Sleep and Depression as Risk Indicators for Temporomandibular Disorders in a Cross-Cultural Perspective: A Case-Control Study

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Purpose: We conducted this case-control study to determine the role of 2 neuropsychologic variables (sleep and depression) as possible risk indicators for the development of temporomandibular disorders (TMD). ***Materials and Methods:*** Neuropsychologic tests, traditional signs and symptoms of TMD, and social and economic variables were analyzed. Seventy-two predominantly muscle-related TMD patients (Research Diagnostic Criteria for TMD groups Ia, Ib, and IIIa) and 30 age- and sex-matched pain-free controls were included in the population. ***Results:*** Overall, TMD patients had statistically significantly higher sleep and depression scores on the Sleep Assessment Questionnaire and on the Brazilian Portuguese version of the Beck Depression Inventory, with odds ratios of 5 and 1.6, respectively. These results remained unchanged even after controlling for 8 confounders in the logistic regression analysis. Spontaneous pain and pain on palpation (grade 2 or higher) were also statistically significantly worse in TMD patients. In the forward-step logistic regression analysis, we also found that the combination of our best TMD predictors (ie, sleep, cigarettes, alcohol) had a better predictive value (percent agreement = 78.69%) than when the variables were analyzed alone. ***Conclusion:*** Sleep and depression are considered important risk indicators for the development of TMD. *Int J Prosthodont 2006;19:154–161.*

Recent evidence supports the biopsychosocial model for chronic temporomandibular disorders (TMD) pain, regardless of origin, with emphasis placed more on centrally mediated factors than on possible local causes. Engineering data suggest that TMD are chronic pain conditions that share many common features (ie, pain parameters, disability, gender, and age distribution) with other chronic pain conditions, such as headaches, back pain, and irritable bowel syndrome.[1,2] Consequently, neuropsychologic assessment in TMD studies has received increased attention, and the multifactorial etiology of TMD and the complete examination of all physical, emotional, and behavioral factors involved in the disease are increasingly emphasized.[3] Some studies have shown that depression and somatization have been heavily implicated in chronic pain, including TMD.[4–6] Indeed, in one longitudinal treatment outcome study, sleep disorders and depression were implicated as perpetuating factors in nonresponding TMD patients.[7]

Therefore, the main objective of this study was to clarify the role of 2 neuropsychologic variables—sleep and depression—both alone and in combination in the etiology of temporomandibular disorders in an analytic (case-control) study. In addition, we compared our results in a southern Brazilian sample of patients with those of a previous study with similar methodology in a Canadian sample and compared our methodology cross-culturally.[7]

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Materials and Methods

Inclusion and Exclusion Criteria

Patients selected for the study were those newly diagnosed in the Orofacial Pain Clinic at the Pontifical Catholic University of Rio Grande do Sul (PUCRS) Dental School, Brazil. The target population, based on the history and clinical examination guidelines of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), was patients with muscle disorders (groups Ia and Ib), including myofascial pain with or without limited opening, as well as those with arthralgia (group IIIa).[8,9] In addition, we only selected women between the age of 15 and 45 years to eliminate age and gender as confounders in the study.

Patients were excluded from the study based on medical history if they were diagnosed with acute muscle spasm, myositis, contracture, polyarthritis (osteoarthritis and osteoarthrosis), and acute traumatic injury. In addition, patients with medical and/or dental emergencies; metabolic diseases (eg, diabetes, hyperthyroidism); neurologic disorders (eg, dyskinesia, trigeminal neuralgia); vascular disease (eg, migraine, hypertension); neoplasia; history of psychiatric disorders; history of drug abuse; motor vehicle accidents; or currently receiving medication or other treatments (eg, acupuncture, physical therapy) were also excluded. Regarding pain medication, only those patients taking those with effects on the central nervous system (eg, muscle relaxants, anticonvulsants, antidepressants) were excluded. Patients taking pain medication such as analgesics and anti-inflammatories were included, but a washout period of 3 days prior to neuropsychologic (sleep and depression) testing was required. Finally, patients with reported major visual, auditory, and motor impairments were also excluded, because this might have affected test performance.[7,10,11]

A concurrent internal control group was required for comparison to determine how well the southern Brazilian sample compared to other groups tested previously.[12] The volunteers were to have no pain (acute or chronic) complaints, but instead came to the Faculty of Dentistry for restorative procedures; therefore, controls were selected from the same source (the Dental School) as the TMD patients to have comparable groups.[13] The exclusion criteria were the same described for the TMD group, with the additional exclusion criterion of previous treatment for chronic pain conditions.

This study had the patients' written consent and the approval of the São Lucas Hospital Human Ethics Committee at the Pontifical Catholic University of Rio Grande do Sul, Brazil.

Sleep and Depression Assessment

The neuropsychologic assessment was made only for sleep and depression; these variables were chosen because they have shown to be good predictors of treatment outcome in patients with TMD.[7,14–16] To assess depression, the long form of the Beck Depression Inventory (BDI) (scores 0 to 63), translated into Brazilian Portuguese with permission (Casa do Psicológo, Brazil, and The Psychological Corporation, USA) and validated, was used.[17,18] The test's norms and its reliability and reproducibility have been extensively reviewed.[17,19] To assess sleep, the validated (polysomnography) 19-item self-administered Sleep Assessment Questionnaire (SAQ) was used, which was translated into Brazilian Portuguese with permission of the authors. Normative data, test description, and its reproducibility and validity have also been published in the literature.[20] The tests were supervised by a single blinded clinical psychologist.[19]

History and Clinical Examination

Social and demographic information as well as the pain symptom questionnaire were self-completed and supervised by 2 clinicians involved in the study. To assess clinical signs (clinical examination form) of TMD, a third independent specialist in the area of orofacial pain, who did not participate in the neuropsychologic testing and symptom questionnaire and who was blinded to both the TMD and the pain-free groups, was chosen.[21]

The examination for signs and symptoms of TMD was based on the standardized RDC/TMD. Subjects entering this investigation underwent extraoral examination, including palpation of the temporomandibular joint (TMJ) (lateral pole), masseter, temporalis, and sternocleidomastoid. All scores assigned were based on the patient's evoked pain reaction when specific muscle and joint sites were palpated. Intraoral examination included: *(1)* maximum unassisted mandibular opening, *(2)* percussion sensitivity, and *(3)* caries to rule out pain from dentoalveolar etiology.[8]

Pain intensity at rest and on chewing were also assessed with 100-mm visual analogue scales (VAS). Anchors to both scales were labeled as "no pain" and "extremely severe pain."[7] The validity and reliability of these scales have been described elsewhere.[22] In addition, other pain dimensions, such as pain duration (months) and pain in other parts of the body, were also included to compensate for the limitations of the one-dimensional evaluation of pain yielded by VAS.[23] Clinical examination, particularly muscle and joint palpation as well as measurement of maximum unassisted mandibular opening, was performed last, because it has been shown to exacerbate pain and

Table 1 Neuropsychologic Test Results (Mean and SD) in TMD Patients and Control Subjects

Dependent variables	TMD group (n = 72)	Control group (n = 30)	Significance*
SAQ (scores 0–68)	26.1 (9.2)	17.8 (8.42)	$P < .001$
BDI (scores 0–63)	12.1 (8.3)	7.6 (7.4)	$P < .01$

*Mann-Whitney *U* test.

neuropsychologic (sleep and depression) test scores.[7] To further confirm this, muscle and/or joint pain exacerbation after examination were also checked.

Confounders and Data Analysis

Confounders, such as age, gender, language, chemical dependency, history of trauma, neurologic disorders, and psychologic disorders, were controlled in this study by restriction in the inclusion/exclusion criteria during the medical history.[12] Circadian rhythms in the pain cycle were controlled by standardization of the time of day (10 am and 4 pm) and site (single isolated room) where the tests were performed.[24] Other confounders that remained after the design stage, such as educational level and employment, were controlled in the analysis stage by logistic regression.[7]

The formula for the calculation of the sample size, for 2 independent means,[25] was calculated using the means and standard deviations of the SAQ and the BDI from a previous study and recalculated after the pilot study without significant changes.[7] To disclose a percent difference that was considered clinically relevant (40%) and statistically significant between the 2 groups (2-sided test at the .05 level and for a power of 80%) in all neuropsychologic tests, it was estimated that at least 27 patients must be screened in each group, which was increased to 30 to compensate for dropouts.[10] The final patient population was increased to 72 to allow multiple-regression analysis; a valid patient/control ratio of 2:1 was kept.[13]

The Mann-Whitney *U* test was used for continuous variables; if the variables were categorical, 2-by-2 tables using chi-square and Fisher exact tests were used, with all tests at a .05 significance level. Odds ratios (critical OR = 2.0) and 95% confidence intervals were used to determine the strength of the association. The role of confounders was calculated by variation (15%) in ORs using logistic regression.[26] Recording procedures (cutoff points) were based on the normative data of the tests (ie, SAQ and BDI).[17,18,20] For sleep and depression, because of the presence of normalization, both sensitivity and specificity were provided. Positive test results were indicated as 1 and negative tests as 0. All analyses were performed using SPSS software, version 11.5 for Windows.

Results

Fifty percent of new TMD patients in the clinic were selected for the study over a period of 1 year by 2 clinicians not involved in the clinical examination and neuropsychologic testing. Among those eligible, slightly more than 80% agreed to participate in the study, and all underwent clinical and neuropsychologic assessment. Similarly, among controls, 60% were included in the study over a period of 9 months and all agreed to participate and finished the assessment.

Neuropsychologic (Sleep and Depression) Assessment

The neuropsychologic assessment yielded the following results (Table 1). The TMD patients showed sleep scores (SAQ) that were 46.6% higher than those of the control group ($P < .001$). In the BDI, TMD patients had scores that were 59.2% higher than those of the controls ($P < .01$).

History, Pain Assessment, and Clinical Examination

Analysis of the clinical examination was carried out for traditional signs and symptoms of TMD.[8,9,16] Some clinical variables did not show statistically significant differences between experimental and control groups. Maximum unassisted mandibular opening (mean ± SD) was very similar between TMD patients (50.2 ± 9.5 mm) and control subjects (47.8 ± 6.3 mm). Additionally, neither group had evidence of caries lesions detectable with a probe, confirming that the pain was not of dental origin. On the other hand, other clinical variables showed statistically significant differences between TMD and control subjects, confirming the separation between the groups (Table 2). Sensitivity to masticatory muscle and TMJ lateral pole palpation, following the RDC/TMD scores II to III, was proportionately greater in TMD patients than controls ($P < .001$). In addition, percussion sensitivity was found in 23.6% of TMD patients, versus none in controls ($P < .01$), which is indicative of parafunction.

As shown in Table 2, there was also a highly statistically significant difference between the experimental

Table 2 Significant Signs and Symptoms in TMD and Control Subjects

Dependent variables (unit or category)	TMD group (n = 72)	Control group (n = 30)	Significance
TMJ lateral pole (%)			
From 0 through I = 0	44.4	96.7	$P < .001$*
From II through III = 1	55.6	3.3	
Masseter (%)			
From 0 through I = 0	33.3	76.7	$P < .001$*
From II through III = 1	66.7	23.3	
Temporalis (%)			
From 0 through I = 0	45.8	96.7	$P < .001$*
From II through III = 1	54.2	3.3	
Sternocleidomastoid (%)			
From 0 through I = 0	61.1	93.3	$P < .01$*
From II through III = 1	38.9	6.7	
Percussion sensitivity (%)			
Negative = 0	76.4	100.0	$P < .01$*
Positive = 1	23.6	0.0	
Exacerbation after examination (%)			
Negative = 0	61.1	100.0	$P < .001$*
Positive = 1	38.9	0.0	
Pain at rest (100-mm VAS) Mean (SD)	33.8 (27.7)	0.0 (0.0)	$P < .001$†
Pain on chewing (100-mm VAS) Mean (SD)	39.1 (29.9)	0.0 (0.0)	$P < .001$†

*Chi Square test; †Mann-Whitney *U* test.

and control groups with respect to pain intensity at rest and during chewing, with TMD patients experiencing mild pain at rest and on chewing versus no pain in the control group ($P < .001$). The average pain duration in months was long in TMD patients (32.7 ± 26.6 months), which is suggestive of a chronic pain problem. Also, almost 70% of TMD patients reported pain in other parts of their body (eg, headaches, back pain, abdominal pain, pain in the eye globe, general body pain), suggesting a high level of comorbidity between TMD and other chronic pain syndromes. In addition, 38.9% of TMD patients had exacerbation of their joint and muscle pain after examination, in contrast to no control patients; this finding justified our protocol of performing the clinical examination after the sleep and depression assessment ($P < .001$).

Assessment of Confounders and Selection of Best Risk Indicators

As depicted in Table 3, traditional confounders not controlled for in the study design have been shown to influence neuropsychologic tests used here.[7,12] Therefore, confounders such as educational level, employment, income, age, marital status, number of children, physical activity, social activity, coffee, and cigarette and alcohol consumption were assessed in the analysis stage (univariate and multivariate analyses). Educational level, income, marital status, number of children, physical activity, social activity, and coffee consumption did not show any statistically significant differences between TMD patients and control subjects. Additionally, none of these confounders reached our critical OR (2.0), which ranged from 0.6 to 1.7. On the other hand, age, which was controlled in the design stage, did show a statistically significant difference ($P < .05$) between experimental and control groups in the analysis stage. Employment was also significantly different ($P < .01$), with TMD patients having more than twice the percentage (64.8%) of unemployment than controls (30%), increasing the risk of being a TMD patient by 4.3 times. Cigarette and alcohol consumption were also statistically significantly different between groups ($P < .05$ and $P < .01$, respectively), but in both cases they acted to reduce the risk of developing TMD (OR = 0.1); this might be owing to the fact that we had neither heavy smokers nor drinkers in our sample.

The role of confounders was calculated by variations (15%) in ORs using logistic regression. Variables that reached statistically significant differences between groups, such as employment, age, and cigarette and alcohol consumption, were selected. In addition, educational level and coffee consumption, because of their marginal critical ORs of 1.7 and 1.6, respectively, were also included. The ORs for all neuropsychologic tests did not change significantly in any direction, both for each individual variable and for all 6 variables in combination. Therefore, we determined that none of the 6 confounders included in our logistic regression analysis influenced the association between the neuropsychologic test scores described in Table 1.

Table 3 Confounders in TMD and Control Subjects

Dependent variables (unit or category)	TMD group (n = 72)	Control group (n = 30)	ORs (95% CI)*	Significance
Educational level (%)				
Postsecondary diploma/ certificate or higher = 0	15.9	24.0	1.7 (0.5–5.1)	NS†
Some education after high school or less = 1	84.1	76.0		
Employment (%)				
Employed = 0	35.2	70.0	4.3	$P < .01$‡
Unemployed = 1	64.8	30.0	(1.7–10.8)	
Income (%)				
5× min wages or more = 0	38.0	26.7	0.6	NS‡
Up to 5× min wages = 1	62.0	73.3	(0.2–1.5)	
Age (y)				
Mean (SD)	32.4 (12.1)	38.7 (13.4)		$P < .05$§
Marital status (%)				
Single = 0	40.8	33.3	0.7	NS‡
Married, separated, divorced, widowed = 1	59.2	66.7	(0.3–1.8)	
No. of children				
Mean (SD)	1.9 (1.0)	1.9 (1.1)		NS§
Physical activity (%)				
Moderate or regular = 0	33.3	30.0	0.8	NS‡
Little or none = 1	66.7	70.0	(0.3–2.5)	
Social activity (%)				
Moderate or regular = 0	63.6	60.0	0.9	NS‡
Little or none = 1	36.4	40.0	(0.3–2.4)	
Coffee consumption (%)				
Up to 2 cups a day = 0	84.8	90.0	1.6	NS†
More than 2 cups = 1	15.2	10.0	(0.3–7.4)	
Cigarette consumption (%)				
None or occasionally = 0	93.9	70.0	0.1	$P < .05$‡
One pack a day or more = 1	6.1	30.0	(0.03–0.80)	
Alcohol consumption (%)				
None = 0	45.5	10.0	0.1	$P < .01$‡
Occasionally = 1	54.5	90.0	(0.03–0.53)	

*Critical OR = 2.0; †Fisher exact test; ‡Chi-square test; §Mann-Whitney *U* test.
CI = confidence interval.

In our final analysis, we also re-coded (dichotomized) the neuropsychologic tests, which revealed significant differences between TMD patients and control subjects—in our case, sleep and depression (Table 4). Both these factors had tests with published norms (SAQ and BDI).[18,20] Individuals who were considered to have sleep disorders (scores equal or greater than 17) had 5 times the risk ($P < .001$) of becoming TMD patients. Also, subjects who were included as having severe depression (scores equal or greater than 20) had 1.6 times the risk of developing TMD, but the results were not significant. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were also calculated for both tests. Scores of 0.75 were considered good for all measures.[8] The SAQ provided high sensitivity (0.83) and PPV (0.80) but low specificity (0.50) and NPV (0.55). Conversely, the BDI yielded low sensitivity (0.18) and NPV (0.31) but high specificity (0.90) and PPV (0.79). Therefore, none of the tests reached good scores in all 4 measures, demonstrating that these tests cannot be used without a thorough clinical examination. For the selection of our best predictors (risk indicators) of TMD, a forward stepwise analysis using our significant neuropsychologic and confounding variables (ie, SAQ, BDI, employment, age, and cigarette and alcohol consumption) was carried out.[27] Sleep (SAQ), depression (BDI), and alcohol and cigarette consumption were considered the best predictors for the development of TMD, with an overall agreement of 78.69% between observed and predicted cases. This overall percent agreement was higher than when the seven variables included in the logistic regression model were used alone, indicating that the combination of selected variables was a better predictor than when the variables were used alone. Finally, the Spearman rho correlation was performed among all 6 variables included in the model, and only depression and sleep scores were highly correlated ($r = 0.71$; $P < .001$).

Table 4 Risk Indicators for the Development of TMD

Independent variables (unit or category)	TMD group (n = 72)	Control group (n = 30)	ORs (95% CI)*	Significance
SAQ (%) (sens = 0.83; spec = 0.50; PPV = 0.80; NPV = 0.55)				
Scores 0 to 16 = 0	16.7	50.0	5.0	$P < .001$†
Scores 17 to 68 = 1	83.3	50.0	(1.9–12.9)	
BDI (%) (sens = 0.18; spec = 0.90; PPV = 0.79; NPV = 0.31)				
Scores from 0 through 19 = 0	84.5	90.0	1.6	NS‡
Scores from 20 through 63 = 1	15.5	10.0	(0.4–6.4)	

*Critical OR = 2.0; †Fisher exact test; ‡ Chi-square test.
CI = confidence interval; sens = sensitivity; spec = specificity.

Discussion

Study Design, Population, and Confounders

In this study, a case-control design was selected because it is the most adequate analytic study in cases where the latency period of the disease is long and/or the incidence is low.[13] Our recruitment rate and TMD sample size were similar to those of previous studies.[14,15,28] The primary diagnosis of myofascial pain with or without limited opening and arthralgia (group Ia, Ib, and IIIa of the RDC/TMD, respectively) was chosen,[8] because it has been documented in the literature that patients diagnosed with myofascial pain and arthralgia had significantly higher levels of depression and somatization than those diagnosed with disk displacements only,[6] and that TMD pain is predominantly muscular in origin,[9] which increases external validity. This is in agreement with a current trend in the TMD literature to study well-defined populations to increase the validity and reproducibility of the results.[6,7,11,14,16] Indeed, studies have shown that different TMD subgroups (eg, posttraumatic TMD as a result of motor vehicle accident, disk displacements, and/or arthritic conditions) have shown different risk indicators and etiologies.[11,29]

Regarding gender, all included TMD subjects were women to increase internal validity and to control an important confounder in the design stage.[13] Despite that, the gender distribution seems to be comparable to that of other studies.[14,15,28,29] In contrast to previous studies,[7,14,15,28] the majority of our TMD population did not have postsecondary education or higher (Table 3) and had high levels of unemployment, which differed from the Canadian sample.[7] Similar to the comparable TMD Canadian sample (57.9%), this study's sample also had low income level, but it contrasted with another study.[28] Unfortunately, not all studies reported employment and income level, and it was difficult to assess their overall differences. The average age of the TMD sample in this investigation was similar to that found in the literature,[6,14,28,30] but it was significantly lower than that of our control group. Overall, the social and demographic variables in this study sample seem to be comparable to similar studies in the literature; nevertheless, the impact of these variables in our results were controlled in our univariate and multivariate analyses, without significant changes.

Depression and Sleep

Our results showed that depression, as measured by the BDI,[17,18] was significantly more common in TMD patients than in controls (Table 1), which agrees with a previous investigation comparing BDI scores between responding TMD patients (rTMD) versus nonresponding TMD patients (nrTMD) and controls.[7] This demonstrated its importance as a risk indicator (OR = 1.6) in the development and perpetuation of TMD. The mean scores of our TMD patient population were 10% higher than the range found in the Canadian study. One surprising finding was that our normative values (Table 1) were 171.4% higher than the Canadian sample and published norms.[7,17] This might be explained in part by the difficult social and economic conditions to which the current control subjects are subjected (Table 3). In this study, 15.5% of TMD patients and 10% of the control population were considered moderately depressed (Brazilian version BDI, scores equal or greater than 20),[18] versus 11.8% (rTMD and nrTMD, combined) in the Canadian sample (English version of the BDI, scores equal to or greater than 16).[7] When we compare our results with studies that did not use the same methodology, our results are still coherent for both TMD (15% to 43%)[11,28,30,31] and control subjects (6%).[32] Finally, the neurophysiologic basis for the association between chronic pain and major depression has already been described in the literature,[33] where Bondy et al found significantly higher serum levels ($P < .001$) of substance P in patients with major depression than in controls. Nevertheless, these symptoms may also be the result of chronic pain. Treatment for depression alleviates pain, but a number of treatment modalities also have the same effect; depression is not an isolated entity but is often associated with symptoms of stress, anxiety, and stress-related oral behaviors.[14]

Sleep, as measured by the SAQ, was demonstrated to be a more important risk indicator (OR = 5) in the development of TMD than depression, and the SAQ scores for TMD patients were significantly higher than those of controls. The absolute SAQ value (26) of our southern Brazilian TMD sample was comparable to the range in the Canadian sample.[7] In the Canadian study, sleep also displayed importance as a perpetuating factor, with nonresponding TMD patients having significantly more sleep disorders than responding ones. Nevertheless, the southern Brazilian control group had scores (Table 1) that were 61% higher than those of the Canadian sample (11) and external controls.[7,20] Similar to depression, this might be the result of unfavorable social and economic conditions (detailed in Table 3). The proportion of TMD individuals with sleep disorders reached 83.3% versus 50% in the control group. This was also similar to 78% in the Canadian TMD (combined rTMD and nrTMD) sample and 27% for the control group.[7] Our results are also comparable with those of the literature that did not use the SAQ, and in these studies, sleep has been closely associated with TMD and other chronic pain[14,34–36]; however, it is difficult to establish a cause-and-effect relationship. Low-quality sleep may be a contributing factor for the potentialization of pain in an individual and/or for a reduction in the ability to tolerate it.[35,36] Some studies using experimental pain (chemical or thermal) have shown minor sleep disturbances,[37,38] while other classic studies have shown that sleep deprivation led to muscle pain and behavioral disturbances.[35,39]

In our forward stepwise analysis,[27] sleep and depression, plus alcohol and cigarette consumption, were considered the best TMD predictors. The latter were higher than when the variables included in the logistic regression model were considered alone. These findings indicate that a combination of risk indicators seems to be more important than the individual variables alone. The results endorse the multifactorial etiology of TMD and the importance of multidisciplinary management. They also support the biopsychosocial model of chronic pain. Finally, only depression and sleep scores were highly correlated among all 6 variables included in the logistic regression model. This confirmed previous findings of a relationship between sleep disorders and psychologic distress. [40]

Limitations and Suggestions for Future Studies

Despite our efforts to blind and standardize our clinical and neuropsychologic evaluations, case-control studies remain vulnerable to biases; therefore, the associations presented here cannot imply cause-and-effect relationships between any studied variable and TMD.[13] Therefore, at face value, the neuropsychologic tests used here must be considered as risk indicators, rather than risk factors, for TMD, and it is necessary to confirm our findings with analytic longitudinal designs. Finally, considering that sleep was one of our best predictors (risk indicators) among all variables (46) studied, randomized controlled trials using particular sleep medications (eg, zopiclone) must be carried out not only in TMD but also in other patients with chronic pain of muscle origin, such as fibromyalgia. In addition, the relationship between sleep and pain as well as psychologic distress (depression) should be further explored. The comorbidity between TMD and other chronic pain conditions, such as fibromyalgia, chronic fatigue syndrome, and irritable bowel syndrome, must be further studied to assess whether they are related or parallel entities. Also, because we found clinical indications, such as percussion sensitivity, of the presence of bruxism, and the fact that bruxism has been closely associated with sleep disorders,[34] it is important to further assess the role of bruxism, using polysomnographic evaluation, in the initiation and perpetuation of TMD. Indeed, one study found that related symptoms, such as tooth clenching, are important risk indicators in TMD.[41]

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References

1. Toner BB, Garfinkel PE, Jeejeebhoy KN, Scher H, Shulhan D, Gasbarro ID. Self-schema in irritable bowel syndrome and depression. Psychosom Med 1990;52:149–155.
2. Von Korff M, Dworkin SF, LeResche L, Kruger A. An epidemiologic comparison of pain complaints. Pain 1988;32:173–183.
3. Rugh JD. Psychologic components of pain. Dent Clin North Am 1987;31:579–594.
4. Dworkin SF, Von Korff MR, LeResche L. Multiple pains and psychiatric disturbance: An epidemiologic investigation. Arch Gen Psychiatry 1990;47:239–244.
5. McCreary CP, Clark GT, Oakley ME, Flack V. Predicting response to treatment for temporomandibular disorders. J Craniomandib Disord Facial Oral Pain 1992;6:161–170.
6. Yap AUJ, Tan KBC, Chua EK, Tan HH. Depression and somatization in patients with temporomandibular disorders. J Prosthet Dent 2002;88:479–484.
7. Grossi ML, Goldberg MB, Locker D, Tenenbaum HC. Reduced neuropsychologic measures as predictors of treatment outcome in patients with temporomandibular disorders. J Orofac Pain 2001;15:329–339.

8. Dworkin SF, LeResche L, eds. Research Diagnostic Criteria for Temporomandibular Disorders. J Craniomandib Disord Facial Oral Pain 1992;6(4):301–355.
9. Stohler CS. Clinical perspectives on masticatory and related muscle disorders. In: Sessle BJ, Bryant PS, Dionne RA (eds). Temporomandibular Disorders and Related Pain Conditions. Progress in Pain Research and Management, vol 4. Seattle: IASP Press, 1995.
10. Dao TTT, Lavigne GJ, Charbonneau A, Feine JS, Lund, JP. The efficacy of oral splints in the treatment of myofascial pain of the jaw muscles: A controlled clinical trial. Pain 1994;56:85–94.
11. Goldberg MB, Mock, D, Ichise M, et al. Neuropsychologic deficits and clinical features of posttraumatic temporomandibular disorders. J Orofac Pain 1996;10(2):126–140.
12. Stuss DT, Levine B. The Dementias: Nosological and Clinical Factors Related to Diagnosis. Toronto: Rotman Research Institute of Baycrest Centre, University of Toronto, 1995.
13. Hennekens CH, Buring JE. Epidemiology in Medicine. Boston/Toronto: Little, Brown and Company, 1987.
14. Fricton JR, Olsen T. Predictors of outcome for treatment of temporomandibular disorders. J Orofacial Pain 1996;10:54–65.
15. Lipton JA, Marbach JJ. Predictors of treatment outcome in patients with myofascial pain-dysfunction syndrome and organic temporomandibular joint disorders. J Prosthet Dent 1984;51(3):387–393.
16. Vallon D, Nilner M, Soderfeldt B. Treatment outcome in patients with craniomandibular disorders of muscular origin: A 7-year follow-up. J Orofac Pain 1998;12:210–218.
17. Beck AT. Depression: Causes and Treatment, ed 1. Philadelphia: University of Pennsylvania Press, 1970.
18. Cunha JA, Prieb RGG, Goulart PM, Lemes RB. The use of the Beck Depression Inventory to evaluate depression in university students [in Portuguese]. Psico 1996;27(1):107–115.
19. Mapou RL, Spector J. Clinical Neuropsychological Assessment: A Cognitive Approach. New York and London: Plenum Press, 1995.
20. Cesta A, Moldofsky H, Sammut C. The University of Toronto Sleep Assessment Questionnaire [abstract]. Sleep Res 1996;25:486.
21. Carlsson GE, Egermark-Eriksson I, Magnusson T. Intra- and interobserver variation in functional examination of the masticatory system. Swed Dent J 1980;4:187–194.
22. Price DD, Bush FM, Long S, Harkins SW. A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. Pain 1994;56:217–226.
23. Magnusson T, List T, Helkimo M. Self-assessment of pain and discomfort in patients with temporomandibular disorders: A comparison of five different scales with respect to their precision and sensitivity as well as their capacity to register memory of pain and discomfort. J Oral Rehabil 1995;22:549–556.
24. Folkard S. Diurnal variation and individual differences in the perception of intractable pain. J Psychosomat Res 1976;20:289–301.
25. Taylor W. How-to-Use Guide to Sample Size Calculation. Ontario: McMaster University, 1981.
26. Greenland S. Modeling and variable selection in epidemiologic analysis. Am J Public Health 1989;79(3):340–349.
27. Norman GR, Streiner DL. PDQ Statistics, ed 2. St Louis: Mosby, 1997.
28. Gerschman JA, Wright JL, Hall WD, Reade PC, Burrows GD, Holwill BJ. Comparisons of psychological and social factors in patients with chronic orofacial pain and dental phobic disorders. Aust Dent J 1987;32:331–335.
29. Pullinger AG, Seligman DA, John MT, Harkins S. Multifactorial comparison of disk displacement with and without reduction to normals according to temporomandibular joint hard tissue anatomic relationships. J Prosthet Dent 2002;87:298–310.
30. Yap AUJ, Dworkin SF, Chua EK, List t, Tan KBC, Tan HH. Prevalence of temporomandibular disorder subtypes, psychologic distress, and psychosocial dysfunction in Asian Patients. J Orofac Pain 2003;17:21–28.
31. Ohrbach R, Dworkin SF. Five-year outcomes in TMD: Relationship of changes in pain to changes in physical and psychological variables. Pain 1998 Feb;74(2–3):315–326.
32. Nielsen AC, Williams TA. Depression in ambulatory medical patients: Prevalence by self-report questionnaire and recognition by nonpsychiatric physicians. Arch Gen Psychiatry 1980;37:999–1004.
33. Bondy B, Baghai TC, Minov C, et al. Substance P serum levels are increased in major depression: Preliminary results. Biol Psychiatry 2003;53(6):538–542.
34. Lavigne GJ, Kato T, Kolta A, Sessle BJ. Neurobiological mechanisms involved in sleep bruxism. Crit Rev Oral Biol Med 2003;14(1):30–46.
35. Lentz MJ, Landis CA, Rohermel J, Shaver JL. Effects of selective slow wave sleep disruption on musculoskeletal pain and fatigue in middle age women. J Rheumatol 1999;26(7):1586–1592.
36. Unger ER, Nisenbaum R, Moldofsky H, Cesta A, Sammut C, Reyes M, et al. Sleep assessment in a population-based study of chronic fatigue syndrome. BMC Neurol 2004 Apr 19;4(1):6.
37. Drewes AM, Nielsen KD, Arendt-Nielsen L, Birket-Smith L, Hansen LM. The effect of cutaneous and deep pain on the electroencephalogram during sleep: An experimental study. Sleep 1997;20(8):632–640.
38. Lavigne G, Zucconi M, Castronovo C, Manzini C, Marchettini P, Smirne S. Sleep arousal response to experimental thermal stimulation during sleep in human subjects free of pain and sleep problems. Pain 2000;84:283–290.
39. Moldofsky H, Scarisbrick P, England R, Smythe H. Musculoskeletal symptoms and non-REM sleep disturbance in patients with "fibrositis syndrome" and healthy subjects. Psychosom Med 1975;34:341–351.
40. Moldofsky H. Sleep and musculoskeletal pain. In: Vaeroy H, Merskey H (eds). Progress in Fibromyalgia and Myofascial Pain. Amsterdam, New York: Elsevier Science, 1993:137–148.
41. Henrikson T, Ekberg EC, Nilner M. Symptoms and signs of temporomandibular disorders in girls with normal occlusion and Class II malocclusion. Acta Odontol Scand 1997;55:229–235.