevant finding.

Discussion

Muscle Tenderness in Subjects with TMD and Concurrent Neck Disability Compared to Healthy Controls

Significant differences in masticatory and cervical muscle tenderness were found between subjects who had TMD with concurrent neck disability and healthy controls. Subjects who had TMD with concurrent neck disability showed a significantly lower PPT at almost all masticatory and cervical sites tested when compared to participants in the healthy control group. Smaller PPT as well as higher effect sizes were found not only for the masticatory muscles, as expected, but also for the cervical muscles, such as the left sternocleidomastoid and left upper trapezius. Moreover, moderate effect sizes were found for the remaining cervical sites (ie, right sternocleidomastoid and right upper trapezius). Although all of the subjects in the TMD group had concurrent neck disability, the main complaint of all patients was jaw pain and that was the main reason for seeking

Table 2 Mean (SD) Pain Pressures Threshold Values of Neck and Masticatory Muscles in Subjects with TMD and Concurrent Neck Disability and Healthy Controls

	Right side		Left side	
Muscle	TMD with concurrent neck disability	Healthy controls	TMD with concurrent neck disability	Healthy controls
Deep masseter	2.37 (0.65)	3.03 (0.93)	2.03 (0.62)	2.72 (0.67)
Anterior masseter	1.92 (0.47)	2.45 (0.65)	1.90 (0.61)	2.54 (0.57)
Inferior masseter	1.81 (0.71)	2.20 (0.64)	1.75 (0.59)	2.38 (0.60)
Anterior temporalis	2.41 (0.70)	3.09 (0.78)	2.34 (0.64)	3.07 (0.70)
Middle temporalis	2.42 (0.71)	3.22 (0.69)	2.33 (0.65)	3.35 (1.00)
Posterior temporalis	2.60 (0.72)	3.46 (0.93)	2.68 (1.01)	3.78 (1.06)
Sternocleidomastoid	2.26 (0.75)	2.70 (0.92)	2.15 (0.50)	2.66 (0.72)
Upper trapezius (occipital region)	3.10 (0.74)	3.88 (1.23)	2.80 (0.80)	3.82 (1.20)
Upper trapezius (halfway between C7 and acromium)	3.82 (1.19)	4.61 (1.15)	3.70 (1.21)	4.88 (1.31)

Table 3 Pairwise Comparisons of Pain Pressure Thresholds Between Subjects with TMD and Concurrent Neck Disability and Healthy Controls

				95% Confidence interval for difference		
Muscle	Mean difference	Standard error	*P*	Lower boundary	Upper boundary	Effect size
Right side						
Deep masseter	0.655	0.25	.013*	0.14	1.17	0.80
Anterior masseter	0.53	0.18	.005*	0.17	0.89	0.92
Inferior masseter	0.40	0.21	.071	-0.03	0.83	0.57
Anterior temporalis	0.67	0.23	.006*	0.20	1.14	0.90
Middle temporalis	0.80	0.22	.001*	0.36	1.25	1.12
Posterior temporalis	0.86	0.26	.002*	0.32	1.39	1.01
Sternocleidomastoid	0.44	0.27	.107	-0.10	0.98	0.48
Upper trapezius (occipital region)	0.79	0.32	.019*	0.14	1.44	0.75
Upper trapezius (halfway between C7 and acromium)	0.79	0.38	.040*	0.04	1.54	0.66
Left side						
Deep masseter	0.68	0.20	.002*	0.27	1.10	1.05
Anterior masseter	0.64	0.19	.001*	0.26	1.02	1.06
Inferior masseter	0.62	0.19	.002*	0.24	1.01	1.04
Anterior temporalis	0.73	0.21	.001*	0.30	1.16	1.06
Middle temporalis	1.02	0.27	.000*	0.48	1.56	1.19
Posterior temporalis	1.10	0.33	.002*	0.43	1.76	1.04
Sternocleidomastoid	0.51	0.19	.013*	0.11	0.90	0.81
Upper trapezius (occipital region)	1.02	0.32	.003*	0.37	1.67	0.98
Upper trapezius (halfway between C7 and acromium)	1.18	0.40	.005*	0.37	1.99	0.92

*The mean difference is significant at the .05 level.

treatment. Neck pain was secondary for this population. The level of jaw disability was significantly higher than the level of neck disability in subjects with TMD.

Studies have shown that TMD and neck dysfunction might be related.[39–47] For example, Pogrel et al[39] showed an increase in thermographic asymmetry in the upper back and neck of subjects with TMD when compared to healthy controls. They also demonstrated that the trapezius muscle had an increased temperature on the symptomatic side in the subjects with TMD, and this difference was both statistically and clinically significant. De Laat et al[40] found with palpation that 23% to 67% of patients with TMD had neck muscle tenderness in the sternocleidomastoid and upper trapezius as well as other cervical and shoulder muscles, which was only rarely present in the control group. Recently, Greenspan et al[48] showed that patients with TMD were more sensitive to a wide range of mechanical and thermal pain tests than control subjects, including not only tests applied to the orofacial area but also to the trapezius muscle.

In summary, all of the studies reviewed showed the involvement of the neck muscles in patients suffering with TMD, which is in accordance with the present study's findings.[43,44]

The results of the present study are also in accordance with other studies[11,14,21,49–53] showing that pain sensitivity, measured through PPT in the masticatory muscles, is lower in subjects with TMD when compared to healthy controls. Only one study (Bragdon et al[54]) did not find differences in pain sensitivity in the masticatory muscles between TMD and healthy subjects, which is contradictory to the present study's findings. However, this conflicting result might be attributed to the fact that the Bragdon et al study[54] measured pain sensitivity by using heat and an ischemic stimulus instead of PPT measurements as used in the present study. The use of heat and tourniquets stimulates different sensory receptors (thermoreceptors and mechanoreceptors, respectively) when compared to those evoked by noxious pressure stimulus (nociceptors), and the stimuli are interpreted differently by the central nervous system.[55] Moreover, longer test sessions, different instrumentation, use of blood drawn at different times during the sessions, as well as the use of laboratory stress and relaxation may have sensitized healthy subjects to the pain stimuli, decreasing the difference between both groups found in that study.[54]

Functional and structural convergence of the trigeminal spinal tract and nucleus into the upper cervical segments might be related to the increased muscle tenderness in the masticatory and neck muscles found in the present study.[7,14,56–58] Trigeminal afferent inputs from the proprioceptive mechanoreceptors located in the orofacial area project to the sensory complex of the fifth cranial nerve in the brainstem and to the first three segments of the cervical spinal cord and the nucleus of the spinal accessory nerve, which innervates the cervico-occipital, trapezius, and sternocleidomastoid muscles, together with the C1 to C3 nerve roots.[5,58,59] Injuries to the jaw often spread tenderness to the neck area and vice-versa, and this tenderness sometimes persists or increases over time, even when tissue healing has apparently taken place.[57,58] Even though this may happen, in part due to a local spreading of pain-producing chemicals through the tissues, studies suggest that the spreading tenderness is more related to changes in central neural circuitry (ie, central sensitization).[57,60,61] In addition, recent evidence regarding the muscular impairments of subjects with TMD when compared to healthy subjects has indicated that subjects with TMD have a reduced endurance of the cervical flexor and extensor muscles, which was demonstrated by increased activity of the superficial muscles of the neck.[43–46] These endurance impairments could make the neck of subjects with TMD more vulnerable to pain and tenderness, since muscles in this region cannot meet the endurance demands imposed on the neck. Since the neck and orofacial regions are interconnected,[41,42,47] these impairments could be involved in maintaining the neck dysfunction seen in patients with TMD.[62] Therefore, clinicians may be able to identify and treat these impairments sooner in their patients with TMD in order to decrease the vulnerability of the neck, help improve the functioning of the craniocervical system, and subsequently reduce nociceptive inputs to the trigeminocervical nucleus.[45]

Pain Sensitivity in the Hand in Subjects with TMD and Concurrent Neck Disability Compared to Healthy Controls

The present study showed that pain sensitivity in the hand in the subjects who had TMD with concurrent neck disability was significantly higher (ie, higher pain sensitivity = lower PPT) than those of the healthy control group. The effect size for this result was moderate (ES = 0.67), indicating that this difference could be considered clinically relevant according to guidelines established by Cohen.[63] Higher pain sensitivity in the hand in patients presenting with TMD along with concurrent neck disability showed that these patients had a tendency to be more sensitive to pain even in parts of the body other than the jaw or neck. Other studies[1,3,64–67] have also found that chronic pain patients have a tendency to have increased general pain sensitivity when compared to healthy controls, which is in accordance with the present study's results. In a scientific review of the literature, Sarlani et al[65] found that four out of seven studies using PPTs to investigate generalized hyperalgesia in patients with TMD showed greater sensitivity in the patient group when compared to healthy controls, which is also in agreement with this study's findings. They found one study showing lower PPT and muscle tolerance in patients with TMD, but the results did not reach statistical significance. Sarlani et al[65] attributed this to the study's small sample size. However, in contrast to all of the findings of their systematic review including the results of that study, two studies found in the systematic review did not find any difference in PPT between patients with TMD and healthy controls.[65] One possible explanation for this discrepancy is the fact that these two studies excluded patients with arthralgia.[65] In the present study, patients with myogenous TMD as well as mixed TMD (ie, patients could have arthralgia in addition to myogenous pain) were included. Sometimes, slight changes in a population and methodology used in a study can lead to different results. Another study by Mohn et al[68] also did not find differences in pain sensitivity between patients with TMD and healthy controls, which is also in contrast with the results of the present study. This difference could be due to the fact that Mohn et al[68] did not record whether medication was used by the subjects in their study. Frequently, chronic pain patients make use of pain medication, which could decrease their sensitivity to pain when evaluated.

Pain sensitivity in the hypothenar region of the left hand can be used to represent the general pain sensitivity of patients with TMD.[3] Investigating generalized pain sensitivity or pain sensitivity in the hand of patients with chronic TMD has important implications for the mechanisms underlying TMD.[65] As explained earlier, there is evidence that greater pain sensitivity in patients with TMD might be attributed to the hyperexcitability of parts of the central nervous system. There are studies showing that patients suffering from TMD present with a widespread decrease in PPT, not only at the facial level but also in other areas such as the neck, shoulders, and lower back.[51,64,67] Studies have shown morphologic abnormalities in the brains of patients with TMD. Younger et al found abnormalities in the trigeminal system that could be a sign of spinal and/or peripheral nervous system dysfunction in patients with chronic TMD.[69] They also found ventral posterior thalamic abnormalities in patients with TMD, suggesting enhanced facilitation of trigeminal sensory transmission (ie, central sensitization).[69] Finally, they also found limbic system abnormalities in patients with TMD, which indicates a possible interplay of psychological and physiological systems in subjects with TMD.[69,70] Although Moayedi et al[70] also showed morphologic abnormalities in the pain, motor, and cognitive areas of the brain in subjects with chronic TMD, Gustin et al[71] did not find significant morphologic abnormalities in the brain of chronic TMD subjects. These results underscore the uncertainty about the mechanisms underlying pain in chronic TMD subjects.

Limitations

The main limitation of the present study was the lack of a group of subjects having only TMD without neck disability. The initial intention when conducting this research was to collect the data by separating the TMD groups into those with and without neck pain (stratification). Following 1 year of data collection, only two subjects had jaw pain without neck pain/disability, which was too small a sample size to have sufficient power to make any group comparisons. Many studies have highlighted the coexistence of cervical spine dysfunction and TMD.[25,72,73] Symptoms from the cervical spine[74] overlap in the same group of patients (TMD and cervical spine dysfunction). Thus, a high prevalence of cervical symptoms has been observed in TMD patients. Furthermore, a recent population-based study has found that neck pain is the most common comorbidity of patients with TMD; TMD patients were found to have almost eight times the odds of having neck pain when compared to subjects without TMD.[74] Since neck disability is common in patients with TMD, it was decided to analyze the data by providing clinicians with the situation they would most commonly see in clinical practice. If a patient with TMD comes to their clinic, there is a high probability that the subject will present with a neck disability requiring treatment. In addition, it was found, in a previous study, that jaw disability is highly correlated with neck disability.[75]

It has to be acknowledged that the present study is cross-sectional in nature, and thus a cause-and-effect relationship between the variables studied and TMD cannot be established. Another limitation could be the small sample size. Nevertheless, although the sample size was smaller than expected from calculations at the beginning of the study, this sample was sufficient to show both statistical significance and clinical relevance of the studied variables.

The results of this study only apply to subjects with TMD and concurrent neck disability and healthy subjects (controls). Only female subjects between 18 and 50 years of age were tested. In order to make future generalizations of these results, further studies including a larger sample size as well as measurement of different subject characteristics, such as psychological factors, physical well-being, and quality of life, are needed.

Conclusions

This study has highlighted the importance of assessing TMD patients not only in the craniofacial region but also in the neck and other parts of the body. Muscle tenderness, however, is only one of the factors that should be taken into account when assessing patients with TMD. TMD is a complex problem and involves many factors, such as the gender, anxiety and stress levels, and socialization level of the patient. Future studies, especially randomized controlled trials, should focus on testing the effectiveness of treatments addressing the neck and the whole-body sensitivity in patients with TMD.

Acknowledgments

The authors acknowledge the University of Alberta for the Queen Elizabeth II Scholarship, and Dr Norman Thie and Dr Sharon Warren. Dr Susan Armijo-Olivo is supported by the Canadian Institutes of Health Research (CIHR) through a full-time Banting fellowship, the Alberta Innovates Health Solution through an incentive award, and from the University of Alberta. The authors report no conflicts of interest related to this study.

References

1. Maixner W, Fillingim R, Sigurdsson A, Shelley Kincaid Silva S. Sensitivity of patients with painful temporomandibular disorders to experimentally evoked pain: Evidence for altered temporal summation of pain. Pain 1998;76:71–81.
2. Mongini F, Ciccone G, Ceccarelli M, Baldi I, Ferrero L. Muscle tenderness in different types of facial pain and its relation to anxiety and depression: A cross-sectional study on 649 patients. Pain 2007;131:106–111.
3. Etoz OA, Ataoglu H. Evaluation of pain perception in patients with temporomandibular disorders. J Oral Maxillofac Surg 2007; 65:2475–2478.
4. De Leeuw R (ed). Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management, ed 4. The American Academy of Orofacial Pain. Chicago: Quintessence, 2008.
5. Wanman A. The relationship between muscle tenderness and craniomandibular disorders: A study of 35-year-olds from the general population. J Orofac Pain 1995;9:235–243.
6. Ciancaglini R, Testa M, Radaelli G. Association of neck pain with symptoms of temporomandibular dysfunction in the general adult population. Scand J Rehabil Med 1999;31:17–22.
7. Browne PA, Clark GT, Kuboki T, Adachi NY. Concurrent cervical and craniofacial pain. A review of empiric and basic science evidence. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;86:633–640.
8. Bernhardt O, Schiffman EL, Look JO. Reliability and validity of a new fingertip-shaped pressure algometer for assessing pressure pain thresholds in the temporomandibular joint and masticatory muscles. J Orofac Pain 2007;21:29–38.
9. List T, Dworkin SF. Comparing TMD diagnoses and clinical findings at Swedish and US TMD centers using Research Diagnostic Criteria for Temporomandibular Disorders. J Orofac Pain 1996;10:240–252.
10. Ueda HM, Kato M, Saifuddin M, Tabe H, Yamaguchi K, Tanne K. Differences in the fatigue of masticatory and neck muscles between male and female. J Oral Rehabil 2002;29:575-582.
11. Farella M, Michelotti A, Steenks MH, Romeo R, Cimino R, Bosman F. The diagnostic value of pressure algometry in myofascial pain of the jaw muscles. J Oral Rehabil 2000;27:9–14.
12. Fischer AA. Reliability of the pressure algometer as a measure of myofascial trigger point sensitivity. Pain 1987;28:411–414.
13. Gallagher RW, Dal Santo FB, Rugh JD. Design and construction of a pressure algometer. J Craniomandib Disord 1989; 3:159–162.
14. Ohrbach R, Gale EN. Pressure pain thresholds in normal muscles: Reliability, measurement effects, and topographic differences. Pain 1989;37:257–263.
15. Baba K, Tsukiyama Y, Yamazaki M, Clark GT. A review of temporomandibular disorder diagnostic techniques. J Prosthet Dent 2001;86:184–194.
16. Ylinen J, Nykanen M, Kautiainen H, Hakkinen A. Evaluation of repeatability of pressure algometry on the neck muscles for clinical use. Manual Ther 2007;12:192–197.
17. Goulet JP Clark GT, Flack VF, Liu C. The reproducibility of muscle and joint tenderness detection methods and maximum mandibular movement measurement for the temporomandibular system. J Orofac Pain 1998;12:17–26.
18. List T, Helkimo M, Karlsson R. Influence of pressure rates on the reliability of a pressure threshold meter. J Craniomandib Disord 1991;5:173–178.
19. Silva RS, Conti PC, Lauris JR, da Silva RO, Pegoraro LF. Pressure pain threshold in the detection of masticatory myofascial pain: An algometer-based study. J Orofac Pain 2005;19: 318–324.
20. Abou-Atme YS, Melis M, Zawawi KH. Pressure pain threshold of the lateral pterygoid muscles in TMD patients and controls. J Contemporary Dental Pract [Electronic Resource] 2005;6:22–29.
21. Svensson P, Arendt-Nielsen L, Nielsen H, Larsen JK. Effect of chronic and experimental jaw muscle pain on pain-pressure thresholds and stimulus-response curves. J Orofac Pain 1995;9:347–356.
22. Hansdottir R, Bakke M. Joint tenderness, jaw opening, chewing velocity, and bite force in patients with temporomandibular joint pain and matched healthy control subjects. J Orofac Pain 2004;18:108–113.
23. Stevens J. Applied Multivariate Statistics for the Social Sciences. London: Lawrence Erlbaum Associates, 2002.
24. John MT, Dworkin SF, Mancl LA. Reliability of clinical temporomandibular disorder diagnoses. Pain 2005;118:61–69.
25. Truelove E, Pan W, Look JO, et al. The Research Diagnostic Criteria for Temporomandibular Disorders. III: Validity of Axis I diagnoses. J Orofac Pain 2010;24:35–47.
26. Look JO, John MT, Tai F, et al. The Research Diagnostic Criteria For Temporomandibular Disorders. II: Reliability of Axis I diagnoses and selected clinical measures. J Orofac Pain 2010;24:25–34.
27. Magee DJ. Orthopedic Physical Assessment, ed 4. Philadelphia: Saunders, 2002.
28. Cleland JA, Childs JD, Whitman JM. Psychometric properties of the Neck Disability Index and Numeric Pain Rating Scale in patients with mechanical neck pain. Arch Phys Med Rehabil 2008;89:69–74.
29. Cook C, Richardson JK, Braga L, et al. Cross-cultural adaptation and validation of the Brazilian Portuguese version of the Neck Disability Index and Neck Pain and Disability Scale. Spine 2006;31:1621–1627.
30. Gay RE, Madson TJ, Cieslak KR. Comparison of the Neck Disability Index and the Neck Bournemouth Questionnaire in a sample of patients with chronic uncomplicated neck pain. J Manipulative Physiol Ther 2007;30:259–262.
31. McCarthy MJ, Grevitt MP, Silcocks P, Hobbs G. The reliability of the Vernon and Mior neck disability index, and its validity compared with the short form-36 health survey questionnaire. Eur Spine J 2007;16:2111–2117.
32. Sugisaki M, Kino K, Yoshida N, Ishikawa T, Amagasa T, Haketa T. Development of a new questionnaire to assess pain-related limitations of daily functions in Japanese patients with temporomandibular disorders. Community Dent Oral Epidemiol 2005; 335:384–395.
33. de Wijer A, Steenks MH, Bosman F, Helders PJ, Faber J. Symptoms of the stomatognathic system in temporomandibular and cervical spine disorders. J Oral Rehabil 1996;23:733–741.
34. Sjolund BH, Persson AL. Pressure pain threshold changes after repeated mechano-nociceptive stimulation of the trapezius muscle: Possible influence of previous pain experience. J Pain 2007;8:355–362.
35. List T, Helkimo M, Falk G. Reliability and validity of a pressure threshold meter in recording tenderness in the masseter muscle and the anterior temporalis muscle. Cranio 1989;7: 223–229.
36. Kirk R. Practical significance: A concept whose time has come. Educational Psychological Measurement 1996;56:746–759.
37. Musselman K. Clinical significance testing in rehabilitation research: What, why, and how? Phys Ther Rev 2007;12: 287–296.
38. Cohen J. Interrater reliability and predictive validity of the FOUR score coma scale in a pediatric population. J Neurosci Nurs 2009;41:261–267.

39. Pogrel MA, McNeill C, Kim JM. The assessment of trapezius muscle symptoms of patients with temporomandibular disorders by the use of liquid crystal thermography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;82:145–151.
40. De Laat A, Meuleman H, Stevens A, Verbeke G. Correlation between cervical spine and temporomandibular disorders. Clin Oral Investig 1998;2:54–57.
41. Bogduk N. Cervicogenic headache: Anatomic basis and pathophysiologic mechanisms. Curr Pain Headache Rep 2001; 5:382–386.
42. Hu JW, Sun KQ, Vernon H, Sessle BJ. Craniofacial inputs to upper cervical dorsal horn: Implications for somatosensory information processing. Brain Res 2005;1044:93–106.
43. Armijo-Olivo S. Relationship between Cervical Musculoskeletal Impairments and Temporomandibular Disorders: Clinical and Electromyographic Variables. Faculty of Rehabilitation Medicine, University of Alberta, 2010:488.
44. Armijo-Olivo S, Silvestre R, Fuentes J, et al. Electromyographic activity of the cervical flexor muscles in patients with temporomandibular disorders while perfoming the craniocervical flexion test: A cross-sectional study. Phys Ther 2011;91:1184–1197.
45. Armijo-Olivo S, Fuentes J, da Costa B, et al. Reduced endurance of the cervical flexor muscles in patients with concurrent temporomandibular disorders and neck disability. Man Ther 2010;15:586–592.
46. Armijo-Olivo SL, Fuentes JP, Major PW, Warren S, Thie NM, Magee DJ. Is maximal strength of the cervical flexor muscles reduced in patients with temporomandibular disorders? Arch Phys Med Rehabil 2010;91:1236–1242.
47. Rantala MA, Ahlberg J, Suvinen TI, et al. Temporomandibular joint related painless symptoms, orofacial pain, neck pain, headache, and psychosocial factors among non-patients. Acta Odontol Scand 2003;61:217–222.
48. Greenspan JD, Slade GD, Bair E, et al. Pain sensitivity risk factors for chronic TMD: Descriptive data and empirically identified domains from the OPPERA case control study. J Pain 2011;12(11 suppl):T61–T74.
49. Visscher CM, Lobbezoo F, Naeije M. Comparison of algometry and palpation in the recognition of temporomandibular disorder pain complaints. J Orofac Pain 2004;18:214–219.
50. Fernandez-de-las-Penas C, Galan-del-Rio F, Fernandez-Carnero J, Pesquera J, Arendt-Nielsen L, Svensson P. Bilateral widespread mechanical pain sensitivity in women with myofascial temporomandibular disorder: Evidence of impairment in central nociceptive processing. J Pain 2009;10:1170–1178.
51. Reid KI, Gracely RH, Dubner RA. The influence of time, facial side, and location on pain-pressure thresholds in chronic myogenous temporomandibular disorder. J Orofac Pain 1994;8:258–265.
52. Gomes MB, Guimaraes JP, Guimaraes FC, Neves AC. Palpation and pressure pain threshold: Reliability and validity in patients with temporomandibular disorders. Cranio 2008; 26:202–210.
53. Vedolin GM, Lobato VV, Conti PC, Lauris JR. The impact of stress and anxiety on the pressure pain threshold of myofascial pain patients. J Oral Rehabil 2009;36:313–321.
54. Bragdon EE, Light KC, Costello NL, et al. Group differences in pain modulation: Pain-free women compared to pain-free men and to women with TMD. Pain 2002;96:227–237.
55. Guyton AC, Hall JE. Human Physiology and Mechanisms of Disease, ed 6. Philadelphia: Saunders, 1997.
56. Fink M, Tschernitschek H, Stiesch-Scholz M. Asymptomatic cervical spine dysfunction (CSD) in patients with internal derangement of the temporomandibular joint. Cranio 2002;20:192–197.
57. Piekartz HV, Bryden L. Craniofacial Dysfunction & Pain: Manual Therapy, Assessment and Management. London: Butterworth Heinemann, 2001.
58. Catanzariti JF, Debuse T, Duquesnoy B. Chronic neck pain and masticatory dysfunction. Joint Bone Spine 2005;72:515–519.
59. Davidoff RA. Trigger points and myofascial pain: Toward understanding how they affect headaches. Cephalalgia 1998; 18:436–448.
60. Wiesinger B, Malker H, Englund E, Wanman A. Does a dose-response relation exist between spinal pain and temporomandibular disorders? BMC Musculoskelet Disord 2009;10:28.
61. Storm C, Wanman A. Temporomandibular disorders, headaches, and cervical pain among females in a Sami population. Acta Odontol Scand 2006;64:319–325.
62. De Leeuw R. Introduction to orofacial pain. In: American Academy of Orofacial Pain, De Leeuw R (ed). Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management. Chicago: Quintessence, 2008:1–24.
63. Cohen J. Statistical Power for the Behavioral Sciences, ed 3. Hillsdale, NJ: Lawrence Erlbaum, 1998.
64. Turp JC, Kowalski CJ, O'Leary N, Stohler CS. Pain maps from facial pain patients indicate a broad pain geography. J Dent Res 1998;77:1465–1472.
65. Sarlani E, Greenspan JD. Evidence for generalized hyperalgesia in temporomandibular disorders patients. Pain 2003; 102:221–226.
66. Fernandez-de-las-Penas C, Galan-del-Rio F, Ortega-Santiago R, Jimenez-Garcia R, Arendt-Nielsen L, Svensson P. Bilateral thermal hyperalgesia in trigeminal and extra-trigeminal regions in patients with myofascial temporomandibular disorders. Exp Brain Res 2010;202:171–179.
67. Sipila K, Zitting P, Siira P, Niinimaa A, Raustia AM. Generalized pain and pain sensitivity in community subjects with facial pain: A case-control study. J Orofac Pain 2005;19:127–132.
68. Mohn C, Vassend O, Knardahl S. Experimental pain sensitivity in women with temporomandibular disorders and pain-free controls: The relationship to orofacial muscular contraction and cardiovascular responses. Clin J Pain 2008;24:343–352.
69. Younger JW, Shen YF, Goddard G, Mackey SC. Chronic myofascial temporomandibular pain is associated with neural abnormalities in the trigeminal and limbic systems. Pain 2010; 149:222–228.
70. Moayedi M, Weissman-Fogel I, Crawley AP, et al. Contribution of chronic pain and neuroticism to abnormal forebrain gray matter in patients with temporomandibular disorder. Neuroimage 2011;55:277–286.
71. Gustin SM, Peck CC, Wilcox SL, Nash PG, Murray GM, Henderson LA. Different pain, different brain: Thalamic anatomy in neuropathic and non-neuropathic chronic pain syndromes. J Neurosci 2011;31:5956–5964.
72. de Wijer A, de Leeuw JR, Steenks MH, Bosman F. Temporomandibular and cervical spine disorders. Self-reported signs and symptoms. Spine 1996;21:1638–1646.
73. De Wijer A, Steenks MH. Cervical spine evaluation for the temporomandibular disorders patient: A review. In: Fricton J, Dubner R (eds). Advances in Orofacial Pain and Temporomandibular Disorders. New York: Raven Press, 1995: 351–361.
74. Plesh O, Adams SH, Gansky SA. Temporomandibular joint and muscle disorder-type pain and comorbid pains in a national US sample. J Orofac Pain 2011;25:190–198.
75. Olivo SA, Fuentes J, Major PW, Warren S, Thie NM, Magee DJ. The association between neck disability and jaw disability. J Oral Rehabil 2010;37:670–679.