MASTICATORY PERFORMANCE IN THOSE WITH TEMPOROMANDIBULAR JOINT AND MUSCLE DISORDER

by

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Abstract

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Tempormandibular Joint and Muscle Disorder (TMJMD) occurs when dysfunction arises in the joints and muscles associated with the functionality of the jaw. Apart from many other complications, one of the problems that TMJMD patients face is difficulty in masticatory performance (i.e., chewing). A population of acute TMJMD patients (N = 408) participating in an early intervention treatment program was randomized into three intervention groups: a high-risk biobehavioral group, a high-risk self-care group; and a low-risk non-intervention group. These individuals were assessed for the purposes of elucidating predictors of masticatory performance and investigating the effectiveness of a biobehavioral intervention with individuals that have TMJMD with regard to their masticatory performance and the pain associated with it. The major findings of the present study were that facial pain was a significant predictor of chewing performance pain, b = .06, SE = .01, $t(379) = 9.16$, $p < .001$, $sr^2 = .18$, and that chewing performance pain decreased over time for all participants, *Mult.* $F(2, 152) = 65.60$, $p < .001$, partial η^2 = .46, Wilks' λ = .54. Overall, this study revealed that the effects of a biobehavioral intervention are most pronounced in the amount of pain that individuals experience while they are chewing.

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Chapter 1

Introduction

Temporomandibular Joint and Muscle Disorder

The temporomandibular joint is located on both sides of the skull and is positioned in front of each ear. It links the temporal bone to the mandible, allowing the jaw to move and facilitate the characteristic movements of the mouth such as talking, eating, and yawning. The functions of the temporomandibular joint are complex in that it enables both horizontal and vertical movements through sliding and bending motions, and, when dysfunction arises, a condition called Temporomandibular Joint and Muscle Disorder (TMJMD) can develop. Typically, there is not a singular cause to TMJMD; it appears to emerge from a variety of causes, often in combination, such as from a traumatic event, stress, or some other medical condition (e.g., bruxism; Demarin & Kes, 2010; Dworkin et al., 2002; NIDCR, 2010; Jerjes et al., 2008; Rodrigues et al., 2010).

TMJMD impairs jaw functioning and can cause pain in the associated joints and muscles; the pain that is characteristic of TMJMD has been linked to poor circulation and uncontrolled muscular activation surrounding the joint, which tends to lead to inflammation (Kitsoulis et al., 2011; Svensson et al., 1996). This muscular tension has the tendency to spread into other regions of the body and cause headaches and pain in areas such as the neck, shoulders, or ears (Jerjes et al., 2008; Wright et al., 2004). Keeping in line with the complex etiology of TMJMD, there are a variety of symptoms that can occur due to the disorder. The wide array of complications include, but are not limited to, orofacial pain, a restricted range of motion in the mandibular joints, and abnormal or audible jaw movements. (Demarin & Kes, 2010; Dworkin et al., 2002; NIDCR, 2010)

Despite the elusive nature of TMJMD's etiology, researchers have identified mechanisms that they suspect are the cause for some of the symptoms related to TMJMD. There appears to be primarily two main schools of thought: the Vicious Cycle Theory and the Pain Adaptation Model. The Vicious Cycle Theory explains the symptomatology of TMJMD as being the result of a type of domino effect, which starts from a triggering event, that perpetuates itself. The Pain Adaptation Model posits that, upon symptom presentation, the jaw joints and muscles adjust to functioning in a manner that is intended to prevent further dysfunction (e.g., avoiding jaw movements that exacerbate pain). Both the Vicious Cycle Theory and the Pain Adaptation Model have been supported and challenged by research, but it is suspected that a more integrative version of the Pain Adaptation Model, which includes the multifaceted nature of the pain experience, is needed to explain the mechanisms behind TMJMD. (Peck, Murray, & Gerzina, 2008)

TMJMD not only impairs the functionality of both the joints and muscles associated with the jaw but also afflicts individuals in other areas of their lives. Being that TMJMD can manifest itself in a variety of ways, it is not always apparent that the temporomandibular joint is where the dysfunction lies, and, due to this, TMJMD sufferers tend to spend copious amounts of money in an attempt to treat the symptoms of their TMJMD without truly pinpointing the root of the problem. In addition to paying for expensive treatments, many of those who suffer from the symptoms of TMJMD find that it also detracts from their livelihood such as by decreasing the amount of time spent at one's occupation or in the emergence or exacerbation of mental health issues (e.g., depression; Plesh, Adams, & Gansky, 2011).

Diagnosis

There is not a unanimously accepted, standardized method of diagnosing TMJMD due to its complex etiology and symptom presentation; however, the Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD) has garnered much acceptance and international use in objectively diagnosing and assessing TMJMD. Though useful, care must be taken in interpreting the diagnostic information gathered from the RDC/TMD. The RDC/TMD is not meant to be used as an exhaustive, singular diagnostic tool for every type of TMJMD, orofacial pain, or psychiatric condition (Dworkin, 2010); instead, its intended use is to provide a standardized method of identifying and classifying subgroups of TMJMD, using the biopsychosocial perspective, which can be replicated in research. Therefore, this diagnostic tool was utilized in the current study. (Garofalo, Gatchel, Wesley, & Ellis, 1998)

One of the strengths of the RDC/TMD lies in the comprehensive quality of its two axes: Axis I measures physical characteristics, and Axis II assesses psychosocial factors (Garofalo et al., 1998). Axis I measures the physical characteristics of TMJMD with regard to three groups: muscle disorders, disc displacements, and other joint conditions. The muscle disorders include the presence of myofascial pain and any limitations in opening the mouth associated with that pain. Disc displacements involve the abnormal placement of a disc in the jaw, which can occur with or without an audition, pain, or realignment upon opening the mouth. The other joint conditions that participants can be diagnosed with are arthralgia, osteoarthritis of the jaw joint, or osteoarthrosis of the jaw joint. (Ohrbach, 2010)

Axis II has five psychosocial measures related to TMJMD: depression, limitations related to mandibular functioning, chronic pain grade classification, painful somatization, and non-painful somatization. The items that measure depression are a

derivative of another depression scale (i.e., the Symptom Checklist 90), and the limitations of mandibular functioning items deal with activities, such as chewing or drinking, which may potentially involve pain. The chronic pain grade classification measure is a combination of the Characteristic Pain Inventory (CPI) score and various disability items; it indicates four grades, with the first grade representing both low disability and a low intensity of pain, and the fourth grade represents high disability and a severe level of pain. Lastly, both of the somatization measures gauge somatization tendencies with and without pain, respectively. (Ohrbach, 2010)

Both of the axes are represented in both portions of the RDC: the questionnaire section and the clinical examination. In the questionnaire section of the RDC, participants are asked various questions regarding the intensity and duration of the pain they experience as well as how or if it interferes with their daily, normal functioning. The response format is either a dichotomous "yes" or "no" response or a Likert scale response. In the clinical examination portion of the RDC, measurements are recorded of each participant's oral range of motion as well as any sounds or abnormalities associated with their jaw movements. The response format for the clinical examination portion includes measurements in millimeters, a notation of the presence or absence of jaw misalignments, and indications of the location of each measurement or sound recorded. After the assessment is administered, it is scored according to official guidelines provided by the Orofacial Pain Research Group at the University of Washington.

Prevalence Rate and Estimated Costs

It is suspected that up to 75 percent of Americans are affected by the symptoms associated with TMJMDs (Ingram et al., 2011; Rodrigues et al., 2010), and it has been documented that TMJMD-related symptoms make up 40 percent of all chronic conditions experienced in North America and Western Europe (Plesh et al., 2011). Therefore, it

would be beneficial to identify those who are at risk for progressing into chronicity, which is what the present study has been able to accomplish. The RDC/TMD is able to predict the likelihood of chronicity among those with TMJMD symptoms by calculating a risk score, which results in a designation of being either high risk or low risk; this score is determined by an algorithm that consists of combining one measure from each of the RDC axes (i.e., the presence of myofascial pain in Axis I and the CPI score in Axis II; Epker, Gatchel, & Ellis, 1999).

Research has shown that there are distinct characteristics among those who acquire TMJMD in terms of demographics. It has reported that racial differences in TMJMD diagnoses are moderated by age such that, at younger ages, Whites have the highest rate of the disorder when compared to other ethnicities of the same age, and Blacks have the highest rate of the disorder when the participants were older. In spite of these findings, however, these results have not been found consistently across research studies. It is suspected that racial differences among those with TMJMD are actually more indicative of treatment-seeking behavior and socioeconomic status. (Isong, Gansky, & Plesh, 2008; Plesh et al., 2011; Riley, Gilbert, & Heft, 2002)

Typically, reproductive females are diagnosed with TMJMD more often than are males (Isong et al., 2008; Gatchel, Stowell, Wildenstein, Riggs, & Ellis, 2006b). Over 80% of those receiving treatment for TMJMD are women, which supports the claim that a gender disparity exists (Demarin & Kes, 2010; Isong et al., 2008; Phillips, Gatchel, Wesley, & Ellis, 2001). This is suspected to be due to a number of reasons. For instance, elevated hormone levels in females may cause them to be more sensitive to stress and pain, and pain thresholds implicate that females may actually be less tolerant of pain. Furthermore, males and females express their symptoms differently, and,

consequently, females tend to report their symptoms in a different fashion than males. (Phillips et al., 2001)

Of the individuals that are affected, it is estimated that people are spending over $4 billion per year to treat their TMJMD symptoms (Dougall et al., 2012; Gatchel et al., 2006b). Such high costs are expended due to the multifaceted symptomatology of the disorder: TMJMD tends to manifest itself in various ways (i.e., depression, pain, restlessness, teeth grinding, etc.) that are not always consistent across those who are affected by it. Given the myriad of symptoms that emerge from TMJMD, its symptoms tend to mimic other medical conditions (Jerjes et al., 2008), and, thus, it is typical for TMJMD sufferers to seek treatment from numerous health professionals (i.e., physical therapists, physicians, dentists, psychiatrists, etc.), which, inevitably, imposes a financial burden on those who seek treatment (Wright et al., 2004).

Treatment

The methods typically used to treat TMJMD can be divided into two categories: invasive treatments and non-invasive treatments. Invasive treatments can include Botox injections, surgery, and implantation. Botox injections are not an approved method for treating TMJMD, but they have been approved for use in other muscle disorders. Therefore, it is suspected to be a viable option to alleviate the symptoms of TMJMD. Surgery provides a direct physiological modification of mandibular functioning. Surgical methods, however, can be dangerous in that they often involve a permanent change in one's bite or the resurfacing of one's teeth. Implants can be used to replace the faulty joint with an artificial material. Such material, though, has the possibility of being defective or malfunctioning over a long period of time. (NIDCR, 2010)

Non-invasive treatments are preferable over invasive treatments because they pose less of a threat to individuals in terms of permanent alterations in jaw functioning

and other adverse side effects. Non-invasive treatments include self-care methods, medication, and splints. Self care methods involve strategies that the affected individual can implement on his or her own such as: making a conscious effort not to consume foods that may exacerbate the condition, avoiding any exaggerated or repetitive motions in the jaw, and engaging in stress reduction. Non-invasive treatments can also include medication, such as non-steroidal anti-inflammatory drugs (NSAIDs) and muscle relaxants, to relieve the discomfort and pain associated with TMJMD. Another non-invasive treatment option is the use of splints, also known as bite guards, to stabilize the jaw; however, splints are not intended for long-term use. (Jerjes et al., 2008; NIDCR, 2010)

Masticatory Performance

Mastication is the process by which an individual breaks down food through chewing (Gambareli, Serra, Pereira, & Gaviao, 2007; Gatchel, Stowell, & Buschang, 2006a). This process must occur before digestion can take place, and, in the event that there is any debilitation or pain involved in one's ability to chew food, malnutrition can occur in that the afflicted individual may avoid foods that are difficult to chew yet are nutritious and necessary in maintaining a healthy diet (English, Buschang, & Throckmorton, 2002; Gatchel et al., 2006a). Mastication is a very complex activity: the bolus (i.e., the food structure) must be strategically transferred to different areas of the mouth in accordance to the sensory information that is gathered (e.g., from the texture of the food), the motions of the tongue, salivary involvement, amount and structure of teeth, and the degeneration of the bolus, which all needs to be integrated into a regulated motion that responds in tandem with the masticatory joints and muscles. Altogether, the intended result is the production of a concerted effort in pulverizing the bolus with

adequate strength (Gambareli et al., 2007; Olthoff, Van Der Glas, & Van Der Bilt, 2007; Yamashita, Hatch, & Rugh, 1999).

Given the characteristic joint and muscle complications, individuals with TMJMD may find that they need more time and more effort to chew their food, and, even still, TMJMD sufferers tend to have difficulty in grinding the food to a degree adequate for digestion (Felicio, Oliveira Melchior, Silva, Santos Celghini, 2007; Svensson et al., 1996). In fact, it has been shown that those who have TMJMD take longer to break down their food and don't break down their food with as much force as those who do not have TMJMD (Hansdottir & Bakke, 2004). Another factor that is essential in mastication is one's occlusion, which is the position that is maintained by the teeth when both the top and bottom jaws are in contact. Occlusion is particularly important because it dictates the chewing pattern; malocclusion, or a misalignment when the jaws come together, can result in an abnormal bite, which inevitably influences chewing ability (Yamashita et al, 1999).

Masticatory performance is an evaluation of mastication. The main determinants of masticatory performance have been found to be the following: the strength of the muscles in the jaw, the teeth, and the different masticatory movements (Lepley, Throckmorton, Ceen, & Buschang, 2011). These factors can be assessed using either natural foods or artificial test foods. It is preferable that test foods be used because natural foods provide inconsistent results being that they introduce issues of spoiling, allergic reactions, variable weights, and differences in texture (Gambareli, et al., 2007). Such issues are either reduced or altogether eliminated when using artificial test foods in that they are typically standardized materials specifically engineered to test mastication objectively. Some may call to question the applicability of the results garnered from studies that use test foods to assess masticatory performance, but there is evidence that

suggests that test foods are masticated in a manner similar to that displayed with natural foods. For example, Fontijn-Tekamp and colleagues (2004) compared three different types of natural foods to a test food material and found that the number of chewing cycles between the natural foods and the test food were highly related.

Purpose of the Current Study

To our knowledge, there is minimal research regarding masticatory performance in a population of those with acute TMJMD, and our overall goal with this study was to elucidate the factors that are involved in improving TMJMD sufferers' ability to chew food. Particularly, we suspect that the findings of this study will enhance the available treatment options for the disorder.

Predicting Masticatory Performance

The purpose of the current study was two-fold. The first purpose of this study was to elucidate predictors of masticatory performance. Given the characteristic dysfunctions displayed by those with poor masticatory performance (e.g., low bite force, longer chewing cycles, and pain), it was our goal to uncover predictors of masticatory performance in those with TMJMD. We suspected that these predictors would be functional health, stress, depression, and facial pain. In 2011, Ingram and colleagues found that there was a strong, positive relationship between functional health and masticatory performance. Functional health can be defined as one's ability to perform normal, everyday activities such as walking or bathing, and, given the wide-ranging effects of TMJMD, it is logical to assume that such activities would be adversely affected by TMJMD. Inasmuch, we expected that an improvement in functional health would afford an improvement in masticatory performance.

It is not uncommon to find that TMJMD sufferers are plagued by stress, which has the ability to encourage teeth grinding and clenching in the jaw (Uhac et al., 2006;

Rodrigues et al, 2010). Researchers have identified that stress occurs when the emotional, mental, or physical demands of an event supersedes an individual's ability to cope with the amount of energy and effort required to be expended (Cohen, Kessler, Underwood Gordon, 1994). There is speculation that the relationship between stress and TMJMD symptoms is linked to the amount of tension that is present both psychologically and physiologically in the afflicted individual and that stress is integral in perpetuating the symptoms of TMJMD (Wright et al., 2004); therefore, we expected than an increase in stress would be associated with a decrease in masticatory performance

Depression and pain also influence masticatory performance. In 2006(a), Gatchel and colleagues found that depression, as measured by the Beck Depression Inventory-II (BDI-II), was a significant predictor of masticatory performance, but this finding was not deemed to be clinically important due to their small sample size of only sixty-three participants. We suspected that, with the sample available in the current study, we would be able to discern a more meaningful effect. Also, Dougall and colleagues (2012) found that those with TMJMD do, indeed, experience pain during chewing, and such pain, as demonstrated in a study reported by Hansdottir and Bakke (2004), can cause individuals to restrain from certain jaw movements, which, we suspected, would undoubtedly affect masticatory performance. Furthermore, prior research (Gatchel et al., 2006b) has shown that a biobehavioral intervention does have the ability reduce pain as measured by the CPI, which can, in turn, increase the masticatory performance. Therefore, we expected masticatory performance to have a positive relationship with both depression and facial pain.

The Influence of a Biobehavioral Intervention on Mastication

The second purpose of the current study was to investigate the effectiveness of a biobehavioral intervention with individuals that have TMJMD with regard to their

masticatory performance. Those with TMJMD tend to experience pain during mastication in addition to having poor masticatory performance, which impairs their ability to break down foods adequately for digestion (Berretin-Felix, Genero, Trindade, & Trindade Junior, 2005; Felicio et al., 2007; Gatchel et al., 2006a; Hansdottir & Bakke, 2004; Pereira, Steenks, DeWijer, Speksnijder, & VanDerBilt, 2009). As demonstrated in prior research, a biobehavioral intervention is expected to be instrumental in managing the pain associated with TMJMD in order to allow for improved masticatory performance (Bernstein & Gatchel, 2000; Gardea, Gatchel, & Mishra, 2001). Particularly, we expected that, when making comparisons among individuals who are deemed to have acute TMJMD, those who are at a high risk for progressing into chronic TMJMD and receive the biobehavioral intervention would exhibit improved masticatory performance following the intervention as opposed to those who do not receive the intervention. Furthermore, we expected that, post-intervention, those who are at a high risk for developing chronic TMJMD would have either comparable or better masticatory performance than those who are at a low risk for chronicity.

Chapter 2

Methods

Participants

To be eligible for the current study, participants were required to meet the inclusion/exclusion criteria, which is as follows: participants must be 18 years old or older, had experienced jaw pain no more than six months prior to entering the study, had no history of chronic jaw or face pain, and had no co-morbid, pain exacerbating condition (e.g. fibromyalgia). We began recruitment for the parent study (see Figure 2-2) beginning in 2008; for the purposes of the current study, recruitment ended in 2013. Participants were individuals in the Dallas-Fort Worth Metroplex who were seeking treatment regarding their TMJMD symptoms. The participants gained entrance into the parent study in the following ways: with the help of referrals from affiliated personnel (e.g., community dental clinics); by flyers posted in the community which described the study; through word-of-mouth; internet advertisements; and through letters about the program disseminated to a mailing list. Before participation in the study began, participants were given a packet of information regarding the parent study and its purpose along with other pertinent information. They were required to initial each page of the packet in addition to putting their signature on the consent page, indicating that they had read and understood the preceding information. This consent form has been approved by the University of Texas at Arlington's (UTA's) Institutional Review Board (IRB).

Our sample was around middle age, $M = 44.25$, SD = 15.49, and, as shown in Table 2-1, mainly consisted of females, Caucasians, married individuals, those who were college-educated, and those at a high risk for developing chronic TMJMD. Each participant was treated ethically according to IRB regulations and was informed that participation was voluntary. Personally identifiable information was kept confidential

through identification numbers, and data were stored on secured networks and in locked cabinets.

Table 2-1 Frequency Statistics for Variables, *N* = 408

Variable	Frequency	(%)
Chronic Risk Status		
Low Risk	124	(30.4)
High Risk	211	(51.7)
Declined to Participate	27	(6.6)
Intent-to-Treat	46	(11.3)
Intervention Group		
High Risk/Biobehavioral	150	(36.8)
High Risk/Self Care	122	(29.9)
Low Risk/Non-Intervention	136	(33.3)
Race		
Caucasian	281	(68.9)
Latino (a)	46	(11.3)
African American	52	(12.7)
Asian	10	(2.5)
Other	15	(3.7)
Missing	1	(0.2)
System Missing	3	(0.7)
Years of Education		
0-12 Years	74	(18.1)
13-16 Years	241	(59.1)
17+ Years	87	(21.3)
System Missing	6	(1.5)
Gender		
Male	84	(20.6)
Female	324	(79.4)
Marital Status		
Single	129	(31.6)
Married	205	(50.2)
Divorced or Separated	56	(13.7)
Widowed	9	(2.2)
Missing	5	(1.2)
System Missing	4	(1)
Current Patient Status		
Pre-Intervention	63	(15.4)
Immediate Post Evaluation	66	(16.2)
12 Month Follow Up	85	(20.8)
24 Month Follow Up	139	(34.1)
Drop Outs	55	(13.5)

*Other consists of "Consented, but Ineligible", "Not Yet Assigned", "Ineligible/Exclusion Criteria", Eligible/Acute, But Declined to Participate", "Ineligible", "Risk Not Yet Determined", "Intent-to-Treat", and/or "Discharged".

Participant information is to be kept for at least three years after the research in the parent study has been completed, and access to the information affiliated with the parent study is limited to the Secretary of the Department of Health and Human Services, the UTA IRB, the Federal Drug Administration (FDA), and the research personnel.

Materials and Measures

Perceived Stress Scale

The Perceived Stress Scale (PSS) measures individuals' personal evaluation of how stressful events are that have occurred in the month prior to completing the scale. The PSS is able to capture one's subjective experience of stress as it relates to a particular event. It consists of ten items, and participants indicate their response on a five-point Likert scale from zero, a designated response of "never", to four, a designated response of "very often". The fourth, fifth, seventh, and eighth items were reversed scored in order to glean a consistent measure from the scale. Responses to all ten of the items were summed, producing a score ranging from zero to forty. A higher score was indicative of a relatively higher level of stress, and, in our sample, the PSS demonstrated high reliability, $\alpha = .91$. (Cohen et al., 1994)

Beck Depression Inventory-II

Though it is not intended for diagnostic purposes, the BDI-II was developed with the intention of being in harmony with the criteria for depression as stated in the Diagnostic and Statistical Manual of Mental Disorders (i.e., DSM-III-R and DSM-IV). Particularly, the BDI-II measures the intensity of the depressive symptoms that one is experiencing. This assessment contains twenty-one items to which respondents can select one of four answer options, from zero to three. The responses to each of these items were totaled to glean a possible maximum score of sixty-three. Higher scores

indicated more severe levels of depression, and, in our sample, the BDI-II rendered high reliability, α = .91. (Beck, Steer, Ball, & Ranieri, 1996)

Characteristic Pain Inventory

As mentioned earlier in this paper, pain is one of the characteristic symptoms of TMJMD, and, in order to get a measure of facial pain, the CPI was used. The CPI is a set of three questions included in the RDC/TMD. These questions ask participants to indicate their level of facial pain, from zero to ten, as related to the time at which the pain was experienced: the current pain at the present time, the worst pain at six months prior, and the average pain at six months prior. The responses to these three questions were averaged and then multiplied by ten to get a level of pain ranging from zero to one-hundred with higher levels corresponding to more pain. In our sample, the CPI showed high reliability, α = .79.

Physical Component Scale of the SF-36

The Short Form-36 (SF-36) is a health survey of thirty-six items that evaluates one's quality of life as a result of his or her current health and is composed of eight scales, which measure different facets of health as related to both physical (i.e., Physical Component Scale, PCS) and mental wellness (i.e., Mental Component Scale, MCS). The PCS gauges functional health and is largely determined by four of the eight scales: Physical Functioning, Role-Physical, Bodily Pain, and General Health. Scores range from zero to one-hundred, and the assessment was scored according to the established guidelines with lower scores indicating poorer functional health. (Ware, 2004)

CutterSil®

CutterSil® is a standardized, artificial test food material that consists of condensed silicone with negligible flavor, scent, or absorptive properties and can be preserved for a total of seven days in its original state; these characteristics make

CutterSil® a superior material in evaluating mastication (Albert, Buschang, & Throckmortion, 2003). CutterSil® is made at the Baylor College of Dentistry (BCD) and is produced into tablets in a Plexiglas template where the silicone material is left to harden for an hour. It is manufactured into small tablets that are five millimeters in thickness and twenty millimeters in diameter (Albert et al., 2003). Afterwards, a durometer (see Figure 2-1) is used to ensure the consistency of the hardness of each tablet. (English, Buschang, & Throckmorton, 2002)

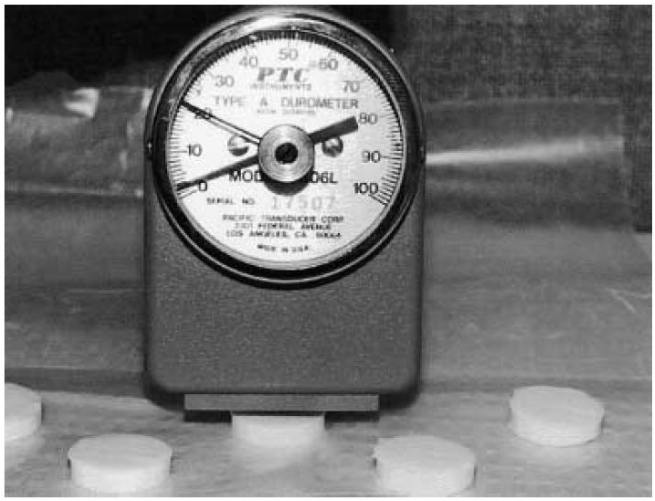

Figure 2-1 Durometer Assessing CutterSil® Tablets (Albert et al., 2003)

Once the tablets are chewed, the expectorated material is transferred to BCD where it is analyzed. The sample is placed in an oven where it is allowed to dry at 808^{o}C for an hour. Once the material has dried, the sample is filtered through seven mesh sieves of different sizes (0.25 mm, 0.425 mm, 0.85 mm, 2.0 mm, 2.8 mm, 4.0 mm, and 5.6 mm) with the vibration from a mechanical shaker, which vibrates for two minutes. Once the sample has filtered through a sieve, it is weighed to the nearest 0.01 gram. (English, Buschang, & Throckmorton, 2002)

Masticatory performance is quantified by the Rosin-Rammler equation: $Q_w = 100 [1-2^{-(x/x_{50})^b}]$. The "$Q_w$" represents the percentage of the weight of the sample that has a diameter that is less than "X", which is the sieve size. The "X_{50}" represents the median particle size (MPS) and is the amount of which fifty percent of the weight could pass through the sieve. The MPS is measured in millimeters and gives an indication of masticatory performance in that a small MPS is indicative of adequate breakdown of the test food material, which can give some implication of better nutritive absoprtion later on in the digestive process (Gatchel et al., 2006a). The "b" represents the broadness of the distribution (BD) of the sample. The BD has no real unit of measurement but serves as an indication of the variance of the sample. A small BD, which is associated with a wider distribution, indicates good masticatory performance. (English, Buschang, & Throckmorton, 2002)

Chewing Performance Evaluation

To get a measure of masticatory performance, participants are asked to chew five tablets of the artificial test food material (i.e., CutterSil®) on each side of their mouths, as they normally would natural food; this is done for twenty chews each. These chewing trials are timed, and, afterwards, participants are asked to expectorate the material into a dish. After the fifth chewing trial, participants are asked to indicate which side of their mouth felt the most comfortable during chewing as well as their level of pain from zero to ten. This pain measure together with both MPS and BD served as the variables from which we quantified masticatory performance.

Study Design

The current study used data gathered from participants that are involved in the parent study (see Figure 2-2), which is a longitudinal, intervention study. The parent study has an experimental design and is conducted by mental health professionals of the

Acute TMJMD Treatment Program at UTA. It is gravely important that such an intervention be introduced while the individual is still considered to be acute because, once the disorder progresses into chronicity, it can become resistant to treatment (Gatchel et al., 2006b) as well as increase the already-massive amount of costs typically used to treat the disorder (Wright et al., 2004).

The Acute TMJMD Treatment Program seeks to prevent those with acute TMJMD from progressing into chronicity, alleviate the symptoms of TMJMD, and provide a way for participants to manage their symptoms by using the principles of the biopsychosocial model. The biopsychosocial model explains health problems in terms of biological, psychological, and social etiological factors (Bernstein & Gatchel, 2000), and, inasmuch, it emphasizes that TMJMD is a multifaceted problem that will, likewise, require a multifaceted solution (Epker & Gatchel, 2000). A similar study (Gatchel et al., 2006b) administered an early biobehavioral intervention to acute TMJMD sufferers and conducted follow-up evaluations at a year post-intervention, and it was found that those who received the intervention experienced a reduction in pain, were better able to cope with their symptoms, and were not as emotionally distressed when compared to those who did not receive the intervention; these results suggest that the benefits to be gained from a biobehavioral intervention are long-lasting (Gardea et al., 2001).

After the participants have signed the consent form and are deemed eligible for the study, the baseline evaluation is completed, which includes the aforementioned assessments as well as others. Once the baseline evaluation has been administered, each participant is randomized into one of three intervention groups: biobehavioral, self-care, or non-intervention. The randomization process is dictated by each participant's chronic risk status such that high risk individuals will be randomized into either the

biobehavioral group (HR/BB) or the self-care group (HR/SC); all low risk individuals are assigned to the non-intervention group (LR/NI).

During the intervention phase, the self-care group is given educational materials about TMJMD as well as about ways to cope with their disorder through the following avenues: medication, more effective communication with medical professionals, and making healthy food choices. The HR/BB group receives a biobehavioral intervention, which includes cognitive behavioral therapy (CBT) and biofeedback (BFB). The intervention phase lasts for about three weeks, depending on the respective participant's schedule, and, afterwards, there are a series of post-intervention follow-up evaluations administered to all participants starting immediately after the intervention and then every three months for the duration of two years. Overall, 675 individuals are expected to be recruited into the parent study; this amount was determined by power analysis.

Biobehavioral Intervention

It has been established for quite some time that there is a link between chronic debilitations and psychosocial problems, and such a link has been found to be addressed by biobehavioral interventions. A biobehavioral intervention targets both biological and psychological aspects of health problems (Bernstein & Gatchel, 2000). Past research has shown that CBT and BFB are the most effective when used in combination with each other for the purpose of enhancing pain management capabilities, especially when treating individuals with TMJMD (Bernstein & Gatchel, 2000; Gardea et al., 2001; Gatchel, 2004; Gatchel et al, 2006b).

CBT is instrumental in helping patients identify the self-defeating, negative thoughts that can adversely influence their health. Once these thoughts have been identified, a trained therapist can aid the patient in correcting those thoughts and modifying them in such a way that will benefit his or her health instead of detracting from it; such methods involve

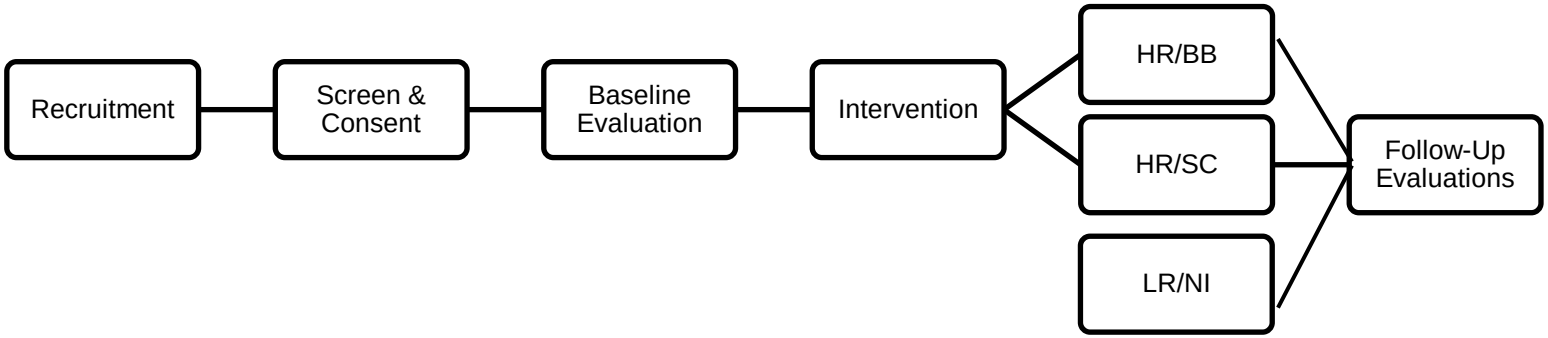

Figure 2-2 Parent Study Design

educating patients on different coping strategies and relaxation techniques. In the parent study, clinicians meet with the high risk participants for six sessions between the pre-intervention and immediate post-intervention assessments. During these sessions, the participants are taught a variety of skills including time management skills as well as relaxation techniques though breathing exercises and muscle relaxation activities.

BFB is a method used to manage pain. It involves a collection of techniques that allow a patient to visually discern his or her physiological responses (i.e., autonomic nervous system responses and muscular activity) as related to behaviors that are under volitional control. This can be done using electrical devices that can quantify such responses through sounds, numbers, or graphs. In this way, participants are made aware of how they can influence the way in which their body reacts in a manner that can reduce pain perceptions in accordance to the behaviors they exhibit. (Pulliam & Gatchel, 2003)

In the parent study, BFB is conducted using three different modalities: electromyography (EMG), respiration, and thermal detection. Sensors are placed on participants' temporalis muscle (i.e., the forehead), and an EMG graph, that is depicted on a laptop screen, shows a graphical display of the amount of tension present in the participants' forehead. For respiration measurements, a strain gauge, which is a rubber band-type instrument, is placed around the participants' abdominal area, and this device is able to measure both the quality and the frequency of breaths taken by the participant, which is also depicted in a graphical display to the participants. For thermal detection, a sensor is placed on the index finger of the participant to get a measurement of peripheral temperature: this gives an indication of the blood flow such that a higher temperature represents better blood flow.

Analytic Plan

All data were screened for violations to assumption before analyses were conducted. A doubly multivariate analysis of variance was used to test masticatory performance (i.e., MPS, BD, and chewing performance pain) among the intervention groups (i.e., HR/BB, HR/SC, and LR/NI) at three time points: pre-intervention (T1), post-intervention (T2), and 12-month follow-up (T3). This analysis was followed-up by multivariate analyses of variance and profile analyses. If an interaction was present, post-hoc analyses were conducted using the Holm-Bonferroni correction. A canonical correlation analysis was used to assess the predictive value of functional health (PCS), facial pain (CPI), depression (BDI), and stress (PSS) with regard to masticatory performance. This analysis was followed-up by multiple regressions.

Chapter 3

Results

Construction of Masticatory Performance Variables

In the parent study, measures of masticatory performance are recorded for both the left and right side of the mouth. We did not deem it as appropriate to test our hypotheses for both sides of the mouth due to the possibility of inflating type I error rates, but we also did not have an empirically-based justification for assessing one side over the other. Therefore, we decided to calculate the MPS and BD as well as to measure chewing performance pain for the side of the mouth that participants indicated was the most uncomfortable. In this way, when testing our hypotheses, we were able to get a more accurate depiction of the relationships involved with masticatory performance; that is, mastication is suspected to be an uncomfortable experience for TMJMD sufferers, but it should gradually become less uncomfortable as a result of our early intervention.

In the parent study, participants indicate which side of their mouth was most comfortable while performing the chewing performance task; for the current study, we recoded these identifications of comfort into identifications of discomfort. To ensure that analyzing the data in this way was statistically-sound, we first conducted chi square tests of independence for each time point and assessed the difference between the frequencies of occurrence among the identification of what side of the mouth was most comfortable (i.e., right, left, or both) while chewing on both the left and right side of the mouth, respectively, and, as expected, we found that there was a significant relationship between the frequencies of the identifications of comfort for both sides of the mouth at each time point: T1, $\chi^2(6, N = 426) = 55.47$, $p < .001$; T2, $\chi^2(4, N = 270) = 54.81$, $p < .001$; and T3, $\chi2(6, N = 174) = 27.55$, $p < .001$. Overall, these results suggested that the identification of comfort while chewing on one side of the mouth is related to the

identification of comfort while chewing on the other side of the mouth, and, therefore, recoding these measures into identifications of discomfort should maintain the integrity of the masticatory performance variables associated with that discomfort.

Table 3-1 Standardized Residuals for Side Most Comfortable

Side Most Comfortable When Chewing on the Left Side	Side Most Comfortable When Chewing on the Right Side		
	Right	Left	Equal for Both
T1			
Right	3.2**	-2.3*	-1.1
Left	-2.9**	3.6***	-1.2
Equal for Both	-0.7	-1.6	3.4***
T2			
Right	3.1**	-1.7	-1.1
Left	-1.3	2.7**	-2.0*
Equal for Both	-2.6**	-1.3	4.4***
T3			
Right	1.8	0	-1.4
Left	-0.6	1.7	-1.3
Equal for Both	-1.6	-1.7	3.0**

*$p < .05$; **$p < .01$; ***$p < .001$.

Being that we endeavored to recode indications of comfort into indications of discomfort, we expected the chi square tests of independence to reveal significantly more patients than expected by chance to indicate that the right side was most comfortable when chewing on the left side and that the left side was most comfortable when chewing on the right side. We also expected that significantly more patients than expected by chance who indicated that both sides were equally comfortable when chewing on the left side would also make this same indication when chewing on the right side. As shown in Table 3-1, the former expectation was not met, but the latter expectation was met. It is important to note that our expectations became more accurate as the participants progressed through the study; therefore, we were confident in our decision to reverse code the comfort measure.

We recoded the indications of comfort into indications of discomfort such that an indication that the same side was comfortable while chewing on either side of the mouth resulted in an indication of the opposite side as being uncomfortable. Both the indication that different sides of the mouth were comfortable when chewing on either side of the mouth and the indication that both sides were equally comfortable resulted in an indication that both sides were equally uncomfortable.

Chi square tests of independence were also conducted to determine differences between the frequencies of occurrence of intervention group assignment and the newly created variable of which side was most uncomfortable. There was a significant relationship at T1, $\chi 2(12, N = 427) = 30.166$, $p = .003$: significantly more patients who were in the HR/BB group indicated that the right side was most uncomfortable ($z = 2.6$, $p < .01$), and significantly more patients who were in the HR/SC group indicated that the left side was most uncomfortable ($z = 2.2$, $p < .05$). However, there was not a significant relationship present at either T2, $\chi 2(6, N = 270) = 6.86$, $p = .33$, or T3, $\chi 2(4, N = 174) = .40$, $p = .98$. These results further suggest that there is no statistical justification to favor one side over the other based on location (i.e., right versus left).

Table 3-2 Descriptive Statistics for Masticatory Performance Variables

Variable	T1		T2		T3	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Median Particle Size	3.81	(1.17)	3.77	(1.27)	3.77	(1.22)
Broadness of the Distribution	14.3	(14.03)	14.41	(14.96)	7.11	(6.23)
Chewing Performance Pain	3.75	(2.53)	2.29	(2.11)	1.43	(1.8)

Data Screening

Prior to testing the hypotheses, all data were screened for the following issues as was dictated by the respective analyses: plausible minimum and maximum values, missing values, both univariate and multivariate outliers, both univariate and multivariate

normality, homogeneity of variance-covariance, homoscedasticity, linearity, and multicollienarity. There were variables that had more than 5% of the data points missing, and, in order to determine the randomness of the missing values on these variables, we ran analyses that tested the difference between the missing and the non-missing values (cf. Tabachnick & Fidell, 2007). We recoded each variable into a dummy variable that had two groups: one with missing values and the other with non-missing values. Afterwards, independent sample *t* tests were conducted to assess the mean differences between the missing and non-missing values on each variable with regard to age. Each test rendered non-significant results with the exception of the BD variable at T3, $t(519) = 2.22$, $p = .03$.

Table 3-3 Descriptive Statistics for Psychosocial Variables

Variable	*M*	(*SD*)	Skew	(*SE*)	Kurtosis	(*SE*)
Perceived Stress Scale	15.66	(7.4)	0.15	(0.12)	-0.61	(0.24)
Characteristic Pain Inventory	56.22	(19.4)	-0.45	(0.12)	0.17	(0.24)
Beck Depression Inventory-II	8.74	(7.6)	1.20	(0.12)	1.47	(0.25)
Physical Component Scale	48.24	(8.7)	-0.82	(0.12)	0.33	(0.25)

Considering the aforementioned non-significant results along with the fact that the masticatory performance measures are often subject to unique complications (i.e., the data analysis results are imported from an auxiliary site, and a portion of the missing data results from an inability to complete the chewing task due to pain), we surmised that the pattern of our missing data was random. Also, there were two multivariate outliers for masticatory performance at T2, and there was one outlier for masticatory performance at T3. Some of the masticatory performance variables were positively skewed (see Table 3-2), and the appropriate transformations were performed: square root transformations for BD at T1 and T2 and for chewing performance pain at T2 and at T3; logarithm transformations for BD at T3. The psychosocial variables (see Table 3-3) used in the

analyses were also shown to be positively skewed; however, upon transformation, the measures became further skewed. Therefore, the original psychosocial variables were used in the analyses.

Predictors of Masticatory Performance

For the first hypothesis, we sought to discover predictors of masticatory performance. A canonical correlation was conducted between the set of psychosocial variables and the set of masticatory performance variables. The psychosocial variables were PSS, PCS, CPI, and BDI. The masticatory performance variables included MPS, BD, and chewing performance pain. All assumptions were met with the exception of the positively skewed masticatory performance variable. The analysis was conducted with and without the transformed variable, and both analyses revealed similar results. The results garnered from the original variables were maintained, and a total of 249 patients were included in the analysis.

It was found that the analysis was significant only when all three dimensions (i.e., MPS, BD, and chewing performance pain) were included, *Mult. F*(12, 630) = 6.73, $p < .001$, Wilks' $\lambda = .69$. The first canonical correlation ($r = .55$) had 29.78% overlapping variance, and the second canonical correlation ($r = .13$) had 1.66% overlapping variance. The third canonical correlation was effectively zero. To further assess the results from the canonical correlation, three multiple regressions were conducted to ascertain whether the psychosocial variables predicted each of the masticatory performance variables at T1. All assumptions were met for the analysis that assessed chewing performance pain, and the set of psychosocial variables did significantly predict chewing performance pain, $R^2 = .23$, $F(4, 326) = 24.20$, $p < .001$. Particularly, CPI was found to be the only significant predictor, $b = .06$, $SE = .01$, $t(326) = 8.14$, $p < .001$, $sr^2 = .16$, such that CPI was positively related to chewing performance pain. BDI was also found to have

marginal significance in predicting chewing performance pain, b = .04, SE = .02, t(326) = 1.91, p = .06, sr^2 = .009.

All assumptions were met for the analysis that included MPS, but it was not significant, R^2 = .01, F(4, 235) = .85, p = .50. Two outliers were found in the analysis that included BD, but the analysis was not significant either with or without the outliers. Furthermore, BD was positively skewed; yet, once again, the analysis was not significant regardless of if the transformed variable was used or if the original variable was used, R^2 = .02, F(4, 216) = 1.09, p = .36.

Differences in Masticatory Performance

Group Differences Across Repeated Measures of Masticatory Performance

For the second hypothesis, we sought to assess group differences across time with regard to masticatory performance. A doubly multivariate analysis of variance was conducted using the three measures of masticatory performance over three time points. A total of 19 participants were included in the analysis. Intervention group served as the between-subjects IV, and the within-subjects IV that was treated multivariately was the three time points at which masticatory performance was assessed.

All assumptions for this analysis were not met: there were three multivariate outliers, the masticatory performance measures were positively skewed, and the sample size included in the analysis was too small (i.e., there were less people in the smallest group than there were DVs). The analysis was conducted both with and without the outliers as well as both with and without the transformed variables, and both sets of analyses rendered identical results. Therefore, we analyzed the original variables. Furthermore, despite the assumption violation of sample size, the analysis revealed that masticatory performance differed significantly over the three time points among the groups (see Table 3-4).

Table 3-4 Means and Standard Errors for Doubly Multivariate Analysis

	HR/BB			HR/SC			LR/NI			TOTAL	
	M	(*SE*)	*N*	*M*	(*SE*)	*N*	*M*	(*SE*)	*n*	*M*	(*SE*)
			6			4			9		
MPS											
T1	4.62	0.45		3.83	0.55		3.13	0.37		3.86	0.27
T2	4.49	0.50		4.05	0.61		2.90	0.41		3.81	0.30
T3	4.25†	0.35		3.66	0.42		2.73†	0.28		3.55	0.21
	4.45	0.38		3.85	0.47		2.92	0.31			
BD											
T1	23.71	6.23		17.96	7.63		10.37	5.08		17.35^{a}	3.69
T2	23.89	6.53		18.27	8.00		10.80	5.34		17.65^{b}	3.88
T3	6.74	1.28		5.65	1.57		4.22	1.05		5.54^{a,b}	0.76
	18.11	4.31		13.96	5.74		8.46	3.52			
Chewing Performance Pain											
T1	4.17^{a,b}	0.90		5.00	1.11		2.00	0.74		3.72^{a}	0.54
T2	1.58^{a}	0.82		4.00	1.00		1.83	0.67		2.47^{a}	0.48
T3	1.08^{b}	0.62		2.75	0.76		0.33	0.50		1.39^{a}	0.37
	2.28	0.66		3.92	0.80		1.39	0.54			

Note. Letters indicate significant differences within columns; symbols indicate significant differences within rows.

There was not a significant interaction between time and group, *Mult.* $F(12, 22) = .71$, $p = .73$, partial $\eta^2 = .28$, Wilks' $\lambda = .52$, but there was a main effect of group, *Mult.* $F(6, 28) = 2.64$, $p = .04$, partial $\eta^2 = .36$, Wilks' $\lambda = .41$. This effect was significant for MPS, $F(2, 16) = 4.96$, $p = .02$, partial $\eta^2 = .38$. Using the Holm-Bonferroni correction, there was a marginally significant difference, which revealed that LR/NI patients had a smaller MPS than HR/BB patients ($p = .02$). All other pairwise comparisons were not significant. The main effect of group was only marginally significant for chewing performance pain, $F(2, 16) = 3.44$, $p = .06$, partial $\eta^2 = .30$, and there was no effect of group for BD, $F(2, 16) = 1.54$, $p = .24$, partial $\eta^2 = .16$.

There was a main effect of time, *Mult.* $F(6, 11) = 4.28$, $p = .02$, partial $\eta^2 = .70$, Wilks' $\lambda = .30$, and this effect was significant for BD, $F(2, 32) = 9.87$, $p < .001$, partial $\eta^2 = .38$. There was both a significant linear trend, $F(1, 16) = 13.23$, $p = .002$, partial $\eta^2 = .45$, and a significant quadratic trend, $F(1, 16) = 5.85$, $p = .03$, partial $\eta^2 = .27$, for BD, and results revealed that BD significantly decreased from T1 and T3 ($p = .007$) and from T2 to T3 ($p = .009$). The main effect of time also existed for chewing performance pain, $F(2, 32) = 13.62$, $p < .001$, partial $\eta^2 = .46$, and a significant linear trend was present, $F(1, 16) = 19.18$, $p < .001$, partial $\eta^2 = .55$. Results showed that chewing performance pain significantly decreased from T1 to T3 ($p = .001$), from T2 to T3 ($p = .02$), and from T1 to T2 ($p = .04$). All other pairwise comparisons were not significant, and there was no main effect of time for MPS, $F(2, 32) = 1.22$, $p = .31$, partial $\eta^2 = .07$.

Group Differences in Masticatory Performance

Being that the amount of participants included in the doubly multivariate analysis was alarmingly small compared to the amount of participants included in the study, we decided to follow up the doubly multivariate test with three between-subjects multivariate analyses of variance to assess masticatory performance at each time point

individually. For the analysis that was conducted at T1, all assumptions were met with the exception of the multivariate outliers and the positively skewed variables. The analyses were conducted with and without the three outliers as well as with and without the transformed variables, and there were identical results between the sets of analyses. Therefore, results with the original variables were maintained.

There was a main effect of group at T1, *Mult. F*(6, 492) = 8.63, $p < .001$, partial η^2 = .10, Wilks' λ = .82, and this result was followed up by a discriminant function analysis and a custom contrast. Two discriminant functions were calculated, and the first discriminant function accounted for 99.9% of the between-group variance in the solution. Chewing performance pain was shown to have the largest absolute size of correlation with the first function (r = .99). The combination of both functions was significant, χ^2 (6, N = 251) = 49.42, $p < .001$, and, once the first function was removed, the second function was not shown to be significant, χ^2 (2, N = 251) = .06, p = .97.

The custom contrast further revealed that there was a significant difference between the low risk group (LR/NI) and the high risk groups (HR/BB and HR/SC) on chewing performance pain ($p < .001$) such that LR/NI patients had a lower level of pain (M = 2.34, SE = .25) than the HR/BB patients (M = 4.58, SE = .25) and the HR/SC patients (M = 4.68, SE = .28), respectively. There was not a significant difference between the high risk groups (p = .78). Also, there was not a main effect of group neither for T2, *Mult. F*(6, 316) = .65, p = .69, partial η2 = .01, Wilks' λ = .98, nor for T3, *Mult. F*(6, 128) = .1.60, p = .15, partial η^2 = .07, Wilks' λ = .87.

Group and Time Effects on Masticatory Performance Variables

To further evaluate the results from the doubly multivariate analysis, three profile analyses were conducted for each masticatory performance variable across time by intervention group (see Table 3-5). For chewing performance pain, there were 156

participants included in the analysis, and the profiles deviated significantly from parallelism, *Mult. F*(4, 304) = 5.14, p = .001, partial η^2 = .06, Wilks' λ = .88. Results showed that HR/BB patients reported a significant decrease in chewing performance pain from T1 to T2 (p < .001), from T2 to T3 (p = .003), and from T1 to T3 (p < .001). For HR/SC patients, chewing performance pain decreased from T1 to T2 (p < .001) and from T1 to T3 (p < .001). For LR/NI patients, chewing performance pain significantly decreased from T1 to T2 (p < .001) and from T2 to T3 (p = .001). Also, the LR/NI group reported significantly less chewing performance pain when compared to both the HR/BB group (p < .001) and the HR/SC group (p < .001), respectively.

Furthermore, there were significant differences among groups for the levels test, *F*(2, 153) = 8.13, p < .001, partial η^2 = .10, such that the LR/NI group had significantly less chewing performance pain than the HR/BB group (p = .004) and the HR/SC group (p = .002), respectively. There was also a significant deviation from flatness, *Mult. F*(2, 152) = 65.60, p < .001, partial η^2 = .46, Wilks' λ = .54. All time points differed significantly from one another at the significance level of p < .001: there was a decrease in chewing performance pain from T1 to both T2 and T3, respectively, and from T2 to T3.

For BD, there were only 20 participants included in the analysis, and the profiles did not deviate significantly from parallelism, *Mult. F*(4, 32) = .59, p = .67, partial η^2 = .07, Wilks' λ = .87. However, using the Holm-Bonferroni correction, there was a marginally significant difference such that HR/BB displayed a significant decrease in BD from T1 to T3 (p = .02). For the levels test, there were no significant differences among groups, *Mult. F*(2, 17) = 1.54, p = .24, partial η^2 = .15. However, there was a significant deviation from flatness, *Mult. F*(2, 16) = 7.13, p = .01, partial η^2 = .47, Wilks' λ = .53, with both a significant linear trend, *F*(1, 17) = 13.43, p = .002, partial η^2 = .44, and a significant quadratic trend, *F*(1, 17) = 6.29, p = .02, partial η^2 = .27.

Table 3-5 Means and Standard Errors for Profile Analyses

	HR/BB			HR/SC			LR/NI			TOTAL	
	M	(*SE*)	*n*	*M*	(*SE*)	*n*	*M*	(*SE*)	*n*	*M*	(*SE*)
MPS											
			6			8			11		
T1	4.62	0.47		3.98	0.41		3.44	0.35		4.01	0.24
T2	4.49	0.50		4.31	0.43		3.24	0.37		4.01	0.25
T3	4.25	0.39		4.32	0.34		2.79	0.29		3.78	0.20
	4.45	0.39		4.20	0.34		3.16	0.29			
BD											
			6			5			9		
T1	23.71	6.15		15.31	6.74		10.37	5.02		16.46^{a}	3.47
T2	23.89	6.43		15.88	7.04		10.80	5.25		16.86^{b}	3.63
T3	6.74	1.28		5.01	1.40		4.22	1.04		$5.32^{a,b}$	0.72
	18.11	4.26		12.07	4.67		8.46	3.48			
Chewing Performance Pain											
			42			43			71		
T1	$4.60^{a,\dagger}$	0.34		$4.08^{a,b,\blacktriangle}$	0.34		$2.36^{a,\dagger,\blacktriangle}$	0.26		3.68^{a}	0.18
T2	2.38^{a}	0.32		2.49^{a}	0.32		$1.89^{a,b}$	0.25		2.26^{a}	0.17
T3	1.43^{a}	0.28		1.94^{b}	0.27		1.11^{b}	0.21		1.49^{a}	0.15
	$2.80^{\dagger}$	0.25		$2.84^{\blacktriangle}$	0.24		$1.79^{\dagger,\blacktriangle}$	0.19			

Note. Letters indicate significant differences within columns; symbols indicate significant differences within rows.

Using the Holm-Bonferroni correction, results showed that there was a significant decrease in BD from T1 to T3 (p = .006) and from T2 to T3 (p = .007).

For MPS, there were only 25 participants included in the analysis, and there was neither a significant deviation from parallelism, *Mult.* $F(4, 42) = .83$, $p = .51$, partial $\eta^2 = .07$, Wilks' $\lambda = .86$, nor a significant deviation from flatness, *Mult.* $F(2, 21) = .65$, $p = .54$, partial $\eta^2 = .06$, Wilks' $\lambda = .94$. There was a significant difference among groups, *Mult.* $F(2, 22) = 4.63$, $p = .02$, partial $\eta^2 = .30$.; however, using the Holm-Bonferroni correction, there were no significant differences in the pairwise comparisons.

Impact Analysis

Impact analyses were conducted to determine the differences in chewing performance pain over time and among groups. The percentage change from T1 to T2 with regard to chewing performance pain was computed by subtracting the T1 measure from the T2 measure, and the result was divided by the T1 measure. The mean of the percentages for the change from T1 to T2 revealed a decrease of 11.88%. By intervention group, the mean percentage of change was as follows: LR/NI (n = 107), 1.52% increase; HR/SC (n = 71), 28.51% decrease; and HR/BB (n = 81), 15.01% decrease. Being that the chewing performance pain measure was positively skewed, a Kruskal-Wallis test was conducted to assess group differences, but there were no significant group differences for the T1 to T2 percentage change, $H(2) = 3.05$, $p = .22$.

Table 3-6 Change Scores from Impact Analyses

	Improvement				
	30%		50%		
	<	≥	<	≥	Total Per Time Range
T1 to T2	126	133	147	112	259
T1 to T3	50	118	61	107	168

Furthermore, for the T1 to T2 change, it was found that 51.4% of patients had equal to or more than a 30% improvement (i.e., equal to or more than a 30% decrease in pain; see Table 3-6) while the remaining patients had less than a 30% improvement (i.e., less than a 30% decrease in chewing performance pain). A chi square test of independence revealed that there was not a significant relationship between the frequencies of intervention group and a 30% improvement, χ^2 (2, N = 259) = 4.38, p = .11, w = .13. We also assessed these differences at a 50% improvement. There were 43.2% of patients that had equal to or more than a 50% improvement while the remaining patients had less than a 50% improvement, but there was no relationship between group and the a 50% improvement, χ^2 (2, N = 259) = 2.67, p = .26, w = .10.

The percentage change was also calculated for the time between T1 to T3. The mean of the percentages from T1 to T3 revealed a 46.28% decrease in chewing performance pain. By group, the mean percentage changes were as follows: HR/BB (n = 44), 63.67% decrease; LR/NI (n = 79) 43.32% decrease; HR/SC (n = 45), 34.46% decrease. Once again, the measure was not normally distributed, and a Kruskal-Wallis test was used to assess group differences. It was found that there were no significant differences among groups for the T1 to T3 change, H(2) = 3.27, p = .20.

Table 3-7 Frequency Distribution of T1 to T3 30% Improvement by Group

	Intervention Group			
T1 to T3 Change ≥ 30% Improvement	HR/BB	HR/SC	LR/NI	Total
No	6	16	28	50
Yes	38	29	51	118

For the T1 to T3 change, it was found that 70.2% of patients had equal to or more than a 30% improvement while the remaining patients had less than a 30% improvement. A chi square test of independence revealed that there was a significant

relationship between group and a 30% improvement, χ^2 (2, N = 168) = 7.42, p = .03, w = .21, in that there were significantly fewer HR/BB patients than expected by chance who failed to reach at least a 30% decrease in chewing performance pain (z = -2.0, p < .05; see Table 3-7). These differences were also analyzed at a 50% improvement. There were 63.7% of patients that had equal to or more than a 50% improvement while the remaining patients that had less than a 50% improvement. However, there was no significant relationship between group and a 50% improvement, χ^2 (2, N = 168) = 1.56, p = .46, w = .10.

Chapter 4

Discussion

Mastication is one of the basic human functions that is integral to both physical and psychological well-being such that deficits in mastication can lead to malnutrition and a reduced quality of life. It is suspected that the TMJMD population is especially vulnerable to such a complication, and, thus, the overall goal of this study was to evaluate masticatory performance in participants with acute TMJMD as influenced by an early intervention treatment program. We sought to achieve this goal by assessing two hypotheses. First, we expected that psychosocial variables would serve as predictors of masticatory performance such that improved masticatory performance would be related to high levels of functional health and low levels of depression, stress, and facial pain. This hypothesis received partial support. Second, we expected that, as a result of the biobehavioral intervention, the HR/BB group would display improved masticatory performance when compared to the HR/SC group and comparable, if not better, masticatory performance when compared to the LR/NI group. This hypothesis was not supported.

Predictors of Masticatory Performance

For the first hypothesis, we found that, as a set, stress, functional health, facial pain, and depression predicted masticatory performance. Furthermore, our follow-up analyses revealed that the set of psychosocial variables were more predictive of chewing performance pain than of either BD or MPS. Specifically, we found that increasing and decreasing levels of facial pain corresponded to increasing and decreasing levels of chewing performance pain, respectively. This finding is similar to that of previous studies, which also found a positive relationship between TMJMD-related pain and

functional pain (i.e., pain while chewing; Dao, Lavigne, Charbonneau, Feine, & Lund, 1994; Gavish, Winocur, Ventura, Halachmi, & Gazit, 2002).

Facial pain was quantified using the CPI, which provides a global assessment of a participant's experience of pain in the facial region, and chewing performance pain indicates an experience of pain that is specifically tied to the activity of mastication. This suggests that the facial pain typically associated with TMJMD extends to specific activities in which the mouth is involved such as eating, talking, or yawning. The fact that the other psychosocial variables were not shown to have predictive value in any of the masticatory performance variables is surprising given all of the evidence that suggests otherwise (Gatchel et al, 2006a, Hansdottir & Bakke, 2004, Ingram et al., 2011; Rodrigues et al., 2010, Uhac et al., 2006, Wright et al, 2004).

Differences in Masticatory Performance

Group Differences Across Repeated Measures of Masticatory Performance

For the second hypothesis, our initial analysis suggested that masticatory performance was influenced by the intervention group to which participants were assigned and was separate from the influence of the time at which masticatory performance was assessed. In terms of a group effect, it appeared as though intervention group assignment influenced MPS and possibly, to a lesser extent, chewing performance pain. However, follow-up analyses rendered results that did not quite reach a level of statistical significance, and we could not infer how the groups differed. The strongest implications, relatively speaking, may be drawn from the effect of time on BD and chewing performance pain. For all participants, chewing performance pain decreased consistently over time, and, similarly, measures of BD were smaller at T3 than at either T1 or T2.

The finding that a strong linear trend existed for BD suggests that it steadily decreases over time, as shown in Table 3-4. Judging from these relatively stronger implications, it appeared as though the early intervention program may support gains in masticatory performance through the reduction of both BD and the pain associated with chewing. Although, taken together with the facts that this initial analysis rendered conflicting results and that only 19 participants out of a possible 408 were included in the analysis leaves much to be desired in regards to external validity and to how well these results actually reflect the condition of the sample we assessed.

Group and Time Effects

In hopes to gain a more accurate assessment of whether there was an actual effect of intervention group, time, or both on masticatory performance, we conducted follow-up analyses, which rendered more satisfactory sample sizes. Unfortunately, the analyses performed on BD and MPS, respectively, mimicked the frighteningly small sample size that was utilized in the initial analysis. With regard to these two measures, the only noteworthy result was the effect of time on BD, which, like the first analysis, revealed a strong linear trend: participants had a smaller BD at T3 than at either T1 or T2. The similarity in results is most likely due to similarities in the samples (i.e., it is possible that many of the same participants were used for both analyses).

The implication of this result remains questionable, but this finding does align with our expectations. Being that BD is a type of variance, a decrease in BD over time suggests that participants are able to pulverize the test food material in such a way that produces a broad distribution of particles that are of a consistent size following the intervention phase, which is indicative of improved masticatory performance. Prior research has shown that BD is inversely related to both the size of the contact area between the teeth and to the distance between the condyle and the first molar; this may

suggest that, due to participation in the study, participants are acquiring or regaining the formation of normal occlusion as well as increasing the range of motion of their jaw (Julien, Buschang, Throckmorton, & Dechow, 1996; Owens, Buschang, Throckmorton, Palmer, & English 2002).

All participants reported less chewing performance pain over time, but only those in the HR/BB group revealed a linear trend (i.e., the HR/SC group did not significantly differ in their report of pain from T2 to T3, and the LR/NI group did not significantly differ in their report of pain from T1 to T3). Based on these results, inferences regarding the intervention cannot be justifiably made. Generally speaking, it is expected that acute pain patients will undergo natural convalescence and improve over time; furthermore, we must also consider the therapeutic effects of factors that are associated with the intervention (e.g., attention, educational/clinical setting, expectation of improvement, etc.) which is suspected to make up at least a third of the explanation for improvement (Dao et al., 1994; Michelotti et al., 2004).

Furthermore, LR/NI participants reported a lower level of pain compared to both of the high risk groups at T1. This result is not surprising being that, by virtue of meeting the criteria for being at a low risk for progressing into chronicity, we would expect that LR/NI participants would report less pain than high risk individuals, especially prior to the administration of the intervention. Though this result does not support our hypothesis, it does encourage confidence in the algorithm (cf. Epker, Gatchel, & Ellis, 1999) used to differentiate low risk individuals from high risk individuals since, at the outset of the study, participants are reporting pain levels that are characteristic of their chronic risk status.

Contrary to our expectations, the high risk groups did not differ from each other, and the HR/BB group did not gain improvements in masticatory performance that either met or exceeded the level of improvement of the LR/NI group. A study with similar

findings suggests that, even though the difference between the high risk groups was not statistically significant, the difference may have clinical importance (Michelotti et al., 2004). As can be seen in Table 3-5, the HR/BB group does have consistently lower pain levels than the HR/SC group following the intervention, which may imply practical significance for the population of acute TMJMD patients that experiences pain while chewing.

Impact Analysis

As an exploratory procedure, we also conducted analyses that assessed the impact of our early intervention program on the chewing performance pain experienced by acute TMJMD patients. Particularly, we assessed the change in chewing performance pain between T1 and T2 as well as between T1 and T3. There existed a mean percentage decrease in pain for all participants for both time ranges with the most substantial reduction in pain evident between T1 and T3: after one year, the chewing performance pain that participants experience at the outset of the study is nearly cut in half. The fact that the decrease in pain was sustained one year following the intervention supports the findings that the benefits of a biobehavioral intervention extend past immediate outcomes into long-term effects (Gardea et al., 2001; Gatchel et al., 2006b; Medlicott & Harris, 2006). Mean percentage decreases in pain were also shown within each group.

For the T1 to T2 change, the largest decrease in pain was reported by the HR/SC group, which was followed by the HR/BB group. Also, the LR/NI group actually revealed a slight increase in pain. These findings are peculiar being that we would expect the largest reduction of pain to be shown in the HR/BB group and participants would all decrease in pain over time. For the T1 to T3 change, the largest decrease in pain was reported by the HR/BB group, which was followed by the LR/NI group and then

by the HR/SC group. Once again, this finding contrasts the expected hierarchy of improvement; however, it is important to note that in both the change from T1 to T2 and from T1 to T3, the HR/BB group consistently exceeded the LR/NI group in pain reduction, which further supports the long-term effects of a biobehavioral intervention.

This finding gives credence to the fact that a biobehavioral intervention supports good masticatory functioning. This suggests that the pain that is associated with mastication in these TMJMD patients has an etiology that exceeds the physical debilitation of jaw dysfunction and that treatment methods, such as a biobehavioral intervention, are needed that can address the psychological aspects of pain (Bernstein & Gatchel, 2000; Gardea et al., 2001; Gatchel, 2004; Gatchel et al, 2006b).

Furthermore, we found that, from T1 to T2, the majority of participants experienced at least a 30% reduction in pain but less than a 50% reduction in pain. From T1 to T3, the majority of participants experienced at least a 30% reduction in pain, and there weren't as many HR/BB participants that were below this level of reduction in pain as would be dictated by chance. This finding is promising because it seems to suggest that the biobehavioral intervention provides HR/BB participants with an advantage that goes against the odds. Additionally, most participants experienced at least a 50% decrease in chewing performance pain from T1 to T3.

Conclusion on Masticatory Performance and TMJMD

The current study is novel in that it is one of the few research studies that includes a measure of chewing performance pain in its assessment of masticatory performance. Oddly enough, its inclusion has been at the forefront of the major findings of this study. It is clear that masticatory performance is vital to both health and the quality of life, which warrants a method of treatment that can serve to improve masticatory functioning in TMJMD patients. This study revealed that the effects of an early

intervention treatment program, which includes a biobehavioral intervention, for individuals with acute TMJMD is most pronounced in the amount of pain that individuals experience while they are chewing: the evidence consistently showed a decrease in pain across time and within each group. Further research needs to be conducted to evaluate how other measures of masticatory performance, such as MPS and BD, are affected by a biobehavioral intervention, but, overall, this study suggests that masticatory functioning is improved upon implementation of such an intervention.

References

Beck, A.T., Steer, R.A., Ball, R., & Ranieri, W.F. (1996). Comparison of Beck depression inventories –IA and –II in psychiatric outpatients. *Journal of Personality Assessment*, 67(3), 588-597.

Bernstein, D.N. & Gatchel, R.J. (2000). Biobehavioral predictor variables of treatment outcome in patients with Temporomandibular disorders. *Journal of Applied Biobehavioral Research*, 5(2), 101-113.

Berretin-Felix, G., Genaro, K.F., Trindade, I.E.K., & Trindade Junior, A.S. (2005). Masticatory function in temporomandibular dysfunction patients: Electromyographic evaluation. *Journal of Applied Oral Science*, 13(4), 360-365.

Cohen, S., Kessler, R. C., & Underwood Gordon, L. (1994). Perceived stress scale. Measuring Stress: A Guide for Health and Social Scientists.

Dao, T.T.T., Lavigne, G.J., Charbonneau, A., Feine, J.S., & Lund, J.P. (1994). The efficacy of oral splints in the treatment of myofascial pain of the jaw muscles: a controlled clinical trial. *Pain*, 56, 85-94.

Demarin, V., & Kes, V. B. (2010). Temporomandibular disorders and migraine headache. *Medical Sciences*, 34, 111-117.

Dougall, A.L., Jimenez, C.A., Haggard, R.A., Stowell, A.W., Riggs, R.R., & Gatchel, R.J. (2012). Biopsychosocial factors associated with the subcategories of acute temporomandibular joint disorders. *Journal of Orofacial Pain*, 26(1), 7-16.

Dworkin, S.F., Huggins, K. H., Wilson, L., Mancl, L., Turner, J., Massoth, D., . . . Truelove, E. (2002). A randomized clinical trial using research diagnostic criteria for temporomandibular disorders-axis II to target clinic cases for a tailored self-care TMD treatment program. *Journal of Orofacial Pain*, 16(1), 48-63.

Dworkin, S. F. (2010). Research diagnostic criteria for temporomandibular disorders:

Current status and future relevance. *Journal of Oral Rehabilitation*, 37, 734-749. doi: 10.1111/j.1365-2842.2010.02090.

English, J.D., Buschang, P.H., Throckmorton, G.S. (2002). Does malocclusion affect masticatory performance? *Angle Orthodontist*, 72(1), 21-27.

Epker, J., & Gatchel, R. J. (2000). Prediction of treatment-seeking behavior in acute TMD patients: Practical application in clinical settings. *Journal of Orofacial Pain*, 14(4), 303-309.

Epker, J., Gatchel, R.J., & Ellis, E. (1999). A model for predicting chronic TMD: Practical application in clinical settings. *Journal of the American Dental Association*, 130, 1470-1475.

Felicio, C.M., Oliveira Melchior, M., Silva, M.A.M.R., & Santos Celeghini, R.M. (2007). Masticatory performance in adults related to temporomandibular disorder and dental occlusion. *Pro-Fono Revista de Atualizacao Cientifica*, 19(2), 151-158.

Fontijn-Tekamp, van der Bilt, A., Abbink, J.H., & Bosman, F. (2004). Swallowing threshold and masticatory performance in dentate adults. *Physiology & Behavior*, 83(3), 431-436.

Gambareli, F.R., Serra, M.D., Pereira, L.J., & Gaviao, M.B.D. (2007). Influence of measurement technique, test food, teeth and muscle force interactions in masticatory performance. *Journal of Texture Studies*, 38, 2-20.

Gardea, M.A., Gatchel, R.J., & Mishra, K.D. (2001). Long-term efficacy of biobehavioral treatment of temporomandibular disorders. *Journal of Behavioral Medicine*, 24(4), 341-359.

Garofalo, J. P., Gatchel, R. J., Wesley, A. L., & Ellis, E. (1998). Predicting chronicity in acute temporomandibular joint disorders using the research diagnostic criteria. *Journal of the American Dental Association*, 129, 438-447.

Gatchel, R.J. (2004). Biofeedback as an adjunctive treatment modality in pain management. *APS Bulletin*, 14(4).

Gatchel, R.J., Stowell, A.W., & Buschang, P. (2006a). The relationships among depression, pain, and masticatory functioning in Temporomandibular disorder patients. *Journal of Orofacial Pain*, 20(4), 288-296.

Gatchel, R. J., Stowell, A. W., Wildenstein, L., Riggs, R., & Ellis, E. (2006b). Efficacy of an early intervention for patients with acute temporomandibular disorder-related pain: A one-year outcome study. *Journal of the American Dental Association*, 137, 339-347.

Gavish, A., Winocur, E., Ventura, Y.S., Halachmi, M., & Gazit, E. (2002). Effect of stabilization splint therapy on pain during chewing in patients suffering from mysofascial pain. *Journal of Oral Rehabilitation*, 29, 1181-1186.

Hansdottir, R. & Bakke, M. (2004). Joint tenderness, jaw opening, chewing velocity, and bite force in patients with Temporomandibular joint pain and matched healthy control subjects. *Journal of Orofacial Pain*, 18(2), 108-113.

Ingram, M., Choi, Y.H., Haggard, R., Dougall, A.L., Gatchel, R.J., Buschang, P., & Chiu, C. (2011). Use of the minimal clinically important difference (MCID) for evaluating treatment outcomes with TMJMD patients: A preliminary study. *Journal of Applied Biobehavioral Research*, 16, 148-146.

Isong, U., Gansky, S. A., & Plesh, O. (2008). Temporomandibular joint and muscle disorder-type pain in US adults: the national health interview survey. *Journal of Orofacial Pain*, 22(4), 317-322.

Jerjes, W., Upile, T., Abbas, S., Kafas, P., Vourvachis, M., Rob, J. … Hopper, C. (2008). Muscle disorders and dentition-related aspects in temporomandibular disorders: controversies in the most commonly used treatment modalities.

International Archives of Medicine, 23(1).

Julien, K.C., Buschang, P.H., Throckmorton, G.S., & Dechow, P.C. (1996). Normal masticatory performance in young adults and children. *Archives of Oral Biology*, 41(1), 69-75.

Kitsoulis, P., Marini, A., Iliou, K. Galani, V., Zimpis, A., Kanavaros, P., & Paraskevas, G. (2011). Signs and symptoms of temporomandibular joint disorders related to the degree of mouth opening and hearing loss. *BMC Ear, Nose and Throat Disorders*, 11(5), 1-8.

Lepley, C.R., Throckmorton, G.S., Ceen, R.F., & Buschang, P.H. (2011). Relative contributions of occlusion, maximum bite force, and chewing cycle kinematics to masticatory performance. *American Journal of Orthodonitics and Dentofacial Orthopedics*, 139(5), 606-613.

Medlicott, M.S. & Harris, S.R. (2006). A systematic review of the effectiveness of exercise, manual therapy, electrotherapy, relaxation training, and biofeedback in the management of temporomandibular disorder. *Physical Therapy*, 86, 955-973.

Michelotti, A., Steenks, M.H., Farella, M., Parisini, F., Cimino, R., & Martina, R. (2004). The additional value of a home therapy regimen versus patient education only for the treatment of myofascial pain of the jaw muscles: Short-term results of a randomized clinical trial. *Journal of Orofacial Pain*, 18(2), 114-125.

NIDCR, NIH. (2010). TMJ Disorders. Retrieved from http://www.nidcr.nih.gov/OralHealth/Topics/TMJ/TMJDisorders.htm.

Ohrbach, R. (2010). Assessment and further development of RDC/TMD Axis II biobehavioural instruments: A research programme progress report. *Journal of Oral Rehabilitation*, 37, 784-798.

Olthoff, L.W., Van Der Glass, H.W., & Van Der Bilt, A. (2007). Influence of occlusal vertical dimension on the masticatory performance during chewing with maxillary splints. *Journal of Oral Rehabilitation*, 34, 560-565.

Owens, S., Buschang, P.H., Throckmorton, G.S., Palmer, L., & English, J. (2002). Masticatory performance and areas of occlusal contact and near contact in subjects with normal occlusion and malocclusion. *The American Journal of Orthodontics and Dentofacial Orthopedics*, 121(6), 602-609.

Peck, C.C., Murray, G.M., & Gerzina, T.M. (2008). How does pain affect jaw muscle activity? The integrated pain adaptation model. *Australian Dental Journal*, 53, 201-207.

Pereira, L.J., Steenks, M.H., DeWijer, A., Speksnijder, C.M., & VanDerBilt, A. (2009). Masticatory function in subacute TMD patients before and after treatment. *Journal of Oral Rehabilitation*, 36, 391-402.

Phillips, J., Gatchel, R. J., Wesley, L., & Ellis, E. (2001). Clinical implications of sex in acute temporomandibular disorders. *The Journal of the American Dental Association*, 132, 49-57.

Plesh, O., Adams, S. H., & Gansky, S.A. (2011a). Racial/ethnic and gender prevalences in reported common pains in a national sample. *Journal of Orofacial Pain*, 25(1), 25-31.

Pulliam, C.B. & Gatchel, R.J. (2003). Biofeedback 2003: Its role in pain management. *Critical Reviews in Physical and Rehabilitation Medicine*, 15(1), 65-82.

Riley, J.L., Gilbert, G.H., & Heft, M.W. (2002). Orofacial pain: Racial and sex differences among older adults. *Journal of Public Health Dentistry*, 62(3), 132-139.

Rodrigues, J.H., Blasotto-Gonzalez, D.A., Bussadori, S.K., Mesquita-Ferrari, R.A.,

Fernandes, K.P.S., Tenis, C.A., Martins, M.D. (2010). Signs and symptoms of Temporomandibular disorders and their impact on psychosocial status in non-patient university student's population. *Physiotherapy Research International*, 17, 21-28.

Svensson, P., Arendt-Nielsen, L., Bjerring, P., Bak, P., Hjorth, T., & Troest, T. (1996). Human mastication modulated by experimental trigeminal and extra-trigeminal painful stimuli. *Journal of Oral Rehabilitation*, 23, 838-848.

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Allyn & Bacon.

Uhac, I., Kovac, A., Muhvic-Urek, M., Kovacevic, D., Franciskovic, T., Simunovic-Soskic, M. The prevalence of temporomandibular disorders in war veters with post-traumatic stress disorder. *Military Medicine*, 171(11), 1147-1149.

Ware, J.E. (2004). SF-36 Health Survey Update. In M. Marush (Ed.), *The use of psychological testing for treatment planning and outcome assessment* (pp. 693-718). New Jersey: Lawrence Erlbaum Associates.

Wright, A.R., Gatchel, R.J., Wildenstein, L., Riggs, R., Buschang, P., & Ellis, E. (2004). Biopsychosocial differences between high-risk and low-risk patients with acute TMD-related pain. *Journal of the American Dental Association*, 135, 474-483.

Yamashita, S., Hatch, J.P., & Rugh, J.D. (1999). Does chewing performance depend upon a specific masticatory pattern? *Journal of Oral Rehabilitation*, 26, 547-553.

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