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"Comparison of Muscle Tenderness and General Pain Sensitivity between Subjects with Temporomandibular Disorders and Concurrent Neck Disability and Healthy Subjects"

by

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Dedication

This thesis is dedicated to my parents, Hilario and Berenice, who taught the importance of education and believing in my dreams. They never measured any efforts to help me accomplish my objectives and always had the right word whenever things were difficult and I might have had some doubts. Thank you very much mom and dad, I love you so much and thanks to you I am here today.

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ABSTRACT

Purpose: The main objective of this study was to compare the masticatory and cervical muscle tenderness and general pain sensitivity between patients with TMD and healthy controls.

Methods: Eligible patients completed the Neck Disability Index and Jaw Dysfunction Index. Tenderness of the masticatory and cervical muscles and general pain sensitivity in the hypothenar region of the left hand were measured using an algometer.

Results: The PPTs of the masticatory as well as cervical muscles of subjects with TMD were significantly lower statistically at almost all sites tested when compared with the healthy controls. Effect sizes were moderate to high indicating a clinically relevant difference between groups. General pain sensitivity of patients with TMD was significantly higher than the healthy control group. The correlation between jaw disability and neck disability was significantly high. **Conclusion:** The results of this study suggest a relationship between neck muscle tenderness and TMD. These findings emphasize the importance of including the neck when evaluating and treating patients with TMD.

Key Words: Temporomandibular disorders, neck disability, pain sensitivity

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CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION AND PROBLEM STATEMENT

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 results in painful and/or dysfunctional conditions of the masticatory muscles, temporomandibular joints, and/or related structures [3]. Muscle pain is the most common complaint among patients with TMD, and it may range from slight tenderness to extreme discomfort [4, 5]. Symptoms affecting head and neck regions such as headaches, earache, cervical spine dysfunction, and altered head and cervical posture are also commonly associated with TMD [6].

The connection between TMD and neck pain is still a focus of discussion [7, 8]. It is believed that there is interdependence between the temporomandibular structures and neck structures, since there are data supporting the concept that disease or injury in one area may induce pain and/or dysfunction in the another area [9]. Ciancaglini et al [8], found a significant relationship between neck pain and TMD, and this association became stronger with increasing severity of the dysfunction. Another study indicated that subjects with myogeneous TMD and subjects with combined myogeneous/arthrogenous TMD had more neck complaints than subjects with only arthrogenous TMD, and controls.

Muscle tenderness is the most common sign found in patients with TMD [7, 11, 12, 13] and its evaluation is still one of the most important methods of establishing a clinical diagnoses of TMD [12, 14]. It is believed that there is a correlation between muscle tenderness in the neck area and the temporomandibular system (consisting of the masticatory musculature, temporomandibular joint and associated structures) [15]. However, this relationship is far from being exhaustively explained. Most of the studies that investigated muscle tenderness in TMD subjects used palpation techniques, which are difficult to quantify and standardize [12]. Moreover, small sample sizes, lack of control groups as well as lack of blinding are some of the weakness found in the studies that affected the generalizability of their results.

Muscle pain is the most common symptom found in TMD subjects [4]. Some studies have shown that TMD patients have different general pain perception when compared with age-matched control subjects [1, 3, 16]. TMD subjects tend to present with a more widespread pain distribution [3, 16, 17, 18]. Maixner et al. [16] stated that TMD subjects are more sensitive to noxious ischemic and thermal stimuli than healthy controls. Nevertheless, the small number of health controls and lack of blinding of the investigator as well as the subjects are some of the limitations of this study. Recently, Etoz et al. [3] found that TMD patients were significantly different from healthy controls in terms of general pain perception. Unfortunately, these authors only measured the pain pressure threshold of the hypothenar region of the left hand. Lack of measurements of the orofacial and neck muscles were a weakness of this study.

Therefore, further studies investigating muscle tenderness of the neck and orofacial muscles as well as general pain perception in TMD patients are needed in order to understand the underlying mechanism of TMD as well as to provide further evidence of the relationship between the craniomandibular system and cervical spine [3]. The main purpose of this present study was to improve the understanding of the muscle tenderness and the general pain sensitivity of patients with TMD and concurrent neck disability and compare them with healthy controls. The main hypothesis of this study was that patients with TMD and concurrent neck disability would have a decreased general sensitivity to pain and would be more prone to develop muscle tenderness than healthy controls subjects.

1.2 DEFINITION OF TERMS

Algometry: Pressure algometry is a valid, reliable, and safe modality that measures the pain pressure threshold, allowing quantitative analysis of muscle pain and tenderness, since it uses a uniform rate of pressure to determine the threshold [3, 26, 27, 28].

Algometer: The mechanical pressure algometer is a manual tool that, when pressed against the body surface, measures the pain pressure threshold [29]. Therefore, it is designed to quantify and record levels of tenderness as well as levels of pain [12]. The algometer is a force gauge fitted with a rubber disk which has a surface area of 1 cm^2 [12]. The algometer may indicate pressure in different units such as kilograms, newtons or pounds per unit area. By knowing the size of the contact area, one can transform the pressure values into pressure units such as kilopascals, newtons per square centimeter, or kilograms per square centimeter [29].

Chronic Pain: According to the International Association for the Study of Pain, a pain that lasts for at least 3 months since the beginning of the symptoms can be considered as chronic [120].

Craniomandibular System (CMS): The craniomandibular system is composed of the head, the cervical spine, temporomandibular joints and surrounding tissues such as muscles, fascia, blood vessels and nerves. These structures are connected biomechanically, anatomically, and physiologically [19].

Jaw Disability Index: The Jaw Dysfunction Index (JDI) was used to measure the jaw function of all the subjects in this study. The subject was asked to choose one of the five ratings on the scale in response to the following question: “How much does your present jaw problem prevent or limit your daily functions?”. The results of the questionnaire established the level of the jaw dysfunction in the subjects [115].

Masticatory Muscles: The masticatory muscles responsible for the mastication process are the superficial masseter, deep masseter, temporalis, external pterygoid, and internal pterygoid muscles [20].

Neck Disabilities: In this study, neck disabilities were defined as mechanical neck pain that had no specific identifiable etiology (i.e. no history of trauma or surgery to the upper quarter, no neurological deficit, and no fractures). Moreover, the neck disabilities were evaluated using the Neck Disability Index which showed how neck pain affected the ability of the subjects to manage their everyday life [20].

Neck Disability Index: The Neck Disability Index (NDI) is a questionnaire designed to give information about how neck pain affects the ability of the subjects to manage their everyday life [71-74]. This index was used as a tool to discriminate the subjects of this study. The subjects who scored less than 4 points in this NDI and not diagnosed with TMD were considered as having no neck disability and they were allocated in the healthy control group. The subjects who scored more than 4 points in this tool as well as were classified as having myogeneous or mixed TMD were allocated in the TMD and concurrent neck disability group.

Pain Pressure Threshold: Pain Pressure Threshold (PPT) is characterized by the first reported pain with an increasing level of pressure [30, 26, 27, 31]. PPT is usually used to evaluate the sensitivity of the nervous system to noxious stimuli. Furthermore, PPT measurements using an algometer are used to evaluate and to do the follow-up of various pain syndromes [12].

Temporomandibular Disorders (TMD): Temporomandibular disorders are also called craniomandibular disorders (CMD). TMD is a term that involves a number of clinical problems that engage the masticatory musculature, the temporomandibular joint (TMJ) and associated structures, or both [21]. Their definition is complex, since there are no agreement about which signs and symptoms are needed to describe this condition[10]. Nevertheless, the three most common cardinal signs among patients with TMD are pain in the joints and/or jaw muscles, clicking or sounds in the temporomandibular joint (TMJ), and alterations in the mobility of the jaw. Alterations in the craniocervical system are sometimes included in the evaluation of the TMD, since some researchers have found that patients with TMD may present with cervical spine problems [10, 23, 24, 25]. This evidence demonstrates that cervical spine and craniomandibular system may be functionally related to the masticatory system.

TMD and Concurrent Neck Disability: In this study, subjects presenting with signs and symptoms of myogeneous or mixed TMD and with a score of at least 5 on the Neck Disability Index were allocated in this group.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study were:

1. To determine whether subjects with TMD and concurrent neck disability had a different general pain sensitivity (as evaluated by the pain pressure threshold in the left hand) than control subjects.
2. To determine whether subjects with TMD and concurrent neck disability were different than healthy control subjects in terms of muscle tenderness (measured by determining the pain pressure thresholds in face and neck muscles);
3. To determine whether the level of muscle tenderness of the analyzed muscles (i.e. sternocleidomastoid, upper trapezius, masseter and temporalis muscles) for subjects with TMD and concurrent neck disability group was related to the level of jaw dysfunction (Jaw Dysfunction Index);

4. To determine whether the level of muscle tenderness of the analyzed muscles (i.e. sternocleidomastoid, upper trapezius, masseter and temporalis muscles) for subjects with TMD and concurrent neck disability group was related to the level of neck dysfunction (Neck Disability Index);
5. To determine whether there was a correlation between general pain sensitivity and jaw dysfunction among all the subjects of the study;
6. To determine whether there was a correlation between general pain sensitivity and neck disability among all the subjects of the study;
7. To determine whether there was a correlation between the neck disability and jaw dysfunction among all the subjects of the study.

1.4 RESEARCH HYPOTHESES

1. Subjects in the TMD and concurrent neck disability group would present with decreased general pain sensitivity when compared to healthy control subjects;
2. Subjects in the TMD and concurrent neck disability group would present with greater cervical and masticatory muscle tenderness than healthy control subjects;
3. Increased muscle tenderness would be related to increased levels of jaw dysfunction in both groups;

4. Increased muscle tenderness would be related to increased levels of neck dysfunction in both groups;
5. There would be a negative correlation between general pain sensitivity and jaw dysfunction in both groups;
6. There would be a negative correlation between general pain sensitivity and neck disability in both groups;
7. There would be a positive correlation between jaw dysfunction and neck disability in both groups.

1.5 LIMITATIONS OF THE STUDY

This study was limited by:

a) Potential subject bias: Since the data was self-reported, the subjects may have reported more pain that they really had, since they might have believed that this was what the investigator was expecting. Therefore, in order to compensate for this disadvantage, before the examination, the procedure was demonstrated on the investigator's hand and a practice trial was performed on the subject's right hand, to assure that the subject understood the procedure.

   Self-selection bias was another potential bias, since all subjects were volunteers. It was difficult to know what characteristics were present in those who offer themselves as subjects, as compared with those who did not, and it was unclear how these attributes might have affected the ability to generalize outcomes [32]. In order to minimize this problem, the inclusion and exclusion criteria were specified, and the control subjects were age matched with TMD and neck disability group, allowing for comparison of both groups.

b) The use of a convenience sample: Although probability samples would have been ideal for this type of study, having accessibility to the general population of TMD patients was limited and having access to all of them would have been expensive and time consuming. Furthermore, even with random selection, not all of the TMD patients who could have been invited to participate in the study would probably have consented.

c) The ability of researcher to apply the same procedure to every subject. In order to minimize this limitation, the following possible confounders were controlled:

    i) Measurement bias was controlled by the use of a valid and reliable test instrument (algometer) and by blinding of the assessor;

    ii) The evaluator was trained in the use of the algometer until consistent measurements were achieved;

    iii) The algometer and the area of application were the same for all subjects. Landmarking were used to allow easy recognition of the point of the algometer application;

    iv) The algometer was calibrated every week for the duration of the experimental procedure to make sure that the rate of force application was consistent;

v) The instructions were the same for all subjects.

d) The ability to generalize the results because of the use of a convenience sample and the small sample size.

e) Subjects who meet the inclusion and exclusion criteria proposed by this study;

f) The muscles described and analyzed in the analysis of this study.

1.6 DELIMITATIONS OF THE STUDY

This study was delimited to:

1) Normal subjects having normal craniomandibular systems with no known pathology;
2) Subjects with TMD and concurrent neck disability;
3) Females subjects between 18 and 50 years of age;
4) The use of a manual algometer to measure the pain pressure threshold (PPT).

1.7 ETHICAL CONSIDERATIONS

The approval from the Ethics Committee of the University of Alberta as well as the consent form from the subjects participating in this study was required prior to the beginning of the study. The total privacy of the subjects was ensured and participants were allowed to withdraw of the study at any time if they so desired without consequences.

It is important to note that this study did not offer any risk for the subjects, since no invasive methods were used. If the subjects experienced some discomfort during the assessment, they were asked to let the investigator know immediately, and the evaluation was stopped. Only the first sensation of pain (i.e. when the sensation of pressure start to be uncomfortable, but still not painful) was measured, which was not sufficient to increase the pain in symptomatic patients.

CHAPTER TWO: LITERATURE REVIEW

2.1 TEMPOROMANDIBULAR DISORDERS

Temporomandibular disorders (TMD) is a term that includes a number of clinical problems that involve the masticatory musculature, the temporomandibular joint (TMJ) and associated structures, or both [21]. TMDs are one of the major causes of nondental pain in the orofacial region and are considered a subclassification of musculoskeletal disorders [6]. TMDs represent a group of related disorders in the masticatory system that has many common symptoms [6]. Localized pain in the muscles of mastication and/or preauricular area is the most common symptom among patients with TMD [4]. This pain may be aggravate by chewing or other jaw activity [4, 6]. Patients with TMD usually present with limited or asymmetric mandibular movements and TMJ sounds that are most frequently described as crepitation, clicking, popping or grating [4, 6]. Common patient complaints include jaw pain, headache, facial pain, neck pain and earache [4, 6].

It is believed that TMD patients have a different general pain perception when compared with age-matched control subjects [3, 16]. Moreover, there are some studies showing that patients with TMD tend to present with a more widespread pain distribution than commonly assumed [1, 3, 17, 18]. Maixner et al [16] found that TMD patients are more sensitive to noxious ischemic and thermal stimuli than healthy controls and they are generally less able to activate endogenous-pain-regulatory systems in response to noxious forearm ischemia compared to patients experiencing acute orofacial pain. Nevertheless, the small number of healthy controls and lack of blinding of the investigator as well as the subjects are some of the limitations of that study. Recently, Etoz et al [3] investigated the pain perception of patients with TMD and the possible association between pain sensitivity and TMD. They concluded that TMD patients were significantly different from healthy controls in terms of general pain perception [3]. However they only measured the pain pressure threshold of the hypothenar region of the left hand. Lack of measurements such as the pain pressure threshold of the orofacial and neck muscles were a weakness of this study. Further studies investigating the general pain perception in TMD patients are needed in order to understand the underlying mechanism of TMD.

2.2 DIAGNOSIS OF TMD

The diagnosis of TMD can be viewed as the most useful summary measure for characterizing this clinical condition [33]. Even though many diagnostic systems have been proposed for TMD, only two are currently being amply used the clinically-oriented American Academy of Orofacial Pain system and the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) [33]. Both systems are similar, having many areas of overlap and agreement [33]. In this study, the RDC/TMD is discussed in more detail, since it was used as a diagnostic system to evaluate the participants of this research. The RDC/TMD was chosen over the AAOPS, since it is more widely used in other studies, which facilitates the comparison of results.

The RDC/TMD diagnostic system was developed by an international team of expert clinician-researchers, and it has been formally translated into 18 languages, being widely used as a diagnostic method around the world [5, 33]. It consists of a dual-axis system to allow both a physical diagnosis and a psychological assessment. Axis I provides a standardized method for evaluating the history of the patient, conducting his/her physical examination, yielding a reliable diagnosis of the most frequent muscles, disc displacements, and degenerative joint disorders that affect TMD patients [5, 34]. Axis II provides methods and measures to evaluate behavioral, psychological, and psychosocial factors throughout four domains that have a good probability of being useful in the clinical management of TMD's patients: pain, mandibular function and behavior, psychological disturbance, and psychological disability [5].

The reliability and validity of the RDC/TMD diagnostic system have been studied by different authors. M.T. John et al. [33] evaluated the reliability of the most commonly occurring TMD clinical diagnoses across several clinical TMD centers (i.e. San Francisco, Portland, Singapore, Sidney, Amsterdam, Heidelberg, Zurich, Naples, Linkoping and Malmo) based on the RDC/TMD diagnostic system. Although variability among the centers was high, the findings of the study showed that the reliability of the RDC/TMD diagnostic system was sufficiently high for the most common diagnoses [33]. They found that the median ICCs for

RDC/TMD had fair to good reliability for myofascial pain with and without limited mouth opening (ICC = 0.75), disc displacement with reduction (ICC = 0.61), and arthralgia (ICC = 0.54). Recently, Look et al. [35] studied the reliability of Axis I diagnoses from RDC/TMD and they found good to excellent intersite reliability for myofascial pain, arthralgia, disc displacement with reduction, and disc displacement without reduction with limited opening. However, Truelove et al. [34] showed that Axis I TMD diagnosis obtained target validity only for myofascial pain without differentiation between limited opening or regular myofascial pain. The other diagnosis from Axis I had sensitivities lower than 0.70 and specificities lower than 0.95. Although the validity of Axis I can still be improved, the validity for myofascial pain diagnosis can be considered fair. Moreover, Axis I is considered reliable by the above studies. Since myofascial pain is the most important diagnosis for this study and the use of the RDC/TMD diagnoses in TMD clinical practice and research is recommended, the RDC/TMD Axis I was used to classify the subjects in this study [33]. Although it is a common clinical practice to use radiographic confirmation for degeneration at the temporomandibular joint, there was no need to use it in the present study, since the main outcome measured was muscle tenderness. Therefore, the use of a valid and reliable tool such as the RDC/TMD was enough to discriminate the groups of the present study.

In the present study, the subjects had to be diagnosed under Axis I on either Group I or a combination of Group I and group II or Group I and Group III. If the subjects were diagnosed as only group II or group III, they were excluded.

Group I characterized myogeneous TMD: myofascial pain (Ia) or myofascial pain with limited opening (Ib) [36]. Group II had subjects with disc displacements: disc displacement with reduction (IIa), disc displacement without reduction with limited opening (IIb), disc displacement without reduction without limited opening (IIc) [36]. Group III consisted of subjects with arthalgia (IIIa), osteoarthritis (IIIb) or osteoarthrosis (IIIc) [36].

2.3 EPIDEMIOLOGY

Epidemiologic studies have shown that 40-75% of non-patient adult populations present with at least one sign of TMD such as tenderness to palpation, movements disorders and/or joint noise [6, 37]. Furthermore, about 33% of selected non-patient populations have at least one symptom of TMD (eg, face pain, joint pain) [6]. Signs such as joint sounds or deviations on mouth opening seem to be relatively common among healthy populations, appearing in approximately 50% of the population [6]. However, it is important to take into account that the results of these epidemiologic studies may vary considerably from study to study, since there are differences in descriptive terminology, data collection, analytic approaches (eg, single-factor versus multifactor analysis), and the individual factors (e.g. age, gender) among them [6, 38].

Despite all of the limitations, many consistencies are apparent in the epidemiologic studies. Approximately 10% of the population older than 18 years of age presents with pain in the TMJ [6]. TMD is primarily a condition of young and middle-aged adults, and women have double the risk of developing TMD when compared to men [6, 38, 39]. Although the prevalence of signs and symptoms of TMD is higher in adults, they are also observed in children and teenagers [6, 39]. While pain severity is the same among all age groups, physical limitations and dysfunction tend to steadily decrease in prevalence and severity in older ages [6, 38, 39].

Among patients seeking treatment for TMD, 26% to 31% report internal derangement and 30% to 33% report a muscle disorder [6]. Schiffman et al [116], using tested diagnostic criteria on a general population, found 33% with TMJ disorders and 41% with masticatory muscle disorders in this population. However, only 7% of the population they studied had a disorder severe enough to be comparable with a clinic population. Nassif et al [37] looked for signs and symptoms of TMD in 523 Saudi military students aged 18–25 years, and they found that 6.9% presented moderate symptoms and ⁄ or moderate signs; 51.4% presented significant moderate symptoms and ⁄ or signs (a TMD comprehensive evaluation was recommended for this population), and 16.7% presented with severe symptoms and ⁄ or signs (a TMD comprehensive evaluation was highly recommended for this population).

Regarding the associated symptoms of TMD, Garro et al [40] investigated the nature of the "TMD" experience among patients. They used the McGill Pain Questionnaire, which asked patients to mark on a body outline areas where they experienced pain. The results of this study showed that one or both jaw joints were the most common pain site selected (100%), other areas frequently selected include the neck (75%), other areas of the head (72%), the back (72%), the shoulders (66%), and the arms (44%). The pain was regularly described as radiating from the head into the neck, shoulders, and back. The majority of the subjects described the pattern of their pain as continuous (56%) and stated that they experienced pain every day (69%).

2.4 ETIOLOGY

The causes of TMD are complex and multifactorial [4, 6]. Many factors may contribute to the development of TMD: *Predisposing factors* that increase the risk of TMD (e.g. age, posture, occlusion, emotional stress); *initiating factors* that cause the onset of TMD (e.g. trauma); and *perpetuating factors* that interfere with healing or enhance the progression of TMDs (e.g. clenching, bruxism) [4,6]. An initial accurate assessment and the identification of the possible contributing factors are essential for a long-term successful management of TMD [4,6].

The major etiologic factors that might lead to TMD are: trauma, emotional stress, parafunctional activities and occlusal condition [4].

Trauma to facial structures might lead to functional disorders in the masticatory system [4]. Both intensity and duration of the trauma need to be considered in the evaluation of a patient [6]. Macrotrauma results from any sudden force that may lead to structural alterations, such as a direct blow to the face [4, 6]. Microtrauma consists of a small force that is repeatedly applied to the structures over a long period of time [4, 6]. Clenching and bruxism are examples of activities that can produce microtrauma to the tissues that are being loaded (i.e., muscles, joints, or teeth) [4, 6].

Increased levels of emotional stress can influence the masticatory system and play an important role in TMD [4]. The body reacts to emotional stress by creating certain demands for readjustment or adaptation [4]. Emotional stress is a type of energy that is created within the body under stressful situations, and it must be released in some way [4]. Increased levels of emotional stress can increase not only the tonicity of head and neck muscles but also the levels of nonfunctional activity such as bruxism and tooth clenching [4]. One possible explanation for this is that stress can activate the hypothalamus, which is responsible for preparing the body to respond to stressful situations through the autonomic nervous system [4]. The hypothalamus, through complex neural pathways, increases the activity of the gamma efferent, which enhance the tonicity of the muscles [4].

Oral habits that are often performed without the individual being aware of them, such as teeth clenching, teeth grinding and lip biting include what are called parafunctional habits [4]. Although parafunctional habits do not necessarily result in TMD symptoms, they have been suggested as initiating and perpetuating factors in certain subgroups of TMD patients [6]. However, since few studies have directly assessed this behavior, the exact role of parafunctional habits in causing TMD remains unclear [6].

Finally, the relationship between oral occlusion and the development of TMD is being widely discussed in the literature [6, 41-44]. Although occlusion was believed to play an important role in the development of TMD, recent studies are showing that this contribution seems to be small [6].

2.5 THE CRANIOMANDIBULAR SYSTEM AND TMD

The association of signs and symptoms of cervical spine disorders with temporomandibular disorders is still a focus of discussion [7, 8, 35]. Furthermore, the relationship between cervical spine disorders and TMD has important practical implications [8, 23, 25, 46-48]. Unfortunately, a cause and effect relationship between cervical pain and TMD is still to be established. Both cervical spine disorders and TMD can be responsible for work loss, and may lead to impairment in the quality of a person's life [7, 8]. In its guidelines, the American Academy of Orofacial Pain considers palpation of cervical muscles to be an important part of the diagnostic protocol for identification of temporomandibular disorders [8, 49].

The prevalence of cervical spine disorders in subjects with temporomandibular joint disorders has been investigated by many authors [8, 15, 18, 23, 47]. Ciancaglini et al [8], found a significant relationship between neck pain and TMD, and this association became stronger with increasing severity of the dysfunction and/or with increasing age. Subjects classified as mild or moderate/severe symptomatically had an estimated risk (odds ratio) of suffering from neck pain equal to 1.24 and 2.37, respectively, when contrasted with subjects without TMD symptoms. Additionally, their analysis found that subjects with moderate/severe TMD had more than double the risk (odds ratio 2.33) of suffering from neck pain. Another study by de Wijer et al [10], indicated that subjects with myogeneous type TMD and subjects with combined myogeneous/arthrogenous TMD had more neck complaints than subjects with only arthrogenous type of TMD, and controls.

Although the association of cervical spine disorders and TMD has been studied by different authors, it is far from being exhaustively explained [8, 45]. It is believed that there may be an anatomical and functional connectivity between the trigeminal nerve root (mandibular sensory-motor branch) and cervical innervated structures, since a neurophysiological and structural convergence of cervical sensory and muscle afferent inputs onto the trigeminal subnucleus caudalis nociceptive and non-nociceptive neurons were found by several authors [9, 15, 45, 50]. These neurophysiological and structural convergences may be responsible for the development of 'silent' functional disorders of the cervical spine in patients with internal derangement of the temporomandibular joint before these patients develop the neck complaints that are typical of cervical spine disorders or vice-versa [15]. Kinesiologic observations have shown that the masticatory muscles can have a synergic or antagonistic relationship with the cervical muscles acting as extensors or flexors of the cervical spine [8, 9]. Differences in length and in the tonic response in cervical muscles might influence the activity of the masticatory muscles [8]. A clinical study by Stiesch-Scholz [15] has also found that pain of cervical origin can influence the facial area, particularly the forehead and the orbital area. A correlation between muscle tenderness in the craniocervical area and the temporomandibular system could be explained by a close functional coupling between the two systems.

If the cervical spine or the TMJ is injured, then the tenderness which arises often spreads after local injury, and sometimes persists or increases over time, even when tissue healing has apparently taken place [45]. Although this may occur, in part, due to a local spreading of pain-producing chemicals through the tissues, there is evidence that the spread of tenderness is more related to changes in spinal circuitry (central sensitization) [3, 45, 51-54]. Trigeminal afferent fibers from the proprioceptive mechanoceptors located in the orofacial area project to the sensory complex of the fifth cranial nerve in the brainstem and from there to the first three segments of the cervical spinal cord and to the nucleus of the spinal accessory nerve, which contributes to the innervations of the cervico-occipital, trapezius and sternocleidomastoid muscles, together with the C1 to C3 nerve roots [7, 50, 55]. A study by De Laat et al [56] investigated the presence of signs of cervical spine disorders in patients with TMD compared to a matched control group. They found that 23 to 67% of the patients with TMD presented with cervical muscle tenderness as well as tenderness of the neck muscles upon palpation which was only rarely present in the healthy control group. Another study by de Wijer et al [22] also assessed the prevalence of signs and symptoms related to cervical spine disorders in patients with TMD, and they found that patients with TMD reported pain on neck palpation more frequently than healthy controls. Wanman [7] investigated the pattern of muscle tenderness and the presence of craniomandibular disorders (CMD) and his major finding was a significantly higher proportion of signs and symptoms of CMD in the subjects who had both jaw muscle and neck/shoulder muscle tenderness and in those with generalized tenderness (i.e. tenderness found in all palpated regions of neck, shoulder, arm, hand, and calf muscles) when compared with a healthy control group. Although all of these studies have showed the presence of neck muscle tenderness in subjects with TMD, their results should be interpreted with caution. All of the studies evaluated the muscle tenderness using manual palpation. Although manual palpation is the most popular method for detecting muscle tenderness, this technique and its interpretation is still a topic of controversy, mainly when the amount of pressure applied is considered [12, 13]. The pressure applied in the diverse methods of manual palpation is difficult to quantify and standardize [12]. Even with extensive examiner training, manual palpation can only achieve marginal levels of reliability [12].

Finally, although the literature has shown evidence of a link between cervical spine, neck structures and craniofacial pain, the levels of evidence are not sufficiently strong. Small sample sizes, different research designs and populations may compromise the comparison and generalization of the results. Further studies, with good, well designed methods are needed in other to provide definitive conclusions.

2.6 PAIN PRESSURE THRESHOLD USING PRESSURE ALGOMETRY

Muscle tenderness and muscle pain are common complaints among patients with TMD and/or neck disability, and their evaluation is of particular interest to clinicians treating orofacial pain patients [7, 15, 31, 57]. Pressure algometry is an investigative tool used to apply a uniform rate of pressure for measurement of muscle tenderness and for the quantification of the pain intensity [3, 26-28]. The tenderness and pain intensity are expressed quantitatively by the pain pressure threshold (PPT), which is characterized by the first reported pain when using an increasing level of pressure [26, 27, 30, 31]. According to Baba et al [30], the reproducibility of applying pressure 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 gender, rate of pressure and site being tested.

Although some studies suggest that gender may influence PPT measurements, this relationship is still not clear [28, 30]. There are some publications stating that women tend to have a lower PPT (i.e. more sensitivity to pain) when compared to men [3, 29, 58-60]. On the other hand, there are other studies that did not find gender differences [61-63]. Therefore, the effect of gender in the PPT measures needs further evaluation.

A study by List et al [31] investigated the relationship between the rate of pressure applied over the masseter muscle. They found that PPT could be significantly influenced by the pressure rate. In order to obtain acceptable reproducibility, the pressure rate should be kept within the rate of 0.50 kg/cm^2/s.

According to the literature, PPT can vary with the site being tested. Ohrbach and Gale [28], for example, found that PPT was significantly higher in the temporalis muscle than in the masseter muscle. They also stated that PPT applied to a tendon area tended to be higher than at the belly area of a muscle.

The use of algometer can improve the reliability of muscle tenderness and pain intensity assessment, since it provides a constant area of skin contact as well as having the ability to control the rate and the direction of pressure [12, 26, 27]. Fisher [26] established normative values for PPT over the upper trapezius, pectotalis major, levator scapulae, teres major, supraspinatus, gluteus medius, infraspinatus, middle deltoid, and paraspinals (L2 and L4) muscles. He measured all of the muscles bilaterally in order to verify whether PPT was reproducible. He concluded that PPT had excellent reproducibility and reliability, since identical results were obtained over muscles of opposite sides. Farella et al [12] found lower PPT in myofascial pain patients than in healthy controls, which supported the use of pressure algometry for the evaluation of muscle tenderness and pain intensity. Ohrbach et al [58] tested the validity and reliability of PPT in patients with myogeneous TMD and matched healthy controls. Their study showed strong validity and reliability of PPT measures, suggesting that PPT could be an important tool in clinical studies of muscle tenderness and pain intensity.

In several studies[14, 64, 65], the intratester repeatability of the PPT measurements has been proven to be satisfactory or good, presenting intraclass correlation coefficient (ICC) between 0.78 and 0.93, showing that PPT measures are highly reliable when measuring facial and cervical muscle tenderness. In addition, PPT measurements have been proven to achieve acceptable values of sensitivity (0.67-0.85) (i.e. the fraction of all those with the disease who will have a positive test result), and specificity (0.77-0.87) (i.e. the fraction of those without the disease that get a negative test result) [12]. Only one study was found that measured normal PPT value in the literature. Only one muscle (upper trapezius) from that study was tested in the present study. Fisher found the value for the upper trapezius in females to be a mean of 3.7 Kg/cm^2 with a SD of 1.9.

CHAPTER THREE: METHODS AND PROCEDURES

3.1 STUDY DESIGN

This was a cross-sectional study, since all subjects were tested only once in one diagnostic session of approximately 1.5 hours long [32]. Having one session eliminated the potential for subject drop out.

The main outcomes of this study were general pain sensitivity and muscle tenderness that were expressed quantitatively by the pain pressure threshold (PPT), which was characterized as the first reported pain with an increasing level of pressure [26, 27, 30, 31]. The manual algometer was used to measure the PPT, since it is a valid and reliable tool [12, 26, 27].

This design allowed the investigator to determine if the general pain sensitivity as well as the development of muscle tenderness were different for those patients with TMD as opposed to healthy subjects (i.e. those without TMD problems).

3.2 SUBJECT RECRUITMENT

TMD subjects were recruited from the TMD/Orofacial Pain Clinic at the University of Alberta and also using advertising on television as well as in different Faculties at the University of Alberta and surrounding area. The

TMD/Orofacial Pain Clinic is a teaching facility at the University of Alberta and its main objective is to diagnose and treat TMD patients using relevant, evidence-based information in order to promote optimal patient care. The TMD/Orofacial Pain Clinic is highly developed in pain research at the basic and clinical science levels which allows most patients with pain disorders to make substantial improvements in their pain relief and quality of life [66]. The main advantages of using patients from one facility were that criteria for diagnosis were standardized as well as the diagnosis was based on expert assessment. Moreover, these patients could be easily followed and relevant information could be readily obtained [32].

Age-matched healthy subjects were sought from across the University campus. The main advantage of this method was that it was easy to find subjects with the specific characteristics required for the study.

The subjects were informed about the nature of the study and an appointment was booked with the subjects who were willing to participate. Once the subjects agreed to participated, they were evaluated to determine whether they met the inclusion and were not excluded by the exclusion criteria. Subjects were also given an informed consent form to read, all the questions regarding the study were answered, and they were asked to sign the form if they were selected for the study, in accordance with the University of Alberta’s policies on research using human subjects.

3.3 STUDY PARTICIPANTS

Participants were subjects diagnosed with TMD with mainly muscle complaints (Myogeneous TMD) or mixed TMD (Myogeneous/Arthrogeneous TMD) and concurrent neck disability as well as healthy controls.

3.3.1 INCLUSION CRITERIA FOR TMD SUBJECTS

Patients with TMD were eligible if they met the following inclusion criteria:

1) Diagnosed by a trained physical therapist as having mainly myogeneous or mixed TMD, according to the Research Diagnostic Criteria for TMD (RDC/TMD) (Appendix 1)
2) Reported orofacial pain of at least 3 months duration and this pain could not be attributed to recent acute trauma, previous infection or an inflammatory cause;
3) Between 18-50 years old, in order to reduce the chance of degeneration factors that may have affected either the temporomandibular joint or the cervical spine, and could have affected the outcomes;
4) Females, since TMD affects more women than men. In addition, females tend to seek treatment for TMD more frequently, since they usually complain more about their pain [12, 13, 67-69];
5) Scored more than 4 points on the Neck Disability Index.

3.3.2 EXCLUSION CRITERIA FOR TMD SUBJECTS

The TMD subjects were excluded from the study if they had any of the following criteria:

1) Medical history of neurological, bone, systemic diseases or cancer;
2) Acute dental problems other than TMD;
3) History of trauma or surgery to the upper quarter within the last year
4) Neurological deficit;
5) Took any pain medication or muscle relaxants less than 4 hours before the diagnostic session.

3.3.3 INCLUSION AND EXCLUSION CRITERIA FOR THE HEALTHY CONTROL GROUP

In order to be included in the healthy control group, the following inclusion and exclusion criteria had to be met:

3.3.3.1 INCLUSION CRITERIA FOR HEALTHY CONTROL GROUP:

1) Females between the ages of 18 and 50 years;
2) Healthy subjects with no chronic pain or clinical pathology or previous surgery related to the masticatory system or cervical spine;
3) Scored less than 4 points on the Neck Disability Index.

3.3.3.2 EXCLUSION CRITERIA FOR HEALTHY CONTROL GROUP:

1) Neurological problems, or any acute or chronic injury, or systemic diseases that may interfere with the procedure and the outcomes;
2) Pain or symptom complaints in the masticatory system or cervical spine for at least one year before the beginning of the study;
3) Took any medication such as pain relieving drugs, muscle relaxants, anti-inflammatory.

The inclusion and exclusion criteria were consisted with previous TMD studies involving the measurement of the muscle tenderness and general pain sensitivity [1,2, 9, 15-18].

3.4 SAMPLE SIZE

Sample size calculation for this study was based on repeated measures analysis of variance with one dependent variable and 2 groups using the guidelines proposed by Stevens (using α= 0.05, β= 0.20, power = 80%, and an effect size, d=0.75) [70]. Approximately 34 subjects were needed per each group.

3.5 DATA COLLECTION

3.5.1 CLINICAL EXAMINATION

Initially, the purpose of the study was explained to the subjects by the researcher. The researcher also gave each subject an information letter (see Appendix 2) about the study. Following this, the subjects who agreed to participate were asked to sign a consent form (see Appendix 3) and were evaluated by a trained physical therapist. Based on the history of the subject as well as in the inclusion and exclusion criteria mentioned above, the subjects were allocated to one of the 2 groups (TMD with concurrent neck disability or healthy control group).

The Research Diagnostic Criteria for TMD (RDC/TMD) was used to discriminate subjects with TMD from controls. The Jaw Disability Index (Appendix 4) and the Neck Disability Index (Appendix 5) were used to evaluate the presence of jaw and neck disabilities in subjects participating in this study.

The measurements in this study were made by 3 different investigators in order to avoid rater bias. The first investigator evaluated and allocated each subject to one of the 2 above mentioned groups. The second and third investigators explained the study to the subject, obtained the subject's consent and measured bilaterally the PPT of the deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, and upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium) muscles as well as the general PPT of all subjects without knowing which group the subject was allocated to. Instructions regarding the blind aspect of the study were given to all subjects, since all the subjects were asked to not mention to the rater (second investigator) which group they belonged to. In order to ensure the reliability and validity of the measurements, three trained physical therapists collected the data.

The deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, and upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium) muscles were chosen based on previous studies that stated that patients with TMD tended to develop tenderness in these muscles[1,2]. Furthermore, these muscles were easy to evaluate because of their anatomic position, which avoided confusion with other anatomic structures such as joints, ligaments and other muscles.

3.5.2 DEMOGRAPHIC DATA COLLECTION

Demographic data such as age were collected in order to keep the groups as similar as possible, allowing a comparison of their data. Other demographic data such as ethnicity was also collected because it was part of the RDC/TMD tool. However, since most of the studies involving muscle tenderness in subjects with myogeneous or mixed TMD do not analyze ethnicity, it was decided to not include ethnicity in the analysis.

3.5.3 RESEARCH DIAGNOSTIC CRITERIA FOR TMD (RDC/TMD)

As mentioned previously, the RDC/TMD is a valid and reliable diagnostic method for classifying TMD subjects that is widely used around the world [5, 33]. In this study, the classification of the subjects were based on Axis I of the RDC/TMD, which provided a standardized method for evaluating the history of the patient, conducting the physical examination and generating a reliable diagnosis of the most frequent muscles that affected TMD's subjects with myogenenous or mixed TMD [5].

3.5.4 LIMITATIONS OF DAILY FUNCTIONS IN TMD QUESTIONNAIRE – JAW DYSFUNCTION INDEX

This Jaw Dysfunction Index (JDI) was used to measure the jaw function of all the subjects in this study. The JDI is multidimensional and includes specific evaluations for TMD patients [115]. The JDI consists of 10 items and 3 factors and these factors are extracted by exploratory factor analysis. The first factor is named "limitation in executing a certain task" and is composed of five items including several problems in daily physical and psychosocial activities; the second factor is called "limitation of mouth opening" which is composed of three items, and the third factor, "limitation of sleeping" is composed of two items. The internal consistency of the questionnaire was calculated using Cronbach alpha which was 0.78 for the 10 items, 0.72 for "limitation in executing a certain task", 0.73 for “limitation of mouth opening”, and 0.77 for “limitation of sleeping”, indicating good consistency. The JDI was tested for concurrent validity with the dental version of the McGill Pain Questionnaire and the authors found correlations ranged between 0.49-0.54 [115].

Each item was evaluated using a five-point numeric rating scale graded from 1 (no problem) to 5 (extremely difficult). The subject was asked to choose one of the five ratings on the scale in response to the following question: “How much does your present jaw problem prevent or limit your daily functions?”. The results of the questionnaire established the level of the jaw dysfunction in the subjects.

3.5.5 NECK DISABILITY INDEX

The Neck Disability Index (NDI) is a questionnaire designed to give information about how neck pain affects the ability of the subject to manage her everyday life [20, 71-74]. The NDI includes 10 items - 7 items are associated with activities of daily living, 2 are linked to pain, and 1 is related to concentration [71, 73]. Each item is scored from 0 (no pain or disability) to 5 (severe pain and disability), and the total score is expressed as a percentage (total possible score = 100%), with higher scores corresponding to greater disability [71, 73]. Depending on the score, the patient was classified as having neck disability or not (0-4 = no disability; 5-14 mild disability; 15-24 = moderate disability; 25-34 = severe disability; >35 = complete disability) [20]. This NDI has proven to be valid and reliable in measuring neck disability, allowing its use as a guide for clinical-decision making [72-74]. The test-retest reliability of the NDI was calculated using an intraclass correlation coefficient (ICC) (NDI ICC=.50; 95% confidence interval [CI], 0.25-0.67) [2]. The concurrent validity of the NDI was tested comparing it with the SF-36 questionnaire using Pearson correlations [72-74]. Correlations between each item of the NDI scores and the total NDI score ranged from 0.447 to 0.659 ($P < 0.001$) [72-74]. Cronbach's alpha for the NDI scale was tested and achieved acceptable outcomes (0.864, 95% confidence limits 0.825-0.894), showing its internal consistency [72-74]. Therefore, this index was used as a tool to discriminate the subjects of this study. The subjects who scored less than 4 points in this NDI and not diagnosed with TMD were considered as having no neck disability and they were allocated in the healthy control group. The subjects who scored more than 4 points in this tool as well as were classified as having myogeneous or mixed TMD were allocated in the TMD and concurrent neck disability group.

3.5.6 GENERAL PAIN SENSITIVITY

The Pain Pressure Threshold (PPT) is a valid and reliable measure for detecting muscle tenderness among patients with chronic pain problems [11-14, 75, 76]. In both groups (TMD and concurrent neck disability and healthy controls), a calibrated manual pressure algometer (Appendix 6) was used to measure the general pain sensibility of the subjects of this study. 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”, the algometer was immediately removed and the PPT noted [11].

Before the test procedure was performed, the procedure was demonstrated on the investigator’s hand and a practice trial was performed on the subject’s right hand (hypothenar region) [11]. The algometer was held perpendicular to the hypothenar region of the left hand and the PPTs were measured. This procedure was repeated 3 times at the site, using a pressure rate of 1 Kg/sec with 30s rest intervals [3, 77]. Using the same procedure for all subjects, pressure was applied until the subject said “yes”, indicating that the sensation of pressure started to become painful. At this moment, the pressure was stopped and the algometer was removed, indicating her PPT [78]. The muscles were tested in a randomized order. Since the first PPT of a session is usually higher than consecutive measurements, it was discarded and the mean of the other two PPT measurements was considered to be the general pain pressure threshold of the subjects [3].

The hypothenar region was chose to measure the general pain sensibility of the patient based on previous studies that stated that this is a reliable and valid region to detect the overall PPT of a subject [3].

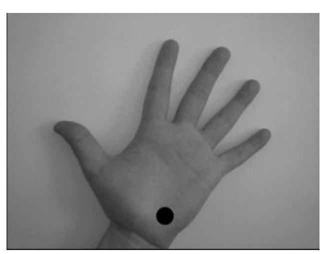

Figure 1 – Hypothenar region of left hand on which algometer will be applied (*black circle*) [3].

3.5.7 MUSCLE TENDERNESS MEASUREMENT

In both groups (TMD and concurrent neck disability; and healthy controls), a calibrated manual pressure algometer was used to measure the PPT of the masseter, temporalis, sternocleidomastoid, and upper trapezius muscles on both sides in a relaxed posture [12]. When taking the measurements, the algometer was held perpendicular to the skin.

The deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, and upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium) muscles sites were marked as showed in Figure 2, and the PPTs were then measured 3 times at each site, with 30 second intervals with an applied pressure rate of 1 Kg/sec for the sternocleidomastoid, upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium) and an applied pressure rate of 0.5 Kg/sec for the deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, and posterior temporalis [3]. Pressure rates were decided based on previously studies that showed the most reliable rates to use on cervical and facial muscles [13, 64, 79, 80]. The algometer was removed when subject said “yes”, indicating her PPT [78]. Since the first PPT of a session is usually higher than consecutive measurements, it was discarded and the mean of the other two PPT measurements were considered [12].

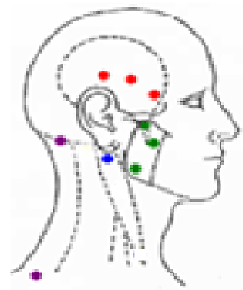

Figure 2 – PPTs points to be evaluated (• = points of temporalis muscle, • = points of the masseter muscle, • = points of the sternocleidomastoid muscle, • = points of the upper trapezius muscle)

3.5.8 GENERAL EXPERIMENTAL PROCEDURE SEQUENCE

1) Subjects were invited to participated of the study, and the ones who agreed and met the criteria to participate were asked to sign a consent form;
2) Subjects were evaluated by a trained physical therapist to determine if they met the inclusion criteria or were excluded by the exclusion criteria for this study;
3) The JDI was administred to measure the jaw dysfunction of the subjects in this study;
4) The PPT of the hypothenar region of the left hand was measured in all subjects of both groups in order to detect the general pain sensitivity;
5) The PPT of the deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, and upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium) muscles were measured in

both sides to detect the level of muscle tenderness of all subjects of both groups;

6) Data analysis was performed.

3.6 DATA ANALYSIS

The muscle tenderness data for all analyzed muscles, jaw dysfunction index, neck dysfunction index as well as general pain sensitivity values for both groups (TMD and concurrent neck disability, and healthy controls) were analyzed descriptively (i.e. mean, standard deviation).

The paired T-test uses t-statistic to establish whether two means collected from the same sample differ significantly [81]. Therefore, a paired T-test was performed in this study to verify whether there were any differences between right and left sides in each pair of muscles (deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium)). Since significant differences were found between right and left sides in the two pairs of the muscles (i.e. deep masseter and upper trapezius (occipital region), sides were included in all further analysis.

The analyses of variance (ANOVA), three-way classification is a multifactor analysis that can be performed with any number of independent variables. In this study, a three–way mixed design ANOVA with repeated measures (3 independent variables: **muscles** (deep masseter, anterior masseter, inferior masseter, anterior temporalis, medial temporalis, posterior temporalis, sternocleidomastoid, upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium)), **sides** (right and left) and **groups** (TMD with concurrent neck disability; and healthy controls) test was used to evaluate the differences in muscle tenderness (dependent variable) as evaluated by pressure pain thresholds for all selected muscles. Also, a pairwise comparison (post hoc test) was used to determine the exactly muscles that were statistically different between TMD with concurrent neck disability group and healthy controls.

The one way ANOVA classification is commonly used when three or more independent group means are compared [32, 82], but a One-Way ANOVA can also be applied to two-group comparisons[32, 82].Hence, a one way ANOVA with repeated measures was used in this study to determine if the groups were significantly different statistically in terms of general pain sensitivity. Also, a pairwise comparison (post hoc test) was used to determine if the general pain sensitivity of the TMD and concurrent neck disability group was bigger or lower than healthy controls.

According to Field [81], finding statistical significant test results do not necessarily mean finding meaningful or important effects. Measuring the size of an effect (effect size) is an objective and standardized way to analyze the magnitude of the observed effect [81]. “Effect size index is a ratio of the mean score divided by the standard deviation of the baseline scores” (p. 648) [81].Therefore, the effect sizes of the objectives 1 and 2 of this study were calculated. The interpretation of the effect sizes of this study was based on Cohen’s theory that an effect size of 0.2 or less represents a small change, 0.5 means a moderate change and 0.8 or larger shows a large change [82].

Spearman rho is a nonparametric test used to assess the correlation between two variables [81, 82]. In this study, Spearman's rho was employed to determine whether the level of muscle tenderness of the analyzed muscles (i.e. sternocleidomastoids, upper trapezius, masseters and temporalis) for subjects having TMD with concurrent neck disability group was related to the level of jaw dysfunction or neck dysfunction. In order to calculate the Spearman rho correlation, the bilateral (right and left) composite means of the temporalis (anterior temporalis + medium temporalis + posterior temporalis), masseter (deep masseter + anterior masseter + inferior masseter), sternocleidomastoids, and upper trapezius (occipital region + half way between C7 and acromium) were calculated. The Spearman rho was also used to determine whether there was a correlation between general pain sensitivity and jaw dysfunction or neck disability as well as whether there was a correlation between the neck disability and jaw dysfunction.

Level of significance for all statistical analyses was set at $\alpha = 0.05$. The SPSS۞ (SPSS Inc, Chicago), Statistical Program version 18.0 (Statistical Package for the Social Sciences) was used to perform the statistical analysis.

CHAPTER FOUR: RESULTS

The present study investigated the differences in muscle tenderness of cervical (i.e. sternocleidomastoid and upper trapezius) and masticatory muscles (i.e. masseter and temporalis) and general pain sensitivity (evaluated through the pain pressure threshold (PPT)) between subjects having TMD with concurrent neck disability and healthy controls. The study also analyzed the correlation between general pain sensitivity and jaw dysfunction; general pain sensitivity and neck disability; and neck disability and jaw dysfunction.

4.1 SUBJECT CHARATERISTICS

A total of 56 females subjects were assessed for inclusion in this study. A total of 16 people were excluded from the study for the following reasons: 2 subjects presented with TMD but no neck disability; 5 subjects presented with only arthrogenic TMD; 4 subjects presented with only neck disability and no TMD; 3 subjects could not be classified as having TMD as well as they could not be considered completely healthy; 1 subject had been diagnosed with fibromyalgia; and 1 subject had taken pain medication before the trial. Therefore, forty (40) female’s subjects were included in the study. Twenty subjects (20) were classified as having TMD with concurrent neck disability and twenty (20) were considered healthy controls. The general demographics of each group are shown in Table 1. An independent t-test showed that there were no significant differences between study groups for age. Mean age was 31.05 (S.D. ± 6.901) for TMD and concurrent neck disability group and 32.30 (S.D. ± 7.168) for healthy control group, $t_{df=38}$ =-0.562, p=0.578. The scores for Neck Disability Index (NDI) and Jaw Disability Index (JDI) are shown in Table 1. The TMD with concurrent neck disability group had significantly higher disability scores for NDI and JDI when compared with the healthy control group ($p<0.05$).

Table 1 – Means of Age, Neck Disability Index and Jaw Disability Index for Subjects with Temporomandibular Disorders and Concurrent Neck Disability, and Healthy controls

Variable	Group	Mean	SD
Age (years)	*TMD with Concurrent Neck Disability*	31.05	6.901
	Healthy Controls	32.3	7.168
Neck Disability Index (0-50)	TMD with Concurrent Neck Disability	13.05*	6.985
	Healthy Controls	2.05	1.276
Jaw Disability Index (10-50 points)	TMD with Concurrent Neck Disability	24.55*	10.865
	Healthy Controls	10.35	0.988

* Significant at α=0.05

4.2 COMPARISON OF MUSCLE TENDERNESS BETWEEN SUBJECTS WITH TMD AND CONCURRENT NECK DISABILITY AND HEALTHY CONTROLS SUBJECTS

The mean PPT values of patients having TMD with concurrent neck disability and healthy control subjects are presented on Table 2.

Table 2 – Descriptive Statistics – Mean Pain Pressures Threshold Values of Neck and Masticatory Muscles in Subjects having Temporomandibular Disorders with Concurrent Neck Disability and Healthy Controls

	Mean and SD for TMD with Concurrent Neck Disability (Right Side)	Mean and SD for Healthy Controls (Right Side)	Mean and SD for TMD with Concurrent Neck Disability (Left Side)	Mean and SD for Healthy Controls (Left Side)
Deep Masseter	2.37 (SD = 0.65)	3.03 (SD= 0.93)	2.03 (SD= 0.62)	2.72 (SD= 0.67)
Anterior Masseter	1.92 (SD= 0.47)	2.45 (SD= 0.65)	1.9 (SD= 0.61)	2.54 (SD= 0.57)
Inferior Masseter	1.81 (SD= 0.71)	2.2 (SD= 0.64)	1.75 (SD= 0.59)	2.38 (SD= 0.60)
Anterior Temporalis	2.41 (SD= 0.70)	3.09 (SD= 0.78)	2.34 (SD= 0.64)	3.07 (SD= 0.70)
Middle Temporalis	2.42 (SD= 0.71)	3.22 (SD= 0.69)	2.33 (SD= 0.65)	3.35 (SD= 1.00)
Posterior Temporalis	2.6 (SD= 0.72)	3.46 (SD= 0.93)	2.68 (SD= 1.01)	3.78 (SD= 1.06)
Sternocleidomastoid	2.26 (SD= 0.75)	2.7 (SD= 0.92)	2.15 (SD= 0.50)	2.66 (SD= 0.72)
Upper Trapezius (occipital region)	3.1 (SD= 0.74)	3.88 (SD= 1.23)	2.8 (SD= 0.80)	3.82 (SD= 1.20)
Upper Trapezius (half way between C7 and acromium)	3.82 (SD= 1.19)	4.61 (SD= 1.15)	3.7 (SD= 1.21)	4.88 (SD= 1.31)

A paired t-test, used to analyze differences between right and left sides among the tested muscles (i.e. deep masseter, anterior masseter, inferior masseter, anterior temporalis, middle temporalis, posterior temporalis, sternocleidomastoid, upper trapezius (occipital region) and upper trapezius (half way between C7 and acromium)) demonstrated that only deep masseter ($p= 0.000$) and upper trapezius (occipital region) ($p=0.013$) had statistically significant differences between sides as shown in Table 3. Since statistical differences were found between these two muscles pairs, it was decided to include right and left sides in all further analyzes.

Table 3 – PPT Mean Differences between Right and Left Sides for Each Pair of Muscle

Paired Samples Test										
		Paired Differences					t	df	Stat. Sig. (2-tailed)
		Mean Difference	SD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	**Right Deep Masseter – Left Deep Masseter**	0.33	0.39	0.06	0.2	0.45	5.27	39	0.000*
Pair 2	**Right Anterior Masseter – Left Anterior Masseter**	-0.04	0.3	0.04784	-0.13177	0.06177	-0.732	39	0.469
Pair 3	**Right Inferior Masseter – Left Inferior Masseter**	-0.06125	0.44943	0.07106	-0.20498	0.08248	-0.862	39	0.394
Pair 4	**Right Sternocleidomastoid – Left Sternocleidomastoid**	0.07375	0.44664	0.07062	-0.06909	0.21659	1.044	39	0.303
Pair 5	**Right Upper Trapezius (occipital region) – Left Upper Trapezius (occipital region)**	0.17875	0.43218	0.06833	0.04053	0.31697	2.616	39	0.013*
Pair 6	**Right Upper Trapezius (half way between C7 and Acromium) – Left Upper Trapezius (half way between C7 and Acromium)**	-0.08075	0.82476	0.13041	-0.34452	0.18302	-0.619	39	0.539
Pair 7	**Right Anterior Temporalis – Left Anterior Temporalis**	0.04375	0.48809	0.07717	-0.11235	0.19985	0.567	39	0.574
Pair 8	**Right Medium Temporalis – Left Medium Temporalis**	-0.0225	0.53946	0.0853	-0.19503	0.15003	-0.264	39	0.793
Pair 9	**Right Posterior Temporalis – Left Posterior Temporalis**	-0.19875	0.67154	0.10618	-0.41352	0.01602	-1.872	39	0.069

* Significant at α=0.05

A three-way ANOVA with repeated measures analysis demonstrated that there were significant differences in muscle tenderness (using the evaluation of the pain pressure thresholds (PPT)) among muscles (F=98.832, p=0.000). Also, there were significant interactions between muscles and groups (F=2.171, p=0.030), sides and groups (F=6.396, p=0.016), and muscles and sides (F=3.768, p=0.00). The pair wise comparisons using Bonferroni test determined that the PPTs of the TMD with concurrent neck disability group were significantly lower statistically at almost all sites tested when compared with the healthy control group as showed on Table 4. The only sites that did not show statistically significant differences were right inferior masseter (p=0.071; S.D.= 0.214) and right sternocleidomastoid (p=0.107 and S.D.= 0.267). Although these two sites did not achieve statistical significance, their p values were close to reaching statistical significance.

The clinical significance evaluation of the results based on the calculated effect sizes showed that the effect sizes obtained from these comparisons were moderate to high, meaning that the differences among sites reached clinical significance as well as showed on Table 4.

Table 4 – Pairwise Comparisons of Pain Pressure Thresholds between subjects with Temporomandibular Disorders and Concurrent Neck Disability Group. and a Healthy Control Group

Side	Muscles	Healthy Controls Group	TMD with concurrent neck disability Group	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference		Effect Size
							Lower Bound	Upper Bound	
RIGHT	Deep Masseter	Healthy Controls	TMD with concurrent neck disability	0.655*	0.253	0.013*	0.144	1.166	0.8
	Anterior Masseter	Healthy Controls	TMD with concurrent neck disability	0.530*	0.179	0.005*	0.168	0.892	0.92
	Inferior Masseter	Healthy Controls	TMD with concurrent neck disability	0.397	0.214	0.071	-0.036	0.831	0.57
									Continued
	Anterior Temporalis	Healthy Controls	TMD with concurrent neck disability	0.673*	0.233	0.006*	0.2	1.145	0.9

	Middle Temporalis	Healthy Controls	TMD with concurrent neck disability	0.805*	0.222	0.001*	0.356	1.254	1.12
	Posterior Temporalis	Healthy Controls	TMD with concurrent neck disability	0.860*	0.264	0.002*	0.325	1.395	1.01
	Sternocleidomastoid	Healthy Controls	TMD with concurrent neck disability	0.44	0.267	0.107	-0.1	0.98	0.48
	Upper Trapezius (occipital region)	Healthy Controls	TMD with concurrent neck disability	0.788*	0.321	0.019*	0.138	1.437	0.75
	Upper Trapezius (middle way between C7 and acromium)	Healthy Controls	TMD with concurrent neck disability	0.788*	0.37	0.04*	0.039	1.536	0.66
LEFT	**Deep Masseter**	Healthy Controls	TMD with concurrent neck disability	0.685*	0.204	0.002*	0.273	1.097	1.05
	Anterior Masseter	Healthy Controls	TMD with concurrent neck disability	0.640*	0.186	0.001*	0.264	1.016	1.06
	Inferior Masseter	Healthy Controls	TMD with concurrent neck disability	0.625*	0.188	0.002*	0.244	1.006	1.04
	Anterior Temporalis	Healthy Controls	TMD with concurrent neck disability	0.735*	0.212	0.001*	0.305	1.165	1.06
	Middle Temporalis	Healthy Controls	TMD with concurrent neck disability	1.020*	0.267	0.00*	0.48	1.56	1.19
	Posterior Temporalis	Healthy Controls	TMD with concurrent neck disability	1.097*	0.327	0.002*	0.435	1.76	1.04
	Sternocleidomastoid	Healthy Controls	TMD with concurrent neck disability	0.508*	0.195	0.013*	0.112	0.903	0.81
	Upper Trapezius (occipital region)	Healthy Controls	TMD with concurrent neck disability	1.020*	0.322	0.003*	0.368	1.672	0.98
	Upper Trapezius (middle way between C7 and acromium)	Healthy Controls	TMD with concurrent neck disability	1.179*	0.399	0.005*	0.371	1.987	0.92

*. The mean difference was significant at the 0.05 level

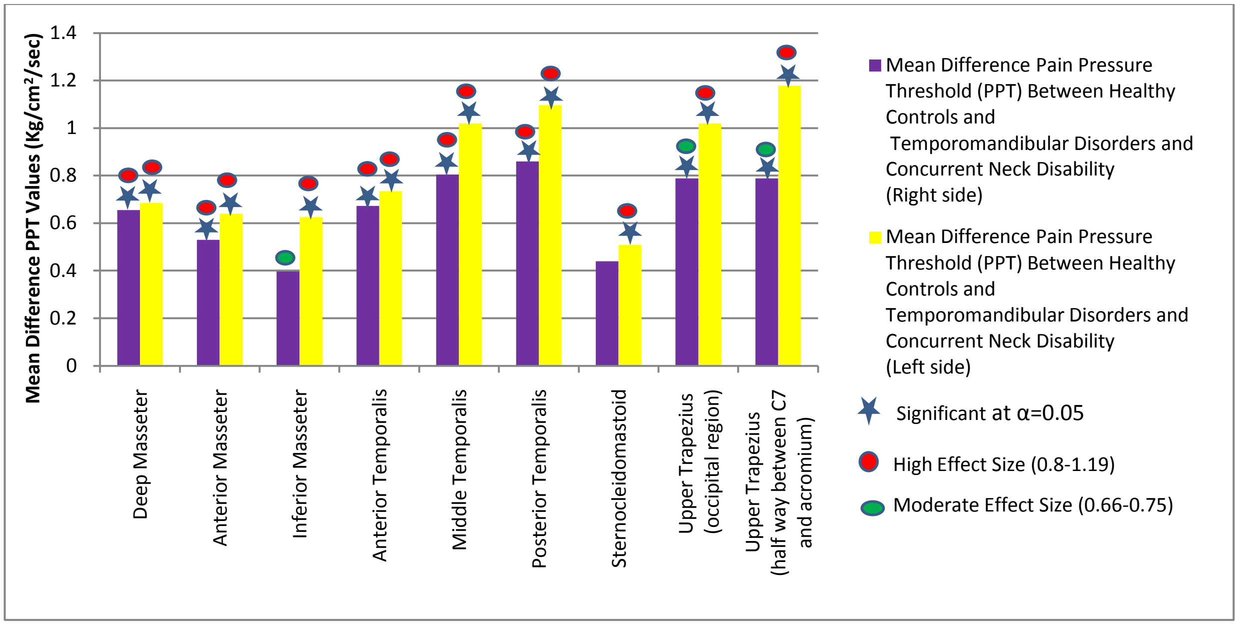

Figure 4 – Mean Difference Between Subjects with Temporomandibular Disorders and Concurrent Neck Disability Group and Healthy Control Group (Right and Left Sides)

4.3 COMPARISON OF GENERAL PAIN SENSITIVITY BETWEEN SUBJECTS WITH TMD AND CONCURRENT NECK DISABILITY, AND HEALTHY CONTROL SUBJECTS

The general pain sensitivity (evaluated by the pain pressure threshold in the hypotenar region of the left hand) mean values for subjects with TMD and concurrent neck disability and healthy subjects are shown on Figure 5. A one way ANOVA determined that there were statistically significant differences in general pain sensitivity between the two groups ($F=4.546$, $df=1$, $p=0.04$). A pairwise comparison using Bonferroni test determined that the general pain sensitivity (measured through the evaluation of the pain pressure threshold in the left hand) of the subjects having TMD with concurrent neck disability were significantly lower than those of the healthy control group, mean difference= 1.042 kg/cm^2/sec, p=0.04 and S.D. = 0.489. In addition, the calculated effect size was 0.67, indicating a clinically significant finding (Table 5).

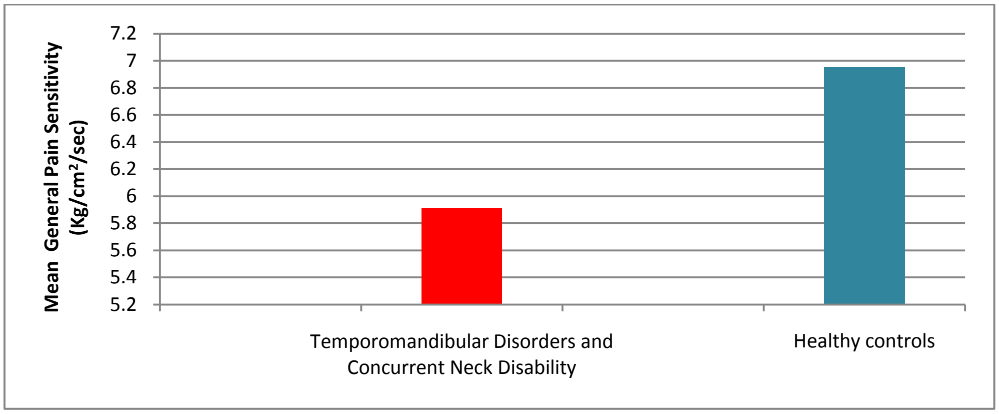

Figure 5 – Mean General Pain Sensitivity (Pain Pressure Threshold from Left Hand)of Subjects with Temporomandibular Disorders and Concurrent Neck Disability and Healthy Controls

Table 5 – Pairwise Comparisons of General Pain Sensitivity (Pain Pressure Threshold at left hand) between Temporomandibular Disorders with Concurrent Neck Disability and Healthy Controls

Healthy Controls Group	TMD with Concurrent Neck Disability Group	Mean Difference	SD	Sig.	95% Confidence Interval for Difference		Effect Size
					Lower Boundary	Upper Boundary	
Healthy Controls	*TMD with Concurrent Neck Disability*	1.042*	0.489	0.04	0.053	2.032	0.67

*. The mean difference is significant at the 0.05 level.

4.4 CORRELATION BETWEEN LEVEL OF MUSCLE TENDERNESS WITH JAW DYSFUNCTION AND NECK DISABILITY

The correlations (Spearman’s rho) between level of muscle tenderness (measured by the PPT of composite means of sternocleidomastoid, upper trapezius, masseter and temporalis muscles) and jaw dysfunction as well as between level of muscle tenderness and neck disability ranged from low to medium values. Spearman's rho ranged from 0.387 to 0.647 for muscle tenderness and jaw dysfunction and Spearman's rho ranged from 0.319 to 0.554 for muscle tenderness and neck disability (Table 6).

Table 6 – Correlation between level of muscle tenderness and Jaw Dysfunction Index (JDI)

	Side	Muscle	Jaw Disability Index	Neck Disability Index
Spearman's rho	Right	Temporalis	-0.585	-0.517
		Masseter	-0.512	-0.443
		Sternocleidomastoid	-0.387	-0.319
		Upper Trapezius	-0.408	-0.352
	Left	Temporalis	-0.646	-0.554
		Masseter	-0.595	-0.48
		Sternocleidomastoid	-0.426	-0.374
		Upper Trapezius	-0.647	-0.518

4.5 CORRELATION BETWEEN GENERAL PAIN SENSITIVITY WITH JAW DYSFUNCTION AND NECK DISABILITY:

The correlations (Spearman’s rho) between general pain sensitivity (measurement of the PPT of the left hand) and jaw dysfunction as well as between general pain sensitivity and neck disability were fair. Spearman's rho= - 0.485; (p= 0.002) for general pain sensitivity and jaw dysfunction and Spearman's rho= -

0.436; (p= 0.005) for general pain sensitivity and neck disability. (Figures 6 and 7)

The presence of one outlier is seen in figure 6. A subject shows high levels of jaw dysfunction as well as high levels of general pain sensitivity. Although this is an extreme score, the sample of this study was too small to generate a full range of observations, making further assumptions beyond the scope of this analysis.

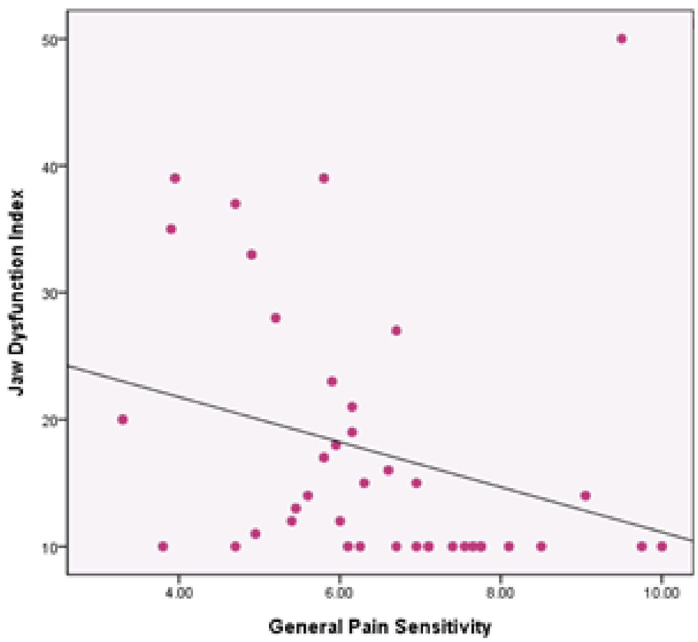

Figure 6 – Correlation between general pain sensitivity (left hand) and Jaw Dysfunction Index (JDI) in patients with TMD and Neck Disability, and Healthy Controls

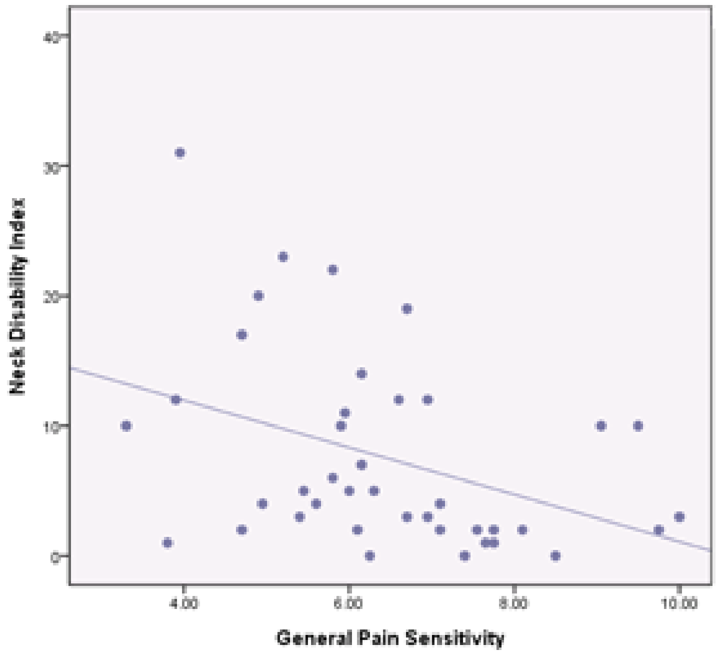

Figure 7 – Correlation between general pain sensitivity (left hand) and Neck Disability Index (NDI) in patients with TMD and Neck Disability, and Healthy Controls

4.6 CORRELATION BETWEEN NECK DISABILITY AND JAW DYSFUNCTION:

It was found that the correlation (Spearman's rho) between jaw disability and neck disability was significantly high (r=0.915, p=0.000). Subjects who had no or low levels of jaw disability (evaluated through the JDI), also presented with no or low levels of neck disability (evaluated through the NDI) in this sample and vice-versa (Figure 8).

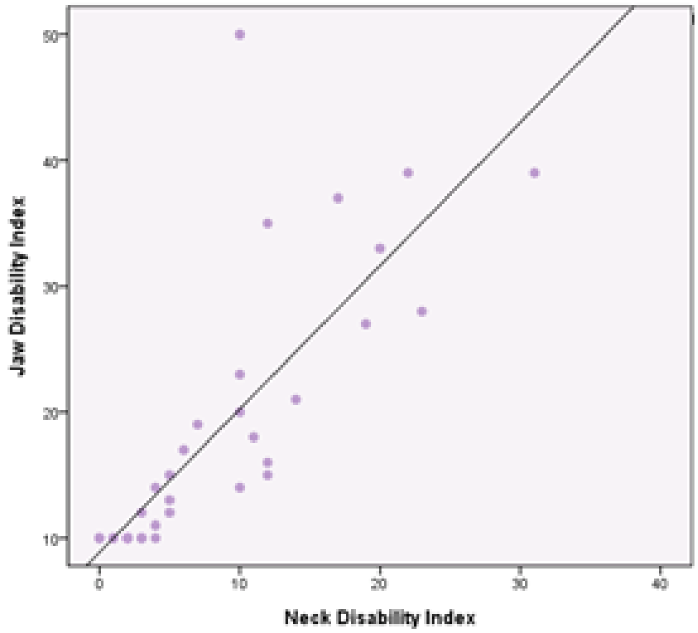

Figure 8 – Correlation between Jaw Disability Index and Neck Disability Index in patients with TMD and Neck Disability, and Healthy Controls

CHAPTER FIVE: DISCUSSION

This study investigated whether TMD were associated with a decreased masticatory and cervical muscle tenderness as well as a generalized pain sensitivity. In addition, this study looked at the following correlations: 1) between levels of muscle tenderness of the masticatory and cervical muscles using the Jaw Dysfunction Index and Neck Disability Index; 2) between general pain sensitivity and jaw dysfunction of all subjects; 3) between general pain sensitivity and neck disability; and 4) between neck disability and jaw dysfunction.

5.1 COMPARISON OF GENERAL PAIN SENSITIVITY BETWEEN SUBJECTS WITH TMD AND CONCURRENT NECK DISABILITY, AND HEALTHY CONTROLS SUBJECTS

The present study showed that general pain sensitivity (measured through the evaluation of the pain pressure threshold in the left hand) of the subjects with TMD and concurrent neck disability were significantly higher than those of the healthy control group, confirming hypotheses 1 of the present study. 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 [102]. Lower general pain sensitivity in patients having TMD with concurrent neck disability show that these patients had a tendency to be more sensitivity to pain even in parts of the body other than the jaw or neck. Other studies [1, 3, 17, 52, 103, 104] have also found that chronic pain patients have a tendency to have decreased general pain sensitivity when compared with healthy controls, which is in accordance with the results of this study. In a scientific review of the literature, Sarlani et al. [104] found that four out of seven studies using pain pressure to investigate generalized hyperalgesia in TMD patients showed greater sensitivity in the patient group when compared to healthy controls which is also in agreement with our findings. They found one study showing lower PPT and tolerance in TMD patients, but the result did not reach statistical significance. Sarlani et al [104] attributed this to small sample sizes. However, in contrast to all of the findings of this systematic review and our own findings, two studies found in the systematic review did not find any difference in PPT between TMD patients and healthy controls [104]. One possible explanation for this discrepancy is the fact that these two studies excluded patients with arthralgia [104]. In the present study, patients with myogenous TMD as well as mixed TMD (patients could have arthralgia on top of myalgic pain) were included. Sometimes, slight changes in the population and methodology used in a study could lead to different results as well. Another study by Mohn et al [51] also did not find differences in pain sensitivity at baseline between TMD patients and healthy controls, which also contrasts with the results of the present study. One possible explanation for this could be the fact that Mohn et al [51] did not record whether medication was used by the subjects of their study. Frequently, chronic pain patients make use of pain medication which could decrease their sensitivity to pain when evaluated.

Investigating generalized pain sensitivity in patients with chronic TMD has important implications for the mechanisms underlying TMD [104]. As explained earlier in this discussion, there is evidence that greater pain sensitivity in patients with TMD might be attributed to the hyperexcitability of the peripheral and central nervous system. There are studies showing that patients suffering from TMD present a widespread decrease in pain pressure threshold, not only at the facial level but also in other areas such as the neck, shoulders and lower back [17, 52, 53]. Recently, Younger et al. [101] found morphological abnormalities in the brains of patients with TMD. They found abnormalities in the early trigeminal system that could be a sign of spinal and/or peripheral nervous system dysfunction in patients with chronic TMD [101]. VP thalamus abnormalities were also found in patients with TMD, suggesting enhanced facilitation of trigeminal sensory messages (central sensitization) [101]. Finally, they also found limbic system abnormalities in patients with TMD, which shows a possible interplay of psychological and physiological systems in subjects with TMD [101].

5.2 COMPARISON OF MUSCLE TENDERNESS BETWEEN SUBJECTS WITH TMD AND CONCURRENT NECK DISABILITY AND HEALTHY CONTROLS SUBJECTS

Significant differences (statistically and clinically) in masticatory and/or cervical muscle tenderness were found between subjects having TMD with concurrent neck disability and healthy controls, confirming hypotheses 2 of this study. Subjects having TMD with concurrent neck disability showed a significantly lower pain pressure threshold (PPT) at almost all masticatory and cervical sites tested when compared with healthy controls. However, the right inferior masseter (p=0.071) and the right sternocleidomastoid (p = 0.107) did not show statistically significant differences, although the inferior masseter p-value was close to reaching statistical significance. As said by Sterne [117],"a p- value around 0.05 might lead to neither belief nor disbelief in the null hypothesis (groups are equal)" (p.226). In fact, a p-value of 0.071 could indicate some evidence (against the null hypothesis) since the smaller the p-value, the stronger the evidence against the null hypothesis [117].Therefore, when considering the p-value obtained in this comparison, there is some evidence against the null hypothesis**.** Since the sample size of this study was small (20 subjects per group instead of the pre-calculated 34), the ability to find true differences between groups was compromised [81]. Moreover, there was a slightly greater variability in this point. Therefore, it is believed that with a bigger sample size the right inferior masseter site could have achieved statistical significance difference. Interestingly, in our study, smaller PPTs as well as high effect sizes were found not only for the masticatory muscles as expected, but also for the cervical muscles such as left sternocleidomastoid and left upper trapezius. Moreover, moderate effect sizes were found for the remaining cervical sites (i.e. right sternocleidomastoid and right upper trapezius). To the best of our knowledge, this is the first study that investigated PPT not only in the facial region but also in the neck area of subjects suffering with TMD (myogeneous and mixed), providing more evidence that patients with TMD presented muscle tenderness in both areas. Although all of the subjects in the TMD group showed concurrent neck disability, the main complaint of all patients was jaw pain and it was the main reason for seeking treatment. Neck pain was secondary for this population. The results showed that the level of jaw disability (mean= 24.55) was significantly higher than the level of neck disability (mean= 13.05) at $p<0.05$. Furthermore, after one year of data collection, only two participants were enrolled who had muscular or mixed TMD with no neck disability. The **s**mall proportion of patients with isolated TMD has also been reported by a previous study [83]. In addition, Stiesch-Scholz et al. [15] found that asymptomatic functional disorders of the cervical spine occurred more frequently in patients with internal derangement of the TMJ than in a control group. Thus, cervical spinal disorders (CSD) could be present in the TMD population even if they are not symptomatic. These findings suggest that neck muscles can be dysfunctional in subjects with temporomandibular disorders and are in accordance with other studies investigating the association between jaw pain and cervical muscles, including the findings of our study [8, 15, 22, 54, 84, 85].

Studies have also shown that TMD and neck disability might be related [56, 84, 86-91, 118]. For example, Pogrel et al. [84] showed an increase in termographic asymmetry in the upper back and neck of the TMD subjects when compared to healthy controls. They also demonstrated that the trapezius muscle had an increased temperature on the symptomatic side in the TMD subjects, and this difference was both statistically and clinical significant. De Laat et al. [56], also found that 23-67% of the patients with TMD also had neck muscle tenderness of the sternocleidomastoid and upper trapezius as well as other cervical and shoulder muscles on palpation, which was only rarely present in the control group. Both studies showed the involvement of the trapezius and sternocleidomastoid in patients suffering with TMD which is in accordance with our findings. In addition, recent evidence regarding the muscular impairments of subjects with TMD when compared with healthy subjects indicated that subjects with TMD have a reduced endurance of the cervical flexor and extensor muscles which was demonstrated by an increased activity of the superficial muscles of the neck [88-91]. These endurance impairments could make the necks of subjects with TMD more vulnerable to pain, since muscles in this region cannot meet the endurance demands imposed on the neck. Since cervical spine and orofacial region are interconnected, [86, 87, 118] these impairments could be involved in maintaining the cervical spinal dysfunction seen in patients with TMD [92]. Therefore, physical therapists who work with patients with TMD might be able to identify and treat these impairments sooner and in order to decrease the vulnerability of the cervical spine, help to improve functioning of the craniocervical system in subjects with TMD and subsequently to reduce painful inputs to the trigeminocervical nucleus [90].

The results of the present study are in accordance with other studies [12, 13, 53, 58, 68, 79, 80, 93] that also showed that pain pressure thresholds in the masticatory muscles are smaller in TMD subjects when compared with healthy controls. Only one study [95] did not find differences in terms of pain sensitivity in the masticatory muscles between TMD and healthy subjects, which is contradictory with our findings. However, this conflicting result might be attributing to the fact that they measured pain sensitivity using heat and ischemic stimulus (using a tourniquet) instead of pain pressure as used in this study. In the human body, there are different sensory receptors such as: mechanoceptors (i.e. detects mechanical deformation), thermoceptors (i.e. detect changes in temperature), nociceptors (i.e. detects pain), electromagnetic receptors (i.e. detect light on the retina of the eye), and chemoreceptors (i.e. detect factors that make up the chemistry of the body) [96]. "Each type of sensory receptor is very highly sensitive to the one type of stimulus for which it is designed and yet is almost nonresponsive to normal intensities of the other types of sensory stimulus" (p.376) [96]. Therefore, the use of heat and tourniquets stimulates different sensory receptors (thermoreceptor and mechanoceptors respectively) when compared to pressure pain stimulus (nociceptors), and the stimuli are interpreted differently at the central nervous system [96]. 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 [95].

The connection between jaw and cervical regions in terms of muscle tenderness might be explained by anatomic, biomechanical and neurologic connections between these two areas. Under normal circumstances, a synergistic connection between neck muscles and muscles of mastication occurs, for example, in activities such as chewing, talking and yawning [97]. According to a critical review [98], several studies have been conducted showing a connection between cervical spine and stomatognathic system. According to this review, most of the studies had limited quality and methodology [98]. However, most of these studies agreed that there was a complex biomechanical interaction between the cervical spine movements and head and jaw position [98]. Also, Zafar [99] showed that jaw opening and closing movements are always paralleled by concomitant head and neck movements, since extension of the neck occurred during jaw opening and flexion of the neck happened during jaw closing in his study. Moreover, Stiesch-Scholz at al. [15] found a significant restriction in the lateroflexion, extension and rotation of the neck in patients who had internal derangements of the temporomandibular joint but without concurrent neck disability.

Neurophysiological and structural convergence of the trigeminal spinal tract and nucleus into the upper cervical segments is another origin of connection between neck and jaw areas [9, 15, 45, 50, 85]. Trigeminal afferent fibers from the proprioceptive mechanoceptors located in the orofacial area project to the sensory complex of the fifth cranial nerve in the brain stem and from there to the first three segments of the cervical spinal cord and to the nucleus of the spinal accessory nerve, which innervates the cervico-occipital, trapezius and sternocleidomastoid muscles, together with the C1 to C3 nerve roots [7, 50, 55]. Injuries to the jaw often spread tenderness to the cervical area and vice-versa, and this tenderness sometimes persists or increases over time, even when tissue healing has apparently taken place [45, 50]. Even though this may happen, in part, due to a local spreading of pain-producing chemicals through the tissues, evidence has shown that the spread of tenderness is more related to changes in spinal circuitry (central sensitization) [45, 54, 100]. It has been hypothesized that peripheral nerve truncks might be sensitized by discharges originating from the central nervous system, which could lead to despolarization of nociceptive second-order neurons [53]. Another possible explanation is that peripheral nociceptive nerve input could be normal, but the central processing might be facilitated or exaggerated [53]. Hence, the actual mechanism responsible for the spread of tenderness between the jaw and neck muscles remains unknown. Recently, a study by Fernandez-de-las-Penas et al [53] showed a bilateral and widespread decrease in PPT in nerve, joint and muscle tissues of subjects with myofascial TMD in both trigeminal (i.e. supra-orbital, infra-orbital and mental nerves as well as lateral pole of the TMJ) and extratrigeminal areas (i.e. median, ulnar, and radial nerves as well as C5-C6 zygapophyseal joint, and tibialis anterior muscle), suggesting multisegmental sensory sensitization or sensitization of the central nervous system in myofascial TMD women. Another study by Younger et al [101] found several regions of neural volume abnormality in areas associated with the sensory and affective components of pain processing, localized in the trigeminothalamocortical and limbic systems of myofascial TMD subjects. "The trigeminothalamocortical system involves inputs from spinal trigeminal nuclei, which then project through brainstem sensory nuclei, to the ventral posterior (VP) nucleus of the thalamus, and finally to the primary somatosensory cortex" [101] (pp 225). According to these authors, neural abnormalities in the early trigeminal system were found in subjects with TMD and this might indicate spinal and/or peripheral nervous system dysfunction in these subjects [101]. Abnormalities in the VP thalamus were also found in TMD subjects, suggesting enhanced facilitation of trigeminal sensory messages in these patients [101]. These studies provide evidence of the influence of the peripheral and central nervous systems in TMD patients, supporting the findings of this study.

5.3 CORRELATION BETWEEN LEVEL OF MUSCLE TENDERNESS OF MASTICATORY AND CERVICAL MUSCLES WITH JAW DYSFUNCTION AND NECK DISABILITY

In the present study, the association between level of muscle tenderness in the masticatory and cervical muscles, jaw dysfunction, and neck disability showed fair to moderate correlations (r = -0.32 to -0.65) [82], showing that there is the need of a bigger sample size to prove hypotheses 3 and 4. Jaw dysfunction had a moderate correlation with the level of muscle tenderness of temporalis (bilaterally) (r = -0.585 for right side and r = -0.646 for left side), masseter (bilaterally) (r = -0.512 for right side and r = -0.646 for left side) and upper trapezius (left side) (r = -0.647) muscles and a fair correlation with sternocleidomastoid (bilaterally) (r = -0.387 for right side and r = -0.426) and upper trapezius (right side) (r = -0.408) muscles. Neck disability was moderately correlated with temporalis (bilaterally) (r = -0.517 for right side and r = -0.554 for left side) and left upper trapezius (r = -0.518) muscles and fairly correlated with both masseters (r = -0.443 for right side and r = -0.48 for left side) and sternocleidomastoid muscles (r = -0.319 for right side and r = -0.374 for left side), and the right upper trapezius (r = -0.352). Several studies examined the presence of signs and symptoms in the cervical area of patients suffering with TMD and they have been showing that the presence of tender points in the cervical area of TMD's patients is quite common, which is line with the findings of this study [7, 15, 22, 56, 85, 105]. However, none of these studies have evaluated the relationship between level of tenderness and jaw dysfunction. Thus, the present study adds to the existing body of knowledge and contributes to understanding the factors related to jaw dysfunction.

Both upper trapezius and temporalis muscles had a moderate correlation with jaw dysfunction and neck disability. This finding indicates that increased levels of tenderness in these two muscles were related to higher levels of dysfunction in patients having TMD with concurrent neck disability. Therefore, assessing temporalis and upper trapezius muscles in patients having TMD with concurrent neck disability might enable physical therapists to have a better understanding of the level of dysfunction of these patients. However, although these results show a trend, moderate correlations just indicate association between levels of dysfunction in patients having TMD and concurrent neck disability with levels of muscle tenderness in both upper trapezius and temporalis muscles [82]. A cause and effect relationship is not possible to achieve with this study design.

Muscle tenderness is only one factor among multiple factors that could contribute to maintaining or perpetuating a level of dysfunction in people with TMD either in the jaw or neck. Usually, jaw dysfunction and neck disability are both related to gender, psychological factors, and social factors. For example, studies have shown that the presence of muscle tenderness is more commonly found in women than in men suffering with signs and symptoms of TMD [7, 38, 39, 42, 106-108]. Females' hormones seem to play a possible etiologic role [38], since there is a higher prevalence of signs and symptoms of TMD in women than in men as well as a lower prevalence for women in the post-menopausal years [38]. Increased rates of occurrence of TMD have been shown during specific phases of the menstrual cycle and possible adverse effects of oral contraceptives (OC) have been cited in the literature [38, 109]. Sherman et al. [109] showed significant differences in terms of pain pressure threshold during different phases of a woman's menstrual cycle. Women who have TMD and have not been using OC showed lower pain pressures thresholds during menses and midluteal phases, while women with TMD and using OC had stable pain pressure threshold throughout menses, ovulatory, and midluteal phases, with increased intensity at the late luteal phase [109]. Fluctuations in estrogen levels during the menstrual cycle may be related to the level of pressure pain in women [109]. These authors speculated that TMD patients, when exposed to experimental pain stimuli, might benefit from the use of OC, since these patients did not experience the same intensity of estrogen depletion levels throughout late luteal and menses phases of the menstrual cycle nor the wide swings in estrogen levels during the ovulation [109].

"Pain is a complex phenomenon influenced by both biologic and psychologic factors" [6] (pp 236). Younger et al. [101] found several limbic abnormalities in subjects suffering with TMD, showing that these patients had alterations not only in their sensory system, but also within their limbic system.

These authors found alterations in the basal ganglia nuclei, which contain neurons responsive to nociceptive input and serve the function of preparing behavioral responses to noxious stimuli [101]. They also found alterations in the anterior insula of patients with TMD. These alterations have been reported to be responsible for the integration of emotional and bodily states. According to the authors, alterations in the anterior insula region appears to be very important in the emotional awareness of internal states and the emotional aspects of the pain experience and anticipation of sensation [101]. It is important to note that pain is also perceived differently by different people, since factors such as fear, anxiety, attention, and expectations of pain can amplify the levels of pain experience [6]. On the other hand, self-confidence, positive emotional state, relaxation, and beliefs that pain is manageable may decrease the sensation of pain [6]. Studies have shown that psychosocial factors are significantly associated with both jaw and neck pain [2, 83, 93, 108]. Vedolin et al [93], for example, showed that the PPTs of jaw muscles of patients with TMD were lower throughout a natural stressful event (i.e. academic examination), showing a relationship between stress and anxiety levels with level of muscle tenderness. Another study by Mongini et al. [2] also showed the relationship between jaw and neck muscle tenderness with the prevalence of anxiety and depression among patients suffering from TMD. Increased levels of stress, anxiety and depression could enhance sympathetic activity and the release of epinephrine at sympathetic terminals, leading to an increase in acetylcholine activity at the motor endplate. This could start a cascade of events, causing a decreased pain pressure threshold in the muscles [93]. The results of these studies suggest that a more integrated treatment approach including psychosocial assessment is important when treating patients with TMD.

Unfortunately, in this study all possible factors that might be related to the development of jaw dysfunction or neck disability were not evaluated, so further conclusions regarding social, emotional and psychological factors are beyond the scope of this specific study.

5.4 CORRELATION BETWEEN GENERAL PAIN SENSITIVITY AND JAW DYSFUNCTION AS WELL AS CORRELATION BETWEEN GENERAL PAIN SENSITIVITY AND NECK DISABILITY

General pain sensitivity showed fair correlation with jaw dysfunction as well as with neck disability, which did not prove hypotheses 5 and 6. One possible explanation for this finding might lay in the fact that general pain sensitivity is a complex construct that depend on many factors, not only physical factors such as muscle tenderness. Usually, general pain sensitivity is associated with psychological problems, specifically with depression and somatization [119], which were not measured in the present study. Other factors such as physical well-being and quality of life might also affect the general pain sensitivity [83]. Lobbezoo et al. [83], for example, investigated the relationship between health status (i.e. physical well-being and quality of life), sleep disorders, and musculoskeletal pain in the jaw, neck and painful body areas below the neck of patients with either no pain, neck pain, TMD or both TMD and neck pain [83]. They found that TMD patients' well-being and quality of life was affected directly by the number of painful areas in the patient's body - the larger the number of painful areas, the worst the well-being and quality of life. They believed that TMD itself might not be enough to affect patients' life profoundly, and that the involvement of the neck region was necessary for such an impact to occur, which is in accordance with our results.

5.5 CORRELATION BETWEEN NECK DISABILITY AND JAW DYSFUNCTION

The correlation (Spearman's rho = 0.915) between jaw disability and neck disability was significantly high in this study, proving hypotheses 7 of this study. Subjects who had high levels jaw disability (evaluated through the JDI) also presented with high levels of neck disability (evaluated through the NDI) and vice-versa. Recently, a study by Armijo-Olivo et al. [110] was the first to show the relationship between jaw and neck disability. As in the present study, they also found high correlations between jaw and neck disability. Until their study, the association between neck and jaw was always shown in terms of signs and symptoms, but these authors showed the importance of assessing the impact that the level of disability can have on patients suffering with TMD.

Disability is a complex concept, since it involves more than accounting for the individual signs and symptoms alone. It also includes the perception of the patient about his or her condition as an important factor [110]. The International

Classification of Functioning, Disability and Health (IFC) from the World Health Organization (WHO) is helping health professionals to understand the importance of viewing chronic pain patients from different perspectives such as body, individual, societal and environmental [111]. The impact that the disability has on patient's body functions, body structures, activities and participation shows a more realistic vision of how the disease is impacting an individual's quality of life [110, 111]. TMD patients are a good example of how signs and symptoms can be perceived differently by different individuals. Sometimes severe TMD signs and symptoms may only have a small impact on the quality of life of a patient, while mild signs and symptoms may greatly interfere on other patients' lives. Therefore, assessing the level of disability of patients suffering with TMD is important to have a better view of how this condition is affecting these patients and which treatment approach is best for each situation [110].

The fact that jaw disability and neck disability are strongly related also shows that one has an effect on the other, which provides further information about the importance of assessing and treating both when seeing chronic TMD patients. Unfortunately, a strong correlation between jaw and neck disability does not indicate a cause and effect relationship. Further studies investigating the natural development of TMD are still necessary to determine any cause and effect connection.

5.6 CLINICAL RELEVANCE

Statistical significance is frequently use by researchers to show outcome differences. However, an outcome that is statistical significant is not necessarily clinical relevant [82, 112]. Statistical significance does not show the magnitude of the effect, it only shows that the outcome did not occur by chance [82]. Clinical relevance on the other hand provides information on how meaningful the outcome really is, which gives more practical information to patients and health care providers [82, 113, 114].

Effect size is the most common estimate used to measure the magnitude of difference between 2 groups, since it also takes into account the group variability [82]. Therefore, effect size is one way to show clinical relevance [82, 114]. In this study, the effect sizes of the main outcomes (i.e. comparison of groups in terms of muscle tenderness as well as in terms of general pain sensitivity) were calculated. The interpretation of these effect sizes was based on Cohen's guidelines that an effect size around 0.2 or less represents a small change, 0.5 means a moderate change and 0.8 or larger shows a large change [102].

Moderate to high effect sizes were found when comparing PPTs between the two groups, showing that the difference in terms of muscle tenderness in the facial and neck areas between subjects with TMD and healthy controls is clinical relevant. This is an important finding, because it shows that patients with TMD have a tendency to have increased muscle tenderness in both the facial and neck area. These findings have implications for health professionals, since by knowing that TMD patients with concurrent neck pain have a tendency to develop more muscle tenderness in some muscles than in others will allow the clinicians to have a more focused assessment and treatment, saving time and decreasing treatment costs.

When comparing groups in terms of general pain sensitivity, the effect size was found to be moderate, demonstrating that the difference was large enough to be considered clinical relevant. This is also important, since the mechanism of TMD development is not yet well established. It is unknown whether TMD is related more to the peripheral or central nervous systems. The clinical finding of this study shows that TMD patients appear to have a tendency to develop pain sensitivity not only in the face, but also in the neck and overall body. This result contributes to the knowledge that patients suffering with TMD and concurrent neck disability might benefit from treatments that have influence on both nervous systems (i.e. peripheral and central). Based on the results of this study, the author believes that TMD patients are first affected at the level of the peripheral nervous system and as the pathology starts to become more severe and chronic, a hypersensitization of the central nervous system will occur as explained previously.

5.7 STRENGTHS AND WEAKNESS OF THIS STUDY

5.7.1 STRENGTHS

To the best of the author's knowledge, this is the first study investigating differences in muscle tenderness in both facial and neck areas in subjects with TMD and healthy controls subjects using algometry, which is a valid and reliable method for assessing muscle tenderness. Previously, studies investigating this matter used palpation, which is difficult to quantify and standardize [12].

This study was designed to minimize bias regarding data collection. The data collection procedure followed the same protocol for each subject and a clear clinical diagnosis to determine subjects' symptomatology was performed. The use of a single-blind design, in which the investigator who collected the outcomes was blind to the status of the participant (i.e. TMD or normal), is another strength of this study. This type of design avoids preconceived expectations by the investigator when approaching the subject and minimizes bias when measuring the outcome. Moreover, the use of a cross-sectional design allowed 100% compliance. Thus, this study provides a stronger methodology than previous studies investigating the association between Cervical Spinal Dysfunction (CSD) and TMD.

The results of this research provided a clinical contribution to the area of physical therapy and TMD and added to TMD knowledge, which will help health care providers to provide a better diagnosis and consequently a better treatment to patients suffering from TMD. It identified one of the muscle impairments (i.e. decreased PPT) that are present in the face and cervical spine in patients with TMD. This information could help guide clinicians in the assessment and prescription of more effective interventions addressing these impairments for individuals with TMD.

5.7.2 WEAKNESSES

The main weakness of this study was the fact that a cross sectional design was used. This design did not allow the researcher to establish a cause and effect relationship between muscle tenderness, general pain sensitivity, and TMD. It was concluded that cervical muscular tenderness as well as decreased general pain sensitivity were present in subjects with TMD and concurrent neck disability. However, it is difficult to say if muscle tenderness or decreased general pain sensitivity were causes or consequences of TMD.

A small sample size was another weakness of this study and could potentially had influence the power of the results. Unfortunately, lack of time and funding were the main factors for stopping data collection. However, although the sample size was smaller than expected from calculations at the beginning of the study, the sample was sufficient to show both statistical significance and clinical relevance.

The fact that a convenience sample was used increased the potential subject self-selection bias. It was difficult to recognize what characteristics were present in those who offer themselves as subjects, as compared with those who did not, and it was unclear how these attributes might have affected the ability to generalize the outcomes [32]. Although probability samples would have been ideal for this type of study, having accessibility to the general population of TMD patients was limited and having access to all of them would have been expensive and time consuming. Furthermore, even with random selection, not all of the TMD patients who could have been invited to participate in the study would consent.

The results of this study only apply to subjects with TMD and concurrent neck disability and normal subjects having normal craniomandibular systems with no known pathology (controls). Only female subjects between 18 and 50 years of age were tested. In order to make further generalizations of these results, further studies including a larger sample size as well as different subjects' characteristics such as psychological factors, physical well-being and quality of life are needed.

CHAPTER SIX: SUMMARY AND CONCLUSIONS

6.1 SUMMARY AND CONCLUSIONS

The objectives of this study were:

1. To determine whether subjects having TMD with concurrent neck disability had a different general pain sensitivity (as evaluated by the pain pressure threshold in left hand) than control subjects;
2. To determine whether subjects having TMD with concurrent neck disability were different than healthy control subjects in terms of muscle tenderness (measured by determining the pain pressure thresholds in neck and face muscles);
3. To determine whether the level of muscle tenderness of the analyzed muscles (i.e. sternocleidomastoid, upper trapezius, masseter and temporalis muscles) for subjects with TMD and concurrent neck disability group is related to the level of jaw dysfunction (Jaw Dysfunction Index) and/or level of neck dysfunction (Neck Disability Index);
4. To determine whether there was a correlation between general pain sensitivity and jaw dysfunction among all the subjects of the study;
5. To determine whether there was a correlation between general pain sensitivity and neck disability among all the subjects of the study;

6. To determine whether there was a correlation between the neck disability and jaw dysfunction among all the subjects of the study;

Based on the results of this study, the following conclusions can be stated:

1. The TMD subjects with concurrent neck disability had increased levels of muscle tenderness when compared to healthy controls. The differences in terms of muscle tenderness between both groups were high enough to generate a high effect size, showing that this result could be considered clinically relevant. To the best of the author's knowledge, this is the first study that investigated muscle tenderness using algometry not only in the facial region but also in the neck area of subjects suffering with TMD. Therefore, this result provides more evidence that patients with a diagnosis of TMD have a tendency to develop muscle tenderness in both areas.
2. TMD subjects with concurrent neck disability were generally more sensitive to pain than healthy control subjects. This means that TMD subjects with concurrent neck disability are sensitize to pain not only at the jaw and neck level, but also in other areas of the body. This result shows the importance of treating the TMD patients not only at the level of the lesion, but also taking into account the patient's whole body.
3. This study showed that the higher the level of muscle tenderness in upper trapezius and temporalis muscles, the higher the level of jaw and neck dysfunction the subject will have. Therefore, assessing these two muscles

in patients having TMD with concurrent neck disability might help health professionals have a better idea about the level of dysfunction of the patient.

4. General pain sensitivity was only fairly correlated to both jaw dysfunction and neck disability. This shows that perhaps general pain sensitivity is a more complex variable that requires more information in order to show a correlation between both variables.
5. Jaw dysfunction and neck disability were strongly correlated, showing that changes in jaw dysfunction might be explained by changes in neck disability and vice-versa in patients suffering with TMD. This provides further information about the importance of assessing and treating both the jaw and neck in TMD patients.

6.2 SUGGESTIONS FOR FUTURE STUDIES

This study has highlighted the importance of assessing and treating TMD patients not only at the level of the jaw, but also including the neck and overall body. Muscle tenderness, however, is only a small part of a bigger picture. TMD is a complex problem and involves many factors such as gender, levels of anxiety and stress, and the level of socialization of the patient. Moreover, the small sample size of this study limited the generalizability of the results as well. Clinical randomized-controlled trials involving a bigger sample size and including factors other than muscle tenderness are still needed. Based on these, some directions for future studies would be:

1. To investigate if women and men suffering with TMD are different in terms of muscle tenderness.
2. To investigate if muscle tenderness affects TMD patients in a different way when considering different age ranges.
3. To investigate if muscle tenderness has any effect in patients with TMD without neck disability.

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Appendix 1 - Research Diagnostic Criteria for TMD

a. Directions for Examination

b. Calculation for Score

c. History Questionnaire

d. Clinical Examination

A. GENERAL DIRECTIONS FOR EXAMINATION

1. All questionnaire and examination items need to be completed unless the subject refuses or is unable to cooperate. In this case, write "SR" (subject refuses) in large block letters adjacent to the examination item and note why the subject refuses or cannot do item.
2. All measurements will be conducted with the jaw muscles in a passive state, unless the examination specifies otherwise. The joints and muscles should not receive additional weight or pressure at any time.
3. All millimeter recordings will be done as single or double digits. If a double-digit reading is only one digit, precede with a lead zero. If a measurement is between two millimeter markings, record the lesser value.
4. Subjects will sit in chairs at approximately a 90-degree angle to the examiner.
5. Examiners will wear gloves at all times.
6. Subjects with replacement prostheses will be examined with the prostheses in their mouth except if it is necessary to remove these for observing the mucosa and gingiva and performing intraoral palpations. Bite plates and other appliances that do not replace teeth are to be removed for the examination.
7. If the subject has a beard, a neck brace or any other potential physical barrier that may interfere with muscle or TMJ palpation, indicate this.
8. Conduct the examination procedures in the order on the form and record all measurements in the appropriate places on the specified form.
9. Items 4.d, Vertical incisal overlap, and 6.d, Midline deviation, are included so corrections to measurements in items 4 and 6, respectively, can be done to determine actual values of openings and excursions. For items 4.a through 4.c, the amount of vertical incisor overlap (4.d) should be added to each of these measurements to determine the actual amount of opening. For items 6.a and 6.b, if midline deviation (6.d) is greater than 0, this measurement should be added to one side of the lateral excursion and subtracted from the other side.

   For example: If a subject has a 2-mm deviation to the right, then subtract 2 mm from the value given to the right lateral excursion and add 2 mm to the value given to the left lateral excursion.

Note: Because the research diagnostic criteria require self-report of pain location (examination items 1 and 2), verified by the examiner, these items have been moved from the questionnaire to the examination. This will allow the examiner the opportunity to reliably confirm the type and location of pain.

B. EXAMINATION

1. Circle the appropriate answer. If the subject indicates midline pain score as "Both."
2. Circle the appropriate answer. If it is unclear to the examiner whether the subject is indicating a joint or muscle, press on the area as lightly as possible to correctly identify the anatomic site. For example, if the subject indicates pain in the joint, but the examiner identifies the location as muscle, the examiner's findings are those which are recorded.
3. *Opening Pattern*. General Instruction: Ask the subject to position the mandible in a comfortable position. ("Place your mouth in a comfortable position with your teeth lightly touching.") Place your thumb under the subject's lower lip so that the lip reveals the lower teeth. This will facilitate observing midline deviation. Ask the subject to open the mouth as wide as possible, even if he/she feels pain. ("I'd like you to open your mouth as wide as you can, even if it's a little painful.") If the degree of deviation is unclear, then use a millimeter ruler held vertically between the maxillary and mandibular incisor embrasures (or mark mandibular incisor if midlines do not match) as a guide. Ask the subject to open three times. If the subject exhibits more than one opening pattern then ask the subject to repeat the three openings and score according to the following criteria (*note:* only opening pattern is assessed).

a. *Straight.* If there is no perceptible deviation upon opening.

b. *Laterial Deviation to Right or Left.* For deviations that are visually perceptible to one side at maximum opening, determine which side of the subject's face the deviation goes towards and record accordingly.

c. *Corrected Deviation ("S" Deviation).* The subject exhibits a perceptible deviation to the right or left but corrects to the midline before or upon reaching the maximum unassisted mandibular opening.

d. *Other.* The subject exhibits jerky opening (not smooth or continuous) or has an opening other than those provided; indicate this and the type of deviation. If the subject has more than one opening pattern, use this category and write "more than one."

4. *Vertical Range of Motion of Mandible.* If the subject is wearing a denture or partial and it is loose, compress it against the ridge for all opening measurements.

   a. *Unassisted (Mandibular) Opening Without Pain*

      i. *Obtaining Measurement.* Ask the subject to place the mandible in a comfortable position. ("Place your mouth in a comfortable position.") Ask the subject to open the mouth as far as possible (unassisted), without feeling any pain. ("I would like for you to open as wide as you can without feeling any pain.") Place the edge of the millimeter ruler at the incisal edge of the maxillary central incisor that is the most vertically oriented and measure vertically to the labioincisal edge of the opposing mandibular incisor; record this measurement. Indicate on the form which maxillary incisor was chosen. If the subject did not open at least 30 mm, to insure understanding, repeat the opening. If the second opening still does not produce more than a 30-mm opening, record the measurement.

   b. *Maximum Unassisted (Mandibular) Opening*

      i. *Obtaining Measurement.* Ask the subject to place the mandible in a comfortable position. ("Place your mouth in a comfortable position.") Then ask the subject to open the mouth as wide as possible, even if he/she feels pain. ("I would like for you to open your mouth as wide as you can, even if it's a little uncomfortable.") Place the edge of the millimeter ruler at the incisal edge of the maxillary central incisor that is the most vertically oriented and measure vertically to the labioincisal edge of the opposing mandibular incisor; record this measurement.

      ii. *Pain.* Ask the subject if he/she felt pain on maximum unassisted opening. ("When you opened this time, did you have any pain?") Record whether or not they had pain, and the location. The location is scored in two ways: by left and/or right side and specifically whether or not the pain is in the joint. Two entries are required for items 4.b and 4.c to assess pain: record side of pain as "None" (0), "Right" (1), "Left" (2) or "Both" (3). Also record if pain in the joint is "Present" (1) or "Absent" (0). If the subject had no pain, circle "NA" (9) for location. If he/she indicates pressure or tightness, score as "None."

   c. *Maximum Assisted (Mandibular) Opening*

      i. *Obtaining Measurement.* Ask the subject to position the mandible in a comfortable position. ("Place your mouth in a comfortable position.") Ask the subject to open the mouth as wide as possible, even if he/she feels pain. ("I would like for you to open your mouth as wide as you can, even if it's a little uncomfortable.") After the subject has opened this wide, place your thumb on the subject's maxillary central incisors, and cross your index finger over to the subject's mandibular central incisors. From this position you will gain the leverage necessary to force the subject's mouth open wider. Use moderate pressure, but do not forcefully open the mouth wider. ("I am checking to see if I can push your mouth open a little further and I will stop if you raise your hand.") Measure from labioincisal edge of the same maxillary central incisor as before to the labioincisal edge of the mandibular incisor with the millimeter ruler; record the measurement.

      ii. *Pain.* Record whether or not the subject felt pain and the location. ("Did you feel any pain when I tried to open your mouth wider with my fingers?") Score pain locations as in maximum unassisted opening. If they indicated feeling pressure or tightness, score as "None."

   d. *Vertical Incisal Overlap.* Ask the patient to close the teeth completely together. With a pen or fingernail, mark the line where the incisal edge of the same maxillary central incisor used before for measurements overlaps the mandibular incisor. Measure the distance from the mandibular incisal edge to the marked line and record the measurement.

5. *Temporomandibular Joint Sounds on Palpation for Vertical Range of Motion.*

   General Instructions: Subjects will indicate the presence or absence of sounds; if present, the examiners will score the *type* of sound observed.

   Place left index finger over the subject's right TMJ and the right index finger over the subject's left TMJ (preauricular area). The pad of the right finger is placed anterior to the tragus of the ear. Ask the subject to slowly open as wide as possible, even if it causes pain. Each closure should bring the teeth completely together in maximum intercuspation. Ask the subject: "While I have my fingers over your joint, I would like you to slowly open as wide as you can and then slowly close until your teeth are completely together." Ask the subject to open and close 3 times. Record the action/sound that the joint produces, on opening or closing as detected by palpation and as defined below.

   a. *Definition of sounds*

      0 = *None*.

      1 = *Click*. A distinct sound, of brief and very limited duration, with a clear beginning and end, which usually sounds like a "click." Circle this item only if the click is reproducible on two of three openings/closings.

      2 = *Coarse Crepitus*. A sound that is continuous, over a longer period of jaw movement. It is not brief like a click or pop; the sound may make overlapping continuous noises. This sound is not muffled; it is the noise of bone grinding against bone, or like a stone grinding against another stone.

      3 = *Fine Crepitus*. Fine crepitus is a fine grating sound that is continuous over a longer period of jaw movement on opening or closing. It is not brief like a click; the sound may make overlapping continuous sounds. It may be described as a rubbing or crackling sound on a rough surface.

   b. *Scoring of clicking sounds*. While many of the following types of sounds are not pertinent to specific diagnostic criteria, this exhaustive list of definitions is provided in order to better delineate how the sound types required to meet RDC may differ from other sounds.

      i. *Reproducible Opening Click*. If upon opening and closing from maximum intercuspation, a click is noted on two of three opening movements, record as positive for opening click.

      ii. *Reproducible Closing Click*. A click present on two of three closing mandibular movements.

      iii. *Reproducible Reciprocal Click*. This sound is determined by the millimeter measurement of opening and closing clicks and the elimination of both clicks when the subject opens and closes from a protruded position. With the millimeter ruler, measure the interincisal distance at which the first opening and closing clicks are heard. Measure from labioincisal embrasure of the maxillary central identified in 4 to the labioincisal embrasure of the opposing mandibular incisor. If the clicking ceases and therefore is not measurable, leave the ___ ___'s unfilled. (Computer analyses will then indicate this is not a reciprocal click; even though a click *had* been present, it did not *continue* to be present.) Assess elimination of clicks on protrusive opening by asking the subject first to maximally protrude. Next ask the subject to open and close from this protruded jaw position. The opening and closing click will normally be eliminated. Circle "Yes" (1) if the click can be eliminated if the jaw is opened and closed in a protruded or more anterior jaw position. If the click is not eliminated, circle "No" (0). If the subject lacks either a reproducible opening click or a reproducible closing click, circle "NA" (9).

      iv. *Non-Reproducible Click* (Do Not Score). A nonreproducible click is present if the sound is only demonstrated periodically during opening or closing; it cannot be reproduced on at least two of three full mandibular movements. More than one sound can be circled overall for Opening (a) and Closing (b). If none (0) is circled, no other responses can be circled.

6. *Mandibular Excursive Movements*

   a. *Right Lateral Excursion*

      i. *Obtaining Measurement*. Ask subject to open slightly and move the mandible as far as possible to the right, even if it is uncomfortable. If necessary, repeat the movement. (*Example:* "Move your jaw as far as possible towards the right, even if it is uncomfortable, and move your jaw back to its normal position. Move your jaw back towards the right again.") With the teeth slightly separated, use a millimeter ruler to measure from the labioincisal embrasure between the maxillary centrals to the labioincisal embrasure of the mandibular incisors; record this measurement.

   ii. *Pain*. Ask the subject if he/she had pain. Record whether or not the subject felt pain and the location. The location is scored in two ways: by left and/or right side and specifically whether or not the pain is in the joint. Two entries are required for items 6.a through 6.c to assess pain: record side of pain as "None" (0), "Right" (1), "Left" (2), or "Both" (3). Also record if pain in the joint is "Present" (1) or "Absent" (0). If the subject indicated feeling pressure or tightness, score as "None."

b. *Left Lateral Excursion*

   i. *Obtaining Measurement*. Ask the subject to move the mandible as far as possible to the other side (left). ("I would like you to now move your jaw as far as possible towards the other side and back to its normal position.") Record this measurement in the same manner as right excursion.

   ii. *Pain*. Ask the subject if he/she had pain. Record whether or not the subject felt pain and the location. ("Did you feel any pain when you moved to the side?") Score pain locations as in right lateral excursion. If the subject indicated feeling pressure or tightness, score as "None."

c. *Protrusion*

   i. *Obtaining Measurement*. Ask the subject to open slightly and protrude the mandible. ("Slide your jaw straight out in front of you as far as you can, even if it is uncomfortable.") If the subject has a deep overbite, ask him/her to open wider so he/she can protrude without getting interference from the maxillary incisors.

   ii. *Pain*. Ask the subject if he/she had pain. Record whether or not the subject felt pain and the location. ("Did you feel any pain when you moved your jaw forward?") Score pain locations as in right lateral excursion. If the subject indicated feeling pressure or tightness, score as "None."

d. *Midline Deviation*. If the incisal embrasures of the maxillary and mandibular incisors do not line up vertically, determine the horizontal difference between the two while the subject is biting together. Measure in millimeters how far the mandibular embrasure is from the maxillary embrasure and on which side of the subject the mandibular embrasure is located. If the midline deviation is less than 1 mm, or there is no deviation, enter "00."

7. *Temporomandibular Joint Sounds on Palpation for Lateral Excursions and Protrusion*

   Ask the subject to move to the right, to the left, and protrude (see 6).

   a. *Definition of Sounds*. Refer to item 5.

   b. *Scoring of Clicking Sounds.*

      i. *Reproducible Laterotrusive and Protrusive Click*. Occurs when the TMJ displays a click with two of three lateral movements or protrusion of the mandible respectively.

      ii. *Nonreproducible Laterotrusive and Protrusive Clicks.* A nonreproducible click is present if the click is only demonstrated periodically during laterotrusion movements or protrusion but cannot be reproduced on at least two of three movements. Do not score.

C. GENERAL INSTRUCTION FOR MUSCLE AND JOINT PALPATION FOR TENDERNESS

1. Examining the muscles and joint capsules for tenderness requires that you press on a specific site using the fingertips of the index and third fingers or the spade-like pad of the distal phalanx of the index finger only with standardized pressure, as follows: palpations will be done with 2 lbs of pressure for extraoral muscles (1 lb of pressure in the Posterior Mandibular Region and Submandibular Region), 1 lb of pressure on the joints and intraoral muscles. Palpate the muscles while using the opposite hand to brace the head to provide stability. The subject's mandible should be in a resting position, without the teeth touching. Palpate while muscles are in a passive state. As needed, have the subject lightly

clench and relax to identify and to insure palpation of the correct muscle site. ("I'm going to press on some muscles. I would like for you to clench your teeth together gently and then relax and have your teeth slightly apart from each other.") First locate the site of palpation using the landmarks described and then press. Because the site of maximum tenderness may vary from subject to subject and is localized, it is important to press in multiple areas in the region specified to determine if tenderness exists. Before beginning the palpations, say: "In the next part of the exam, we'd like you to record whether you feel pain or pressure when I palpate or press on certain parts of your head and face." Ask the subject to determine if the palpation hurts (painful) or if he/she just feels pressure. If it hurts, ask the subject to indicate if the pain is mild, moderate, or severe. Record any equivocal response or the report of pressure only as "No Pain."

2. *Description of Specific Extraoral Muscle Sites (2 lbs digital pressure) *(1 lb of digital pressure)*

   a. *Temporalis (Posterior).* Palpate posterior fibers behind the ears to directly above the ears. Ask the subject to clench and then relax to help identify muscle. Walk fingers towards the subject's face (medially) to the anterior border of the ear.

   b. *Temporalis (Middle).* Palpate fibers in the depression about 4-5 cm lateral to the lateral border of the eyebrow.

   c. *Temporalis (Anterior).* Palpate fibers over the infratemporal fossa, immediately above the zygomatic process. Ask the subject to clench and relax to help identify muscle.

   d. *Origin of Masseter.* Ask the subject to first clench then relax and observe masseter for location. Palpate the origin of the muscle beginning in the area 1 cm immediately in front of the TMJ and immediately below the zygomatic arch, and palpate anteriorly to the border of the muscle.

   e. *Body of the Masseter.* Start just below the zygomatic process at the anterior border of the muscle. Palpate from here down and back to the angle of the mandible across a surface area about two fingers wide.

   f. *Insertion of the Masseter.* Palpate the area 1 cm superior and anterior to the angle of the mandible.

   *g. *Posterior Mandibular Region (Stylohyoid / Posterior Digastric).* Ask the subject to tip the head back a little. Locate the area between the insertion of the SCM and the posterior border of the mandible. Place finger so it is going medially and upwards (and not on the mandible). Palpate the area immediately medial and posterior to the angle of the mandible.

   *h. *Submandibular Region (Medial Pterygoid, Suprahyoid, Anterior Digastric).* Locate the site under the mandible at a point 2 cm anterior to the angle of the mandible. Palpate superiorly, pulling toward the mandible. If a subject has a lot of pain in this area, try to determine if the subject is reporting muscle or nodular pain. If it is nodes, indicate on the exam form.

3. *Description of Specific Joint Palpation Sites (1 lb digital pressure)*

   a. *Lateral Pole.* Place index finger just anterior to the tragus of the ear and over the subject's TMJ. Ask the subject to open slightly until the examiner feels the lateral pole of the condyle translated forward. Use 1 lb pressure on the side that is being palpated, supporting the head with the opposite hand.

   b. *Posterior Attachment.* This site can be palpated intrameatally. Place tips of the right little finger into the subject's left external meatus and the tip of the left little finger into the subject's right external meatus. Point the fingertips towards the examiner and ask subject to slightly open the mouth (or wide open if necessary) to make sure the joint movement is felt with the fingertips. Place firm pressure on the right side and then the left side while the subject's teeth are completely together.

   (Change examination gloves.)

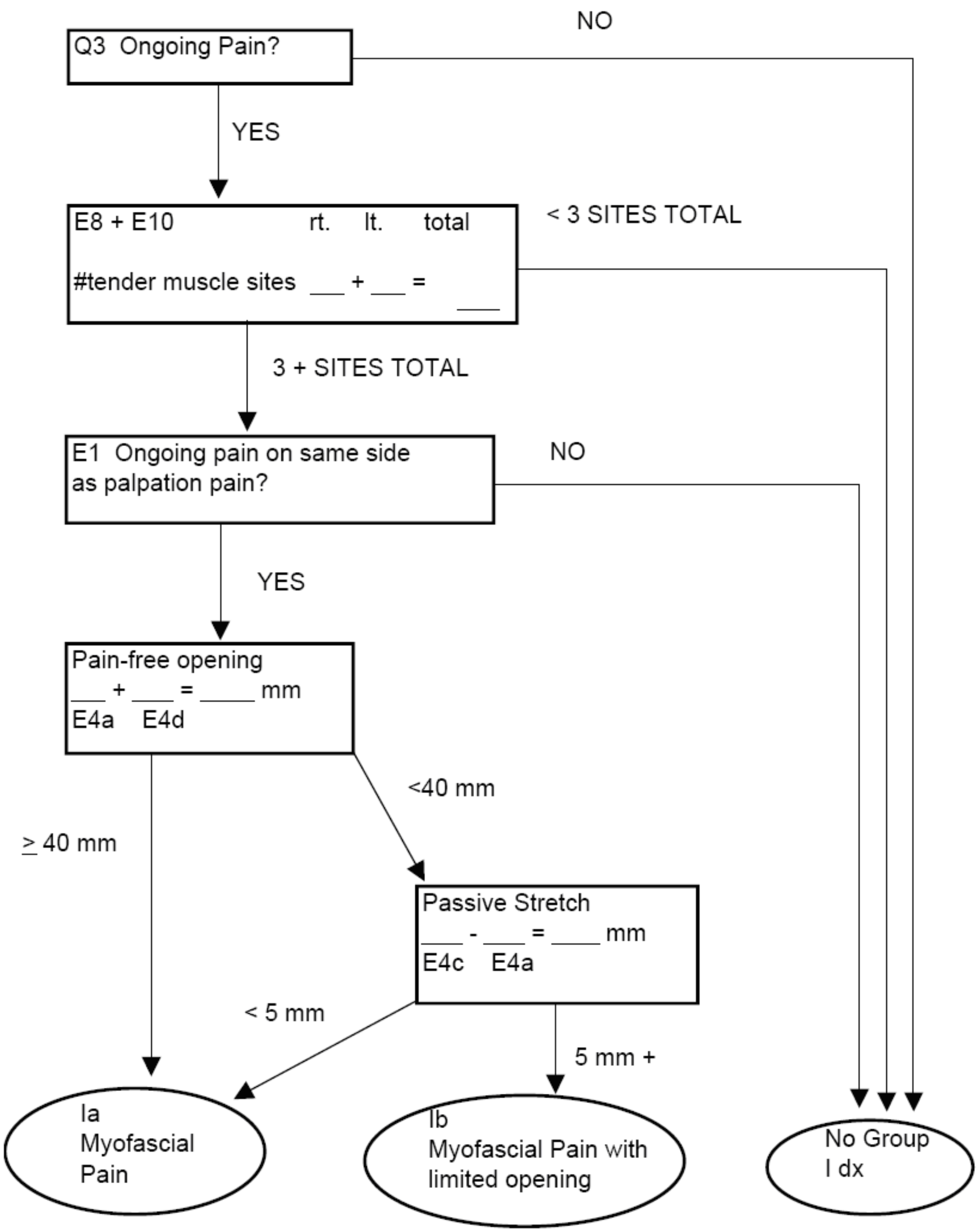
4. *Description of Specific Intraoral Palpation Sites (1 lb digital pressure)*

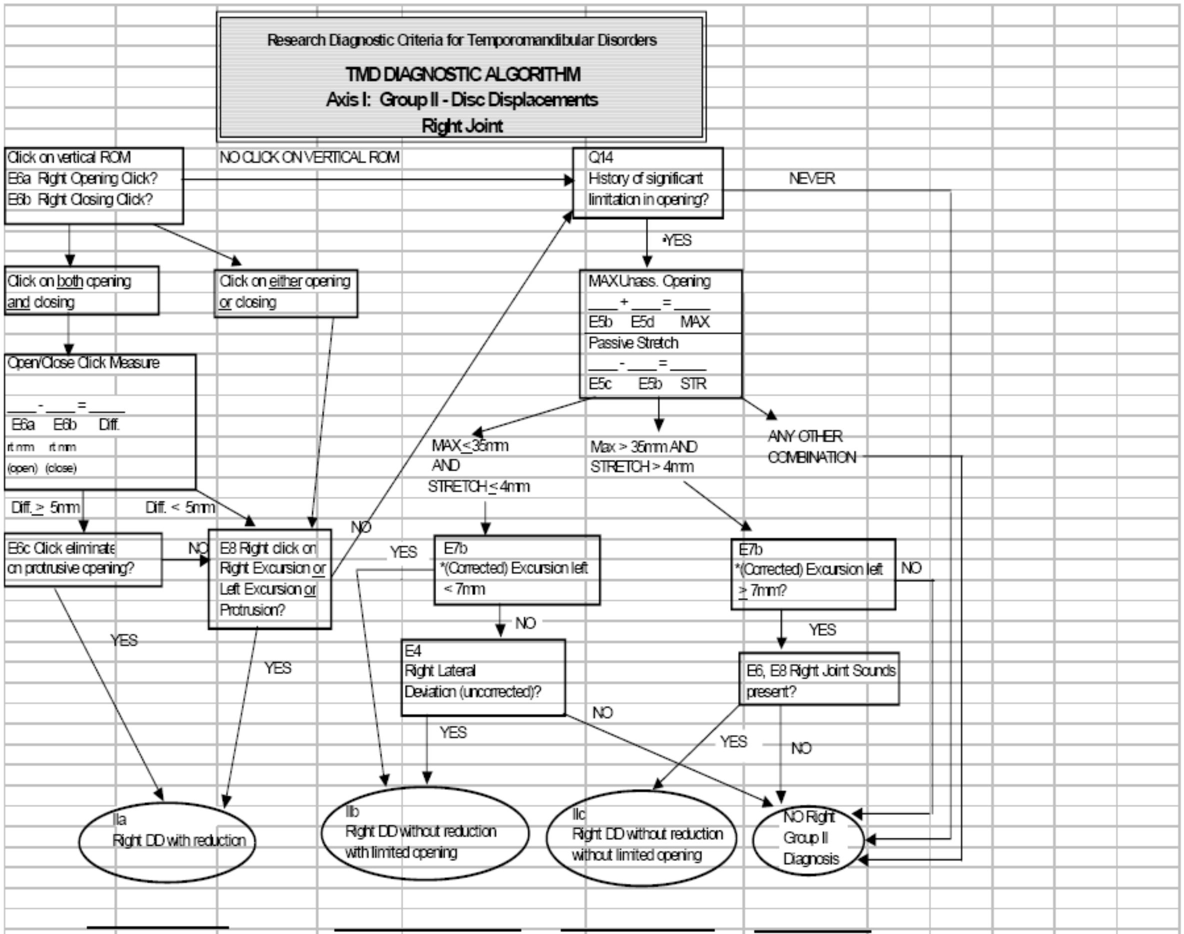
   Explain to the subject that you will now be palpating the inside of the mouth: ("Now I am going to palpate around the inside of your mouth. While I do these palpations I would like you to keep your jaw in a relaxed position.")

a. *Lateral Pterygoid Area.* Before palpating, make sure the fingernail of the index finger is trimmed to avoid false positives. Ask the subject to open the mouth and move the jaw to the side that is being examined. ("Move your jaw towards this hand.") Place the index finger on lateral side of alveolar ridge above the right maxillary molars. Move finger distally, upward, and medial to palpate. If the index finger is too large, use the little finger (5th digit).

b. *Tendon of Temporalis.* After completing the lateral pterygoid, rotate your index finger laterally near the coronoid process, ask the subject to open slightly, and move your index finger up the anterior ridge of the coronoid process. Palpate on the most superior aspect of the process. *Note:* If it is difficult to determine in some subjects if they are feeling pain in the lateral pterygoid or the tendon of the temporalis, rotate and palpate with the index finger medially then laterally. If there is still difficulty, the lateral pterygoid is usually the more tender of the two

Group I


Q3 Ongoing Pain?
NO
YES
E8 + E10 rt. lt. total
#tender muscle sites ___ + ___ = ___
< 3 SITES TOTAL
3 + SITES TOTAL
E1 Ongoing pain on same side as palpation pain?
NO
YES
Pain-free opening
___ + ___ = _____ mm
E4a E4d
<40 mm
≥ 40 mm
Passive Stretch
____ - ____ = ____ mm
E4c E4a
< 5 mm
5 mm +
Ia Myofascial Pain
Ib Myofascial Pain with limited opening
No Group I dx



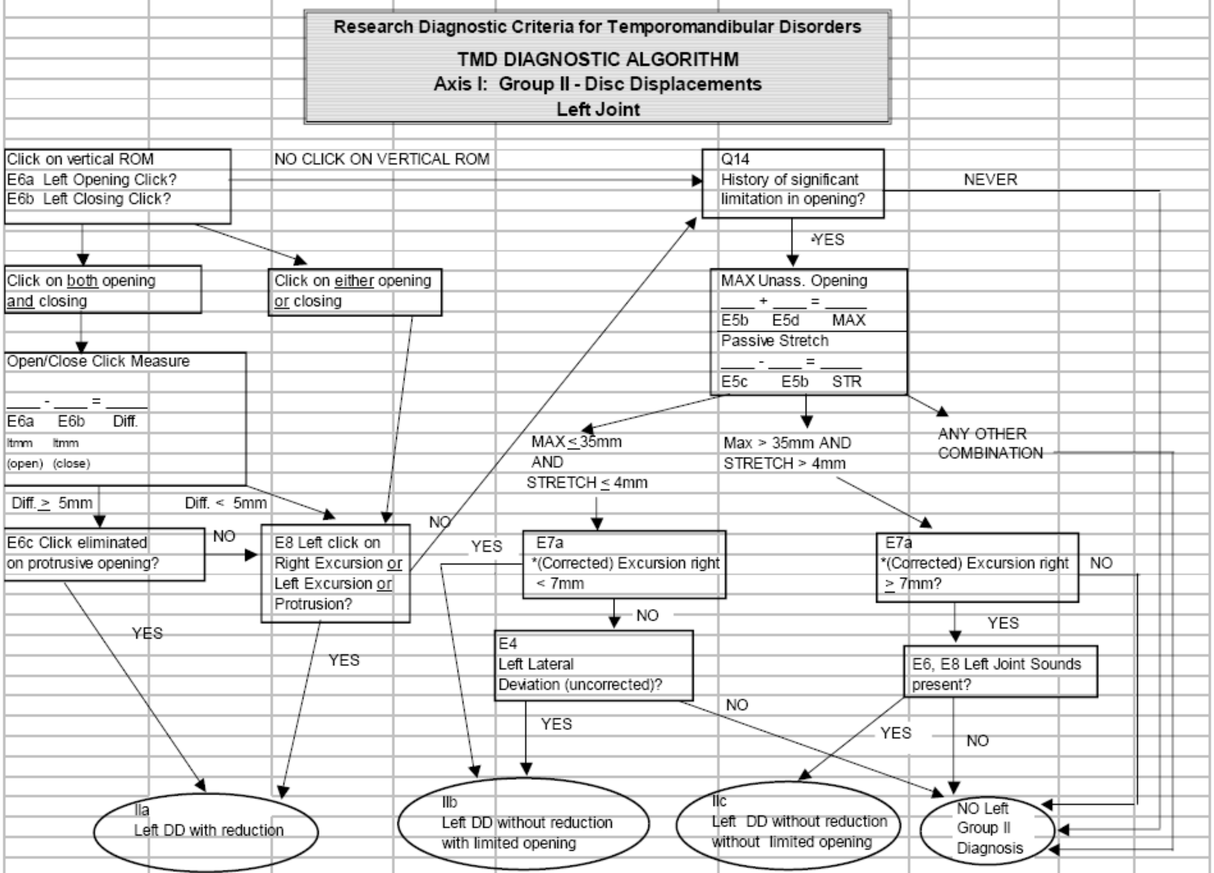
*To calculate corrected excursion:

Amount of midline deviation __ __
7 d

If midline = "00" continue to follow algorithm/diagram above.

If midline = "01" or greater:

For Midline Deviation to the Right	For Midline Deviation to the Left
Left excursion =	Left excursion =
__ __ + __ __ = corrected left excursion	__ __ - __ __ = corrected left excursion
7 b 7 d	7 b 7 d



*To calculate corrected excursion:**

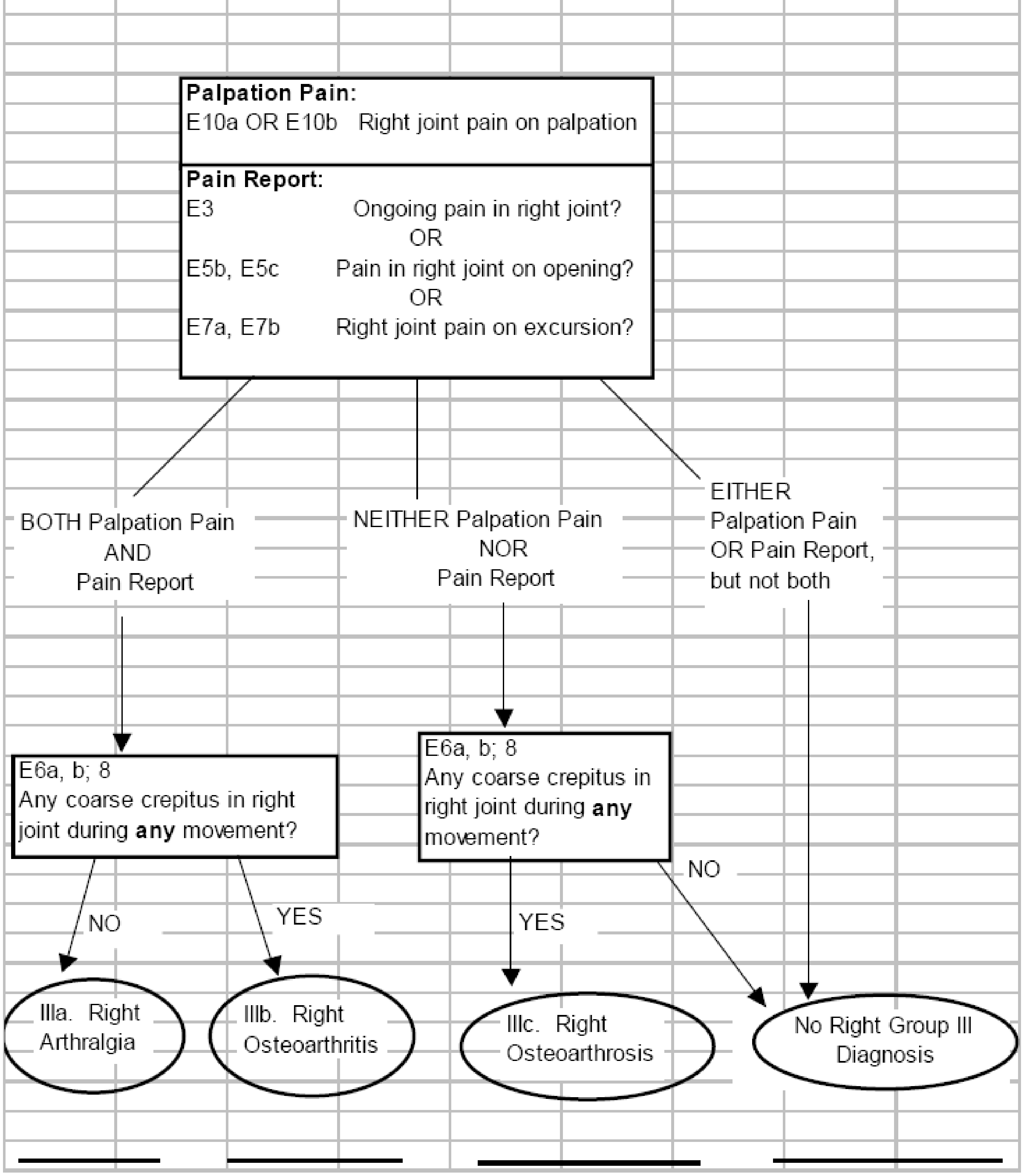
Amount of midline deviation __ __
7 d

If midline = "00" continue to follow algorithm/diagram above.
If midline = "01" or greater:

For Midline Deviation to the Right	For Midline Deviation to the Left
Right excursion =	Right excursion =
__ __ - __ __ = corrected right excursion (7 a, 7 d)	__ __ + __ __ = corrected right excursion (7 a, 7 d)

Research Diagnostic Criteria for Temporomandibular Disorders

TMD DIAGNOSTIC ALGORITHM
Axis I: Group III - Other Joint Conditions
Right Joint



HISTORY QUESTIONNAIRE

ID# ____________

Date: ___ ___ / ___ ___ / ____ ___

Please read each question and respond accordingly. For each of the questions below circle only one response.

1. Would you say your health in general is excellent, very good, good, fair or poor?

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

2. Would you say your oral health in general is excellent, very good, good, fair or poor?

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

3. Have you had pain in the face, jaw, temple, in front of the ear or in the ear in the past month?

No	0
Yes	1

[If no pain in the past month, SKIP to question 14]

If Yes,

4.a. How many years ago did your facial pain begin for the first time?

___ ___ years

[If one year ago or more SKIP to question 5] **[If less than one year ago, code 00]**

4.b. How many months ago did your facial pain begin for the first time?

____ ____ months

5. Is your facial pain persistent, recurrent or was it only a one-time problem?

Persistent	1
Recurrent	2
One-Time	3

6. Have you ever gone to a physician, dentist, chiropractor or other health professional for facial ache or pain?

No	1
Yes, in the last six months	2
Yes, more than six months ago	3

7. How would you rate your facial pain on a 0 to 10 scale at the present time, that is right now, where 0 is "no pain" and 10 is "pain as bad as could be"?

No pain										**Pain as bad as could be**
0	1	2	3	4	5	6	7	8	9	10

8. In the past six months, how intense was your worst pain rated on a 0 to 10 scale where 0 is "no pain" and 10 is "pain as bad as could be"?

No pain										**Pain as bad as could be**
0	1	2	3	4	5	6	7	8	9	10

9. In the past six months, on the average, how intense was your pain rated on a 0 to 10 scale where 0 is "no pain" and 10 is "pain as bad as could be"? [That is, your usual pain at times you were experiencing pain].

No pain										**Pain as bad as could be**
0	1	2	3	4	5	6	7	8	9	10

10. About how many days in the last six months have you been kept from your usual activities (work, school or housework) because of facial pain?

_____ _____ _____
DAYS

11. In the past six months, how much has facial pain interfered with your daily activities rated on a 0 to 10 scale where 0 is "no interference" and 10 is "unable to carry on any activities"?

No Interference										**Unable To Carry On Any Activities**
0	1	2	3	4	5	6	7	8	9	10

12. In the past six months, how much has facial pain changed your ability to take part in recreational, social and family activities where 0 is "no change" and 10 is "extreme change"?

No **Change**										**Unable To Carry On Any Activities**
0	1	2	3	4	5	6	7	8	9	10

13. In the past six months, how much has facial pain changed your ability to work including housework) where 0 is "no change" and 10 is "extreme change"?

No Change										**Unable To Carry On Any Activities**
0	1	2	3	4	5	6	7	8	9	10

14.a.	Have you ever had your jaw lock or catch so that it won't open all the way?	No Yes	0 1

[If no problem opening all the way, SKIP to question 15]

If Yes,

14.b.	Was this limitation in jaw opening severe enough to interfere with your ability to eat?	No Yes	0 1

15.	a.	Does your jaw click or pop when you open or close your mouth or when chewing?	No Yes	0 1	d.	During the day, do you grind your teeth or clench your jaw?	No Yes	0 1
	b.	Does your jaw make a grating or grinding noise when it opens and closes or when chewing?	No Yes	0 1	e.	Does your jaw ache or feel stiff when you wake up in the morning?	No Yes	0 1
	c.	Have you been told, or do you notice that you grind your teeth or clench your jaw while sleeping at night?	No Yes	0 1	f.	Do you have noises or ringing in your ears?	No Yes	0 1
					g.	Does your bite feel uncomfortable or unusual?	No Yes	0 1

16.a.	Do you have rheumatoid arthritis, lupus, or other systemic arthritic disease?	No Yes	0 1
16.b.	Do you know of anyone in your family who has had any of these diseases?	No Yes	0 1
16.c.	Have you had or do you have any swollen or painful joint(s) other than the joints close to your ears (TMJ)?	No Yes	0 1

[If no swollen or painful joints, SKIP to question 17.a.]

If Yes,

16.d.	Is this a persistent pain which you have had for at least one year?	No Yes	0 1
17.a.	Have you had a recent injury to your face or jaw?	No Yes	0 1

[If no recent injuries, SKIP to question 18]

If Yes,

17.b.	Did you have jaw pain before the injury?	No Yes	0 1
18.	During the last six months have you had a problem with headaches or migraines?	No Yes	0 1

19. What activities does your present jaw problem prevent or limit you from doing?

a. Chewing	No 0 Yes 1		g. Sexual activity	No 0 Yes 1	
b. Drinking	No 0 Yes 1		h. Cleaning teeth or face	No 0 Yes 1	
c. Exercising	No 0 Yes 1		i. Yawning	No 0 Yes 1	
d. Eating hard foods	No 0 Yes 1		j. Swallowing	No 0 Yes 1	
e. Eating soft foods	No 0 Yes 1		k. Talking	No 0 Yes 1	
f. Smiling/laughing	No 0 Yes 1		l. Having your usual facial appearance	No 0 Yes 1	

20. In the last month, how much have you been distressed by. . .

		Not At All	A Little Bit	Moder-ately	Quite A Bit	Ex-tremely
a.	Headaches	0	1	2	3	4
b.	Loss of sexual interest or pleasure	0	1	2	3	4
c.	Faintness or dizziness	0	1	2	3	4
d.	Pains in the heart or chest	0	1	2	3	4
e.	Feeling low in energy or slowed down	0	1	2	3	4
f.	Thoughts of death or dying	0	1	2	3	4
g.	Poor appetite	0	1	2	3	4
h.	Crying easily	0	1	2	3	4
i.	Blaming yourself for things	0	1	2	3	4
j.	Pains in the lower back	0	1	2	3	4
k.	Feeling lonely	0	1	2	3	4
l.	Feeling blue	0	1	2	3	4
m.	Worrying too much about things	0	1	2	3	4
n.	Feeling no interest in things	0	1	2	3	4
o.	Nausea or upset stomach	0	1	2	3	4
p.	Soreness of your muscles	0	1	2	3	4
q.	Trouble falling asleep	0	1	2	3	4
r.	Trouble getting your breath	0	1	2	3	4
s.	Hot or cold spells	0	1	2	3	4
t.	Numbness or tingling in parts of your body	0	1	2	3	4
u.	A lump in your throat	0	1	2	3	4
v.	Feeling hopeless about the future	0	1	2	3	4
w.	Feeling weak in parts of your body	0	1	2	3	4
x.	Heavy feelings in your arms or legs	0	1	2	3	4
y.	Thoughts of ending your life	0	1	2	3	4
z.	Overeating	0	1	2	3	4
aa.	Awakening in the early morning	0	1	2	3	4

		Not At All	A Little Bit	Moder-ately	Quite A Bit	Ex-tremely
bb.	Sleep that is restless or disturbed	0	1	2	3	4
cc.	Feeling everything is an effort	0	1	2	3	4
dd.	Feelings of worthlessness	0	1	2	3	4
ee.	Feeling of being caught or trapped	0	1	2	3	4
ff.	Feelings of guilt	0	1	2	3	4

21. How good a job do you feel you are doing in taking care of your health overall?

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

22. How good a job do you feel you are doing in taking care of your oral health?

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

23. When were you born? Month __ __ Day __ __ Year __ __

24. Are you male or female?

Male	1
Female	2

25. Which of the following groups best represent your race?

Aleut, Eskimo or American Indian	1
Asian or Pacific Islander	2
Black	3
White	4
Other	5
(please specify) ________________	

26. Are any of these groups your national origin or ancestry?

Puerto Rican	1	Chicano	5
Cuban	2	Other Latin American	6
Mexican/Mexicano	3	Other Spanish	7
Mexican American	4	None of the above	8

27. What is the highest grade or year of regular school that you have completed?

Never attended or Kindergarten:	00							
Elementary School:	1	2	3	4	5	6	7	8
High School:	9	10	11	12				
College:	13	14	15	16	17	18+		

28. During the past 2 weeks, did you work at a job or business not counting work around the house (include unpaid work in the family farm/business)?

Yes	1
No	2

29. Are you married, widowed, divorced, separated or never been married?

Married-spouse in household	1
Married-spouse not in household	2
Widowed	3
Divorced	4
Separated	5
Never Married	6

RESEARCH DIAGNOSTIC CRITERIA
TMD CLINICAL EXAMINATION FORM

ID# ______________________________

Date: ___ ___ / ___ ___ / ____ ___

1. Do you have pain on the right side of your face, the left side or both sides?

None	0
Right	1
Left	2
Both	3

2. Could you point to the areas where you feel pain?

Right		Left	
None	0	None	0
Jaw Joint	1	Jaw Joint	1
Muscles	2	Muscles	2
Both	3	Both	3

[Examiner feels area subject points to, if it is unclear whether it is joint or muscle pain]

3. Opening Pattern

Straight	0
Right Lateral Deviation (uncorrected)	1
Right Corrected ("S") Deviation	2
Left Lateral Deviation (uncorrected)	3
Left Corrected ("S") Deviation	4
Other	5

Type____________________________
(specify)

4. Vertical Range of Motion

Score 8 for Pressure or Tightness

Score 9 for No Pain

		MUSCLE PAIN				JOINT PAIN			
		None	Right	Left	Both	None	Right	Left	Both
a. Unassisted opening without pain	___ ___mm								
b. Maximum unassisted opening	___ ___mm	0	1	2	3	0	1	2	3
c. Maximum assisted opening	___ ___mm	0	1	2	3	0	1	2	3
d. Vertical incisal overlap	___ ___mm								

5. Joint Sounds (palpation)

			RIGHT	LEFT
a.	Opening	None	0	0
		Click	1	1
		Coarse Crepitus	2	2
		Fine Crepitus	3	3
	Measurement of Opening Click		___ ___mm	___ ___mm
b.	Closing	None	0	0
		Click	1	1
		Coarse Crepitus	2	2
		Fine Crepitus	3	3
	Measurement of Closing Click		___ ___mm	___ ___mm
c.	Reciprocal click eliminated on protrusive opening	No	0	0
		Yes	1	1
		NA	8	8

6. Excursions (Mandibular Movements)

		MUSCLE PAIN				JOINT PAIN			
		None	Right	Left	Both	None	Right	Left	Both
a. Right Lateral Excursion	___ ___mm	0	1	2	3	0	1	2	3
b. Left Lateral Excursion	___ ___mm	0	1	2	3	0	1	2	3
c. Protrusion	___ ___mm	0	1	2	3	0	1	2	3

		RIGHT	LEFT	NA
d. Midline Deviation	___ ___mm	1	2	8

7. Joint Sounds on Excursions

Right Sounds:

	None	Click	Coarse Crepitus	Fine Crepitus
Excursion Right	0	1	2	3
Excursion Left	0	1	2	3
Protrusion	0	1	2	3

Left Sounds:

	None	Coarse Click	Fine Crepitus	Crepitus
Excursion Right	0	1	2	3
Excursion Left	0	1	2	3
Protrusion	0	1	2	3

DIRECTIONS, ITEMS 8-10

The examiner will be palpating (touching) different areas of your face, head and neck. We would like you to indicate if you do not feel pain or just feel pressure (0), or pain (1-3). Please rate how much pain you feel for each of the palpations according to the scale below. Circle the number that corresponds to the amount of pain you feel. We would like you to make a separate rating for both the right and left palpations.

0 = No Pain/Pressure Only

1 = Mild Pain

2 = Moderate Pain

3 = Severe Pain

8. Extraoral muscle pain with palpation:

		RIGHT	LEFT
a.	Temporalis (posterior) "Back of temple"	0 1 2 3	0 1 2 3
b.	Temporalis (middle) "Middle of temple"	0 1 2 3	0 1 2 3
c.	Temporalis (anterior) "Front of temple"	0 1 2 3	0 1 2 3
d.	Masseter (superior) "Cheek/under cheekbone"	0 1 2 3	0 1 2 3
e.	Masseter (middle) "Cheek/side of face"	0 1 2 3	0 1 2 3
f.	Masseter (inferior) "Cheek/jawline"	0 1 2 3	0 1 2 3
g.	Posterior mandibular region (Stylohyoid/posterior digastric region) "Jaw/throat region"	0 1 2 3	0 1 2 3
h.	Submandibular region (Medial pterygoid/Suprahyoid/anterior digastric region) "Under chin"	0 1 2 3	0 1 2 3

9. Joint pain with palpation:

		RIGHT	LEFT
a.	Lateral pole "outside"	0 1 2 3	0 1 2 3
b.	Posterior attachment "inside ear"	0 1 2 3	0 1 2 3

10. Intraoral muscle pain with palpation:

		RIGHT	LEFT
a.	Lateral pterygoid area "Behind upper molars"	0 1 2 3	0 1 2 3
b.	Tendon of temporalis "Tendon"	0 1 2 3	0 1 2 3

Appendix 2 – Information Letter

University of Alberta

Information Letter

Evaluation of Muscle Tenderness and General Pain Perception among Subjects with Temporomandibular disorders (TMD) alone, Subjects with TMD with Neck Disability and Controls

Academic Advisor/Investigator: Dr. David Magee, Professor in the Department of Physical Therapy, Faculty of Rehabilitation Medicine at the University of Alberta

Co-Investigator: Anelise Silveira, MSc student at the Faculty of Rehabilitation Medicine, University of Alberta

Purpose: Nowadays many people are developing muscle pain as a consequence of jaw problems. The majority of patients who have pain in their jaw also have pain in their neck muscles. However, the relationship between a jaw problem and neck muscle pain is not clear. Moreover, it is believed that people with jaw pain usually have a different pain sensibility when compared with people without jaw pain. Thus, your participation will allow us to have a stronger understanding of the relationship between neck pain and jaw problems as well as a better understanding of the general pain sensibility in people with jaw pain. Subsequently, your participation will also help us to improve the diagnosis and the treatment of patients with jaw and neck pain.

This study will consist of one diagnostic session of approximately one hour and a half. Please read the following information and decide if you want to participate.

Procedure: You will be evaluated by a qualified physical therapist to determine if you meet the inclusion criteriaor if you are excluded by the exclusion criteria for this study. According to the evaluation based on the RDC/TMD criteria (Axis I - Group I), you will be classified as having or not having mainly muscular TMD. According to the Neck Disability Index, you will be classified as having or not neck problems. Based on the results of both tools, you will be allocated into one of the following groups: *TMD Alone*: if you have signs and symptoms of TMD but without signs and symptoms of a neck disability; *TMD combined with neck disability*: if you are presented with signs and symptoms of TMD as well as with signs and symptoms of a neck disability; or *Controls*: if you do not present signs and symptoms of TMD nor signs and symptoms of neck problems.

The LDF-TMDQ will be used to measure your jaw function. This tool will detect if you present with limitations in your daily activities because of your jaw problem.

The study will utilize a tool called an algometer that will be used to detect your first sensation of pain. Before the examination, the procedure will be demonstrated on the investigator's hand and a practice trial will be performed on your forehead. Next, the algometer will be placed in your jaw, neck muscles and hand, and a pressure will be applied at a rate of 1KG/sec until you feel that the sensation of pressure is becoming the sensation of pain. When you feel this pressure, you will ask the investigator to stop the procedure. It is important to emphasize that the procedure is not painful; you will just feel the first sensation of pain.

Benefits: The benefit of participating in this study is that you will help us to understand if neck muscles are involved in jaw pain as well as how is the overall pain sensibility of people with jaw pain. Moreover, you will have a free evaluation of your jaw and neck muscles.

Risks: There are no known risk involved related to the procedure.

Privacy/confidentiality: All data will be kept private, except when codes of ethics or the law requires. The data you give will be kept for at least 5 years after the study is completed. The data will be kept in a locked filing cabinet. Your name or any other identifying data will not be attached to the data you generate by your test. Your name will never be used in any presentations or publications related to the study results.

Freedom to withdraw: your participation is completely voluntary. If at any time you wish to withdraw you are completely free to do so.

Contact information: If you have any questions, concerns or complaints regarding the study and procedures, please feel free to contact Dr. Joanne Velden (780-492-9674), Associate Dean – Research in the Faculty of Rehabilitation Medicine.

If you have any questions regarding the study you can contact Anelise Silveira (780-492-4824) or Dr. David Magee (780-492-5765).

Appendix 3 – Consent Form

Subjects Consent Form

Title of Project: **Evaluation of Muscle Tenderness and General Pain Perception among Subjects with Temporomandibular disorders (TMD) alone, Subjects Combined with TMD with Neck Disability and Controls** Part 1: Researcher Information		
Name of Principal Investigator/Supervisor: Dr. David Magee Affiliation: Professor and Associate Dean Contact Information: david.magee@ualberta.ca or (780) 492-5765		
Name of Co- Investigator: Anelise Silveira Affiliation: Master Student Contact Information: asilveir@ualberta.ca or (780) 492-4824		
Part 2: Consent of Subject		
	Yes	**No**
Do you understand that you have been asked to be in a research study?		
Have you read and received a copy of the attached information sheet?		
Do you understand the benefits and risks involved in taking part in this research study?		
Have you had an opportunity to ask questions and discuss the study?		
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not affect your care.		
Has the issue of confidentiality been explained to you? Do you understand who will have access to your records/information?		
Do you want the investigator(s) to inform your family doctor that you are participating in this research study? If so, please provide your doctor's name: ____ (This question is optional).		
Part 3: Signatures		
This study was explained to me by:______________________________ Date:______________________________		
I agree to take part in this study. Signature of Research Participant:______________________________ Printed Name:______________________________		
Witness (if available):______________________________ Printed Name:______________________________		
I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate. Researcher:______________________________ Printed Name:______________________________		

Appendix 4 – Jaw Dysfunction Index

ITEMS	1 No problem	2 Slightly difficult	3 Moderately difficult	4 Very difficult	5 Extremely difficult
How much does your present jaw problem prevent or limit you for talking for a long period of time including telephone conversations					
How much does your present jaw problem prevent or limit you from grinding thin foods					
How much does your present jaw problem prevent or limit you from prolonged chewing during meals					
How much does your present jaw problem prevent or limit you from activity at home, school, and/or work					
How much does your present jaw problem prevent or limit you from clenching teeth when participating in sports (contact teeth together during sports)					
How much does your present jaw problem prevent or limit you from opening your mouth widely					
How much does your present jaw problem prevent or limit you from yawning					
How much does your present jaw problem prevent or limit you from brushing your back teeth					
How much does your present jaw problem prevent or limit you from falling asleep					
How much does your present jaw problem prevent or limit you from sleeping through the night					

Appendix 5 – Neck Disability Index

Magee DJ. Orthopedic Physical Assessment. Fourth ed. Philadelphia: Saunders; 2002.

Neck Disability Index

This questionnaire has been designed to give the doctor information as to how your neck pain has affected your ability to manage in every-day life. Please answer every section and mark in each section only the ONE box which applies to you. We realize you may consider that two of the statements in any one section relate to you, but please just mark the box which most closely describes your problem.

Section 1 — Pain Intensity

- ☐ I have no pain at the moment. (0)
- ☐ The pain is very mild at the moment. (1)
- ☐ The pain is moderate at the moment. (2)
- ☐ The pain is fairly severe at the moment. (3)
- ☐ The pain is very severe at the moment. (4)
- ☐ The pain is the worst imaginable at the moment. (5)

Section 2 — Personal Care (Washing, Dressing, etc.)

- ☐ I can look after myself normally without causing extra pain. (0)
- ☐ I can look after myself normally but it causes extra pain. (1)
- ☐ It is painful to look after myself and I am slow and careful. (2)
- ☐ I need some help but manage most of my personal care. (3)
- ☐ I need help every day in most aspects of self care. (4)
- ☐ I do not get dressed, I wash with difficulty and stay in bed. (5)

Section 3 — Lifting

- ☐ I can lift heavy weights without extra pain. (0)
- ☐ I can lift heavy weights but it gives extra pain. (1)
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table. (2)
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned. (3)
- ☐ I can lift very light weights. (4)
- ☐ I cannot lift or carry anything at all. (5)

Section 4 — Reading

- ☐ I can read as much as I want to with no pain in my neck. (0)
- ☐ I can read as much as I want to with slight pain in my neck. (1)
- ☐ I can read as much as I want with moderate pain in my neck. (2)
- ☐ I cannot read as much as I want because of moderate pain in my neck. (3)
- ☐ I can hardly read at all because of severe pain in my neck. (4)
- ☐ I cannot read at all. (5)

Section 5 — Headaches

- ☐ I have no headaches at all. (0)
- ☐ I have slight headaches that come infrequently. (1)
- ☐ I have moderate headaches which come infrequently. (2)
- ☐ I have moderate headaches which come frequently. (3)
- ☐ I have severe headaches which come frequently. (4)
- ☐ I have headaches almost all the time. (5)

Section 6 — Concentration

- ☐ I can concentrate fully when I want to with no difficulty. (0)
- ☐ I can concentrate fully when I want to with slight difficulty. (1)
- ☐ I have a fair degree of difficulty in concentrating when I want to. (2)
- ☐ I have a lot of difficulty in concentrating when I want to. (3)
- ☐ I have a great deal of difficulty in concentrating when I want to. (4)
- ☐ I cannot concentrate at all. (5)

Section 7 — Work

- ☐ I can do as much work as I want to. (0)
- ☐ I can do my usual work, but no more. (1)
- ☐ I can do most of my usual work, but no more. (2)
- ☐ I cannot do my usual work. (3)
- ☐ I can hardly do any work at all. (4)
- ☐ I cannot do any work at all. (5)

Section 8 — Driving

- ☐ I can drive my car without any neck pain. (0)
- ☐ I can drive my car as long as I want with slight pain in my neck. (1)
- ☐ I can drive my car as long as I want with moderate pain in my neck. (2)
- ☐ I cannot drive my car as long as I want because of moderate pain in my neck. (3)
- ☐ I can hardly drive at all because of severe pain in my neck. (4)
- ☐ I cannot drive my car at all. (5)

Section 9 — Sleeping

- ☐ I have no trouble sleeping. (0)
- ☐ My sleep is slightly disturbed (less than 1 hr. sleepless). (1)
- ☐ My sleep is mildly disturbed (1–2 hrs. sleepless). (2)
- ☐ My sleep is moderately disturbed (2–3 hrs. sleepless). (3)
- ☐ My sleep is greatly disturbed (3–5 hrs. sleepless). (4)
- ☐ My sleep is completely disturbed (5–7 hrs. sleepless). (5)

Section 10 — Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all. (0)
- ☐ I am able to engage in all my recreation activities, with some pain in my neck. (1)
- ☐ I am able to engage in most, but not all, of my usual recreation activities because of pain in my neck. (2)
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck. (3)
- ☐ I can hardly do any recreation activities because of pain in my neck. (4)
- ☐ I cannot do any recreation activities at all. (5)

Scores (out of 50): 0–4 No disability
5–14 Mild disability
15–24 Moderate disability
25–34 Severe disability
>35 Complete disability

Appendix 6 - Algometer

Algometer - Tool that will measure the muscle tenderness and the overall level of pain of the subjects

(www.wagnerinstruments.com/force_gauges/fdk_mechanical_dial_force_gauge.php)

Figure 2 – Algometer

TEST STAND USE:	Mounting arrangements are provided for test stand use and for attachment of optional handles
TENSION / COMPRESSION:	Push and pull from opposite ends.
RUGGED CONSTRUCTION:	High impact plastic case, precision steel spring, brass mechanism, stainless steel plunger and accessories.
PEAK FORCE HOLD:	Push button maximum reading hold.
DIAL DISPLAY:	Large 2 ¼" dial with precise dual graduations in; Decimal Pound/Gram, Ounce/Gram, or Newton/Gram.
PLUNGER MOVEMENT:	10 mm (0.4") full scale deflection.
ACCESSORIES:	Included are three stainless steel attachments; flat, tension hook and extended point, case and manual.
COMPACT:	2 ¼" dial diameter: Net weight: 10 ounces.
ACCURACY:	± 2 Grads (thru 2500 gf), ± 1 Grad (over 2500 gf).

NIST Calibration Certificates are available for the FDK Series. The FDK/FDN is calibrated in the horizontal position to the stated accuracy using certified test weights

Appendix 7 – Poster Advertisement for TMD with Concurrent Neck Disability

VOLUNTEERS NEEDED FOR THE PROJECT:

"*Evaluation of Muscle Tenderness and General Pain Perception among Subjects with Temporomandibular disorders (TMD) alone, Subjects with TMD with Neck Disability and Controls*"

Do you have jaw pain?

Are you female?

Are you between 18 and 50 years old?

We invite you to participate in our study. We are evaluating the muscle tenderness of the jaw and neck muscles and overall pain sensitivity of people with jaw pain. This study will help people who suffer muscular pain in jaw and neck area. The entire procedure will take only 2 hours!!! The evaluation will take place at Corbett Hall, University of Alberta.

If you want to volunteer for this project or more information, please contact:
Anelise Silveira, by email (asilveir@ualberta.ca) or phone (780) 492-4824

Jaw and Neck Assessment
Anelise Silveira – (780) 492-4824
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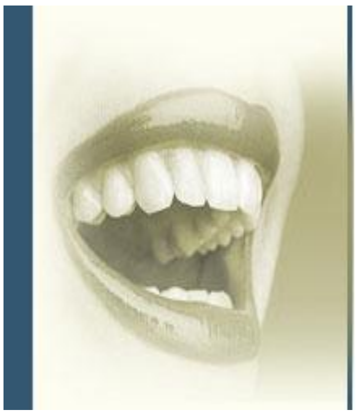
asilveir@ualberta.ca

Appendix 8 – Poster Advertisement for Healthy Controls

VOLUNTEERS NEEDED FOR THE PROJECT:

“*Evaluation of Muscle Tenderness and General Pain Perception among Subjects with Temporomandibular disorders (TMD) alone, Subjects with TMD with Neck Disability and Controls*”



Are you female?

Are you between 18 and 50 years old?

Are you healthy, with no pain or clinical pathology or previous surgery related to the masticatory system or neck?

We invite you to participate in our study. We are evaluating the muscle tenderness of the jaw and neck muscles and overall pain sensitivity of people with jaw pain as well as healthy controls. This study will help people who suffer muscular pain in jaw and neck area. The entire procedure will take only 2 hours!!! The evaluation will take place at Corbett Hall, University of Alberta.

If you want to volunteer for this project or more information, please contact:
Anelise Silveira, by email (asilveir@ualberta.ca) or phone (780) 492-4824

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