Are Pain-Related Temporomandibular Disorders the Product of an Interaction Between Psychological Factors and Self-Reported Bruxism?

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Aims: To investigate whether pain-related temporomandibular disorders (TMD) are the product of an interaction between psychological factors and self-reported bruxism activities. **Methods:** Patients referred to a specialized clinic for complaints of orofacial pain and dysfunction completed a digital questionnaire prior to the first clinical visit. The patient sample was then split into a case group consisting of 268 patients diagnosed with TMD pain according to the Diagnostic Criteria for Temporomandibular Disorders (85.8% women; mean ± standard deviation [SD] age = 40.1 ± 14.5 years) and a control group consisting of 254 patients without any pain in the orofacial area (50.8% women; 46.9 ± 13.6 years). The possible moderating roles of six psychological factors (depression, somatic symptoms, anxiety, stress, optimism, and prior psychological treatment) on the relationship between self-reported bruxism and the clinical presence of TMD pain were examined. **Results:** Patients with TMD pain reported significantly more bruxism than patients without any report of orofacial pain. Furthermore, bruxism intensity was associated with a variety of psychological factors; however, there were no significant interactions between any of the psychological factors and bruxism with respect to the clinical presence of TMD pain. **Conclusion:** These findings do not support the view that the effect of bruxism on TMD pain is stronger in patients who experience higher levels of psychological distress compared to those with lower levels of distress.
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Dentists are frequently confronted with patients who suffer from chronic pain in the orofacial area. After "true" dental causes such as endodontic and periodontal problems, temporomandibular disorders (TMD) represent the most frequent orofacial pain condition, occurring in approximately 10% of the population over the age of 18 years.[1–3] Pain-related TMD can originate from the temporomandibular joints (TMJs), but more frequently the masticatory muscles are involved.[4,5] Virtually all studies assessing age-specific prevalence rates for TMD pain have reported that this type of pain is primarily a condition in young and middle-aged adults and that it declines in frequency after about 45 years of age.[1,6] In addition, most studies have noted that the risk of being diagnosed with TMD pain is higher for women than for men, with proportions varying from two to six women diagnosed for each man.[1,6,7]

In line with the perspective that pain-related TMD must be envisaged within a biopsychosocial model of illness,[8,9] a variety of psychological characteristics (such as stress and anxiety) and social characteristics (such as the role of family and environment) have been suggested to play a role in the development and/or maintenance of TMD pain.[1,9] From a biologic point of view, parafunctional activities of the masticatory system and oral habits such as teeth grinding or jaw clenching [ie, bruxism], biting on pens or pencils, and gum chewing are thought to create an overload of the masticatory system, thus causing TMD pain.[10,11] However, no single risk factor has yet been identified as a necessary or sufficient cause for the development of TMD pain. On the contrary, it has been suggested that TMD pain can be the result of mutually interacting physical and psychological factors.[12,13] However, evidence that sustains this suggestion is still lacking. This might be due to the fact that most studies that have investigated the etiology of TMD pain have focused on documenting bivariate associations only (ie, relationships between an independent variable and the outcome variable) instead of looking for other variables that modify such relationships (ie, interactions).

Since psychological factors play an important role in the presence of pain-related TMD[9,14] and are also associated with bruxism activities,[11,15] it can be speculated that psychological factors can alter the strength of the relationship between bruxism and TMD pain. This would imply that the effect of bruxism on TMD pain is stronger in patients who experience considerable distress compared to those with lower levels of distress. To test this assumption, the effect on TMD pain of the interactions between physical and psychological factors must be investigated. Therefore, the aim of the current study was to investigate whether pain-related TMD is the product of an interaction between psychological factors and self-reported bruxism activities.

Materials and Methods

Participants

Patients with complaints in the orofacial area who were referred to the specialty University Clinic for Orofacial Pain and Dysfunction of the Department of Oral Kinesiology at the Academic Centre for Dentistry Amsterdam (ACTA) were recruited between September 2013 and March 2015. Reasons for referral to this clinic are orofacial pain complaints (including TMD), bruxism, tooth wear, and/or sleep apnea.

Data Collection

Prior to the first clinical visit, all patients were asked to complete a digital questionnaire. This questionnaire contains various screening instruments derived from the Axis II protocol of the newly recommended Diagnostic Criteria for Temporomandibular Disorders (DC/TMD).[16] These screening instruments include items that assess pain intensity, pain-related disability, psychological distress, jaw function limitations, parafunctional activities (including bruxism), and the presence of comorbid pain conditions. The questionnaire also collects contextual information, such as the status of the patient's general health and previously received treatment. Since the original Axis II protocol is in the English language, it was translated into Dutch by following strict guidelines as outlined on the website of the International RDC/TMD Consortium Network (available at www.rdc-tmdinternational.org).

After verifying that the pain complaint as reported in the digital questionnaire was located in the orofacial area, dentists carried out a clinical examination that included palpation of the masticatory muscles and the TMJs. These examinations were performed by dentists extensively trained in the DC/TMD Axis I protocol. To that end, a DC/TMD training, calibration, and reliability session was organized at ACTA in June 2013, provided by an official DC/TMD trainer. On that occasion, three members of the staff were calibrated in the DC/TMD, after which all dentists working in the clinic were trained in DC/TMD in order to achieve reliable and comparable diagnostic results. Following the use of the diagnostic algorithms implemented in the DC/TMD Axis I protocol, a clinical diagnosis of TMD pain was established.[16] Since the TMD pain algorithm requires that any pain provoked with palpation or opening must be familiar pain (ie, pain similar or like the patient's pain complaint), the patients were asked whether they experienced any pain during the clinical tests, and if so, if this was the pain for which they sought help.[17,18]

At the time the data were collected at the specialty clinic, all patients were informed through the ACTA website that their data could be used anonymously for research not regulated by the Dutch law Medical Research Involving Human Subjects Act (WMO) (ie, medical interventions for research purposes). If a patient did not wish their data to be used, it was clearly indicated that they could inform their dentist that they wanted their data not to be used for research purposes and that this would not influence the care of that patient in any way. Furthermore, the internal ethical committee pronounced that the study complied with the ethical research code of conduct at ACTA, and that the patient data could be used in this retrospective medical file study.

Outcome Variable: TMD Pain

The potential moderating effects of psychological variables were tested on the relationship between bruxism and TMD pain. When any of the DC/TMD Axis I diagnoses were made that required TMD pain of a type and location specified by the DC/TMD (ie, different types of myalgia and TMJ arthralgia), TMD pain was determined to be present.[16] To that end, a distinction was made between patients who were clinically diagnosed with TMD pain (case group) and patients without any pain in the orofacial area as reported in the questionnaire (control group). Within both groups, no exclusion criteria were applied except that all patients had to be at least 18 years of age.

Independent Variable: Bruxism

The Dutch version of the Oral Behaviors Checklist (OBC) was used to measure bruxism.[19] The OBC is a 21-item scale used for identifying and quantifying the frequency of jaw overuse behaviors (such as clenching the teeth or bracing the jaw) and is implemented in the new DC/TMD Axis II instruments.[16,20] For the present study, the sum score of the following four bruxism-related questions was employed: *(1)* Clenching or grinding the teeth when asleep; *(2)* Grinding the teeth together during waking hours; *(3)* Clenching the teeth together during waking hours; and *(4)* pressing, touching, or holding the teeth together other than while eating. For all questions, the possible responses ranged between 0 (none of the time) and 4 (occurring 4 to 7 nights per week for question 1; all of the time for questions 2 to 4). The total sum score could be between 0 and 16.

Moderator Variables

Depression. The Patient Health Questionnaire (PHQ)-9 is a valid and reliable screening instrument for detecting psychological distress due to depression[21] and is implemented in the DC/TMD Axis II instruments.[16] This nine-item instrument can grade severity of depressive symptoms. A sum PHQ-9 score, which can range from 0 to 27, is derived by assigning scores from 0 (not at all) to 3 (nearly every day) to the nine items.

Somatic Symptoms. The PHQ-15, which is included in the DC/TMD,[16] is a self-administered diagnostic instrument developed for the detection of somatoform disorders.[22] The PHQ-15 consists of a list of 15 somatic symptom clusters that account for more than 90% of all physical complaints. Each symptom is scored from 0 (not bothered at all) to 2 (bothered a lot), and the total score ranges from 0 to 30.

Anxiety. The Generalized Anxiety Disorder-7 (GAD-7) is a brief self-report questionnaire for screening and measuring severity of generalized anxiety.[23] This instrument is also implemented in the DC/TMD.[16] Scores for all seven items range from 0 (not at all) to 3 (nearly every day), and total sum score is used for assessment (sum scores can range from 0 to 20).

Optimism. Optimism was measured with the Life Orientation Test-Revised (LOT-R) questionnaire.[24] This is a self-report measure that assesses individual differences in generalized optimism vs pessimism. The LOT-R contains 10 items scored from 0 (strongly disagree) to 4 (strongly agree). Of the 10 items, 3 measure optimism, 3 measure pessimism, and 4 serve as fillers. The total sum score is the sum of all 6 nonfiller items and can be from 0 to 24, with a higher score implying less optimism. As was also done for the PHQ-9, PHQ-15, and GAD-7, the LOT-R was translated into Dutch by using a forward/backward translation protocol according to guidelines set out by the International RDC/TMD Consortium.

Psychological Stress. The amount of stress was measured by asking a single question: "What was the overall amount of stress experienced during the past month?"[25] Patients could choose scores between 0 (none) and 4 (a lot).

Psychological Treatment. All patients were asked whether they had received previous psychological treatment with the question: "In the past or at present, did (or do) you receive any psychological treatment?" The answer was dichotomous (yes or no).

Confounders

Since the relationship between bruxism and TMD pain might be confounded by age and gender, the possible confounding role of these factors was assessed. Because prevalence rates of TMD pain are reported to be lower among people aged 45+ years than in people aged 18 to 44 years,[1,6] age was treated as a binary variable (age between 18 and 45 years = 0; age ≥ 45 years = 1).

Data Analyses

For both the case group and the control group, summary statistics were performed to examine the median and interquartile range (IQR; ie, 25th and 75th percentiles) for the ordinal variables depression, somatic symptoms, anxiety, optimism, and bruxism. Frequency counts are given for the dichotomous variables (age, gender, and received psychological treatment). Group comparisons were made by using chi-square tests for dichotomous variables and Mann-Whitney U rank tests for ordinal variables. In addition, Spearman correlation coefficients were calculated to explore the bivariate associations between the main variables in the total patient group.

The hypothesis that psychological distress might moderate the association between bruxism and TMD pain was tested by using hierarchical logistic regression analysis. First, it had to be proven that patients with TMD pain reported higher levels of bruxism compared to patients without any pain in the orofacial area. Therefore, in the first step, the bivariate association between bruxism and the presence of TMD pain was determined by using a single regression analysis.

In the second step, it was determined whether this association was confounded by the presence of age or gender. The confounding variables were entered as second predictor (ie, together with bruxism) in a multiple regression model with the presence of TMD pain as the outcome variable. Confounding was considered present when the initial regression coefficient (b) of bruxism from the single regression model (step 1) changed by more than 10% after addition of the potential confounder.[26]

In the third step, it was examined whether the clinical presence of TMD pain was the product of

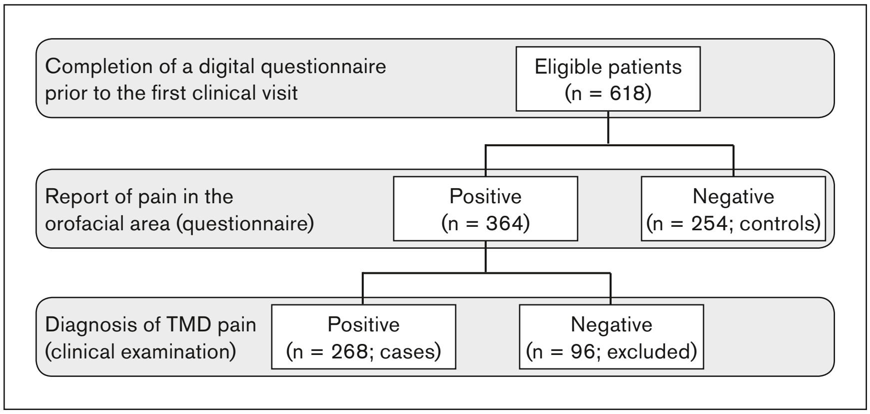

Fig 1 Flow chart of the study participants. Two patient groups were included in the study: a case group (patients clinically diagnosed with TMD pain) and a control group (patients who visited the clinic without reporting any pain in the orofacial area in the questionnaire).

an interaction between physical and psychological factors. This was done by using moderation analysis, which is another term for the statistical concept of investigating interaction effects. Moderation analysis is a methodology that statistically defines the relationship between two variables as a function of a third variable. Moderation is considered present in cases where a relationship between an independent variable and an outcome variable is different at different levels of the so-called moderator variable.[27,28] Following previous recommendations,[28,29] the independent variable (bruxism), the potential moderator variables (depression, somatic symptoms, anxiety, optimism, stress, and prior psychological treatment), and the interaction between the moderator variable and the independent variable (ie, interaction term) were added simultaneously to the multiple regression model while adjusting for any of the variables that confounded the association between bruxism and the presence of TMD pain (step 2). Moderation was considered present when the interaction term in the multiple regression model was significant. In that case, stratified analyses were performed by examining the association between bruxism and TMD pain with different moderator variables.

Data were analyzed with the IBM SPSS Statistics 23 software package. *P* values of less than .05 were considered statistically significant.

Results

A total of 618 patients participated in this study (Fig 1). Of these patients, 254 reported no pain in the orofacial area in their self-report questionnaire (control group: 50.8% women; mean age ± standard deviation [SD] = 46.9 ± 13.6 years). Of the 364 patients who reported pain in the orofacial region, a diagnosis of TMD pain was clinically established in 268 (case group: 85.8% women; mean age ± SD = 40.1 ± 14.5 years). The remaining 96 patients who reported a positive score on the question about orofacial pain but in whom no diagnosis of TMD pain was clinically established were removed from the dataset. In these cases, the orofacial pain may have had its origin in neurologic or vascular causes, but it is equally likely the pain was dental in origin.

Descriptive statistics are presented in Table 1. There were significant differences between the case and control groups in depression, somatic symptoms, anxiety, stress, optimism, bruxism, age, gender, and received psychological treatment.

For all ordinal variables of interest, the Spearman rank-order correlations are presented in Table 2. As shown, all variables were significantly correlated with one another. All variables showed significant positive associations with each other except for generalized optimism, which had an inverse relationship with scoring (ie, a high score implies pessimism) and therefore showed significant negative correlations with all variables. This also accounted for the associations with bruxism: higher rates of bruxism were related to higher levels of depression, somatic symptoms, anxiety, and stress.

Table 3 presents the outcomes of the tests for confounding variables and moderation. According to the single regression analysis (step 1), patients with TMD pain reported higher levels of bruxism compared to patients without any pain in the orofacial area. Inclusion of gender in this model (step 2) produced a change of more than 10% in the initial regression coefficient (b) of bruxism. Such a confounding effect

Table 1 Descriptive Statistics of the Main Study Variables in Relation to Both Study Groups

	Controls (n = 254)	Cases (n = 268)	*P* value
Bruxism (sum score range: 0–16)	4 (1–8)	7 (4–10)	< .001
Depression (sum score range: 0–27)	3 (1–6)	5 (2–9)	< .001
Somatic symptoms (sum score range: 0–30)	4 (2–8)	9 (6–13)	< .001
Anxiety disorder (sum score range: 0–21)	2 (0–5)	3 (1–6)	< .001
Generalized optimism (sum score range: 0–24)	17 (14–19)	16 (12–19)	.033
Amount of stress (sum score range: 0–4)	1 (1–2)	1 (1–2)	< .001
Psychological treatment	58 (22.8)	99 (36.9)	.001
Age (45+ y)	153 (60.2)	109 (40.7)	< .001
Gender (women)	129 (50.8)	230 (85.8)	< .001

Ordinal variables with non-normal distributions are presented as median (interquartile range) and dichotomous variables are presented as count (percentage). Comparisons were made for ordinal variables with Mann-Whitney *U* test and for dichotomous variables with chi-square test.

Table 2 Spearman Correlations Among the Ordinal Study Variables for the Total Study Sample (n = 522)

Variable (sum score range)	1	2	3	4	5	6
1. Depression (0–27)	–					
2. Somatic symptoms (0–30)	0.643**	–				
3. Anxiety disorder (0–21)	0.716**	0.497**	–			
4. Generalized optimism (0–24)	−0.355**	−0.256**	−0.355**	–		
5. Amount of stress (0–4)	0.559**	0.384**	0.678**	−0.257**	–	
6. Bruxism (0–16)	0.236**	0.246**	0.258**	−0.101*	0.232**	–

*$P < .05$.
**$P < .01$.

Table 3 Single (Step 1) and Multiple Logistic Regression Analyses for the Presence of TMD Pain With Tests for Confounding (Step 2) and Moderation (Step 3)

	b	OR	95% CI	*P* value	Adjusted R^2
Step 1					
Bruxism	0.124	1.132	1.08–1.183	< .001	0.078
Step 2					
Bruxism	**0.138**	1.148	1.094–1.206	< .001	
Gender (female = 1)	1.860	6.423	4.129–9.992	< .001	0.25
Bruxism	0.113	1.120	1.070–1.172	< .001	
Age (≥ 45 y = 1)	−0.685	0.504	0.352–0.723	< .001	0.13
Step 3					
Bruxism	0.128	1.14	1.08–1.20	< .001	
Depression	0.075	1.08	1.04–1.13	.001	
Bruxism × depression	0.001	1.00	0.99–1.01	.833	0.28
Bruxism	0.116	1.12	1.06–1.18	<.001	
Somatic symptoms	0.157	1.17	1.17–1.23	< .001	
Bruxism × somatic symptoms	0.006	1.01	0.99–1.02	.321	0.36
Bruxism	0.137	1.15	1.09–1.21	< .001	
Anxiety	0.048	1.06	1.05–1.10	.064	
Bruxism × anxiety	0.012	1.01	1.00–1.03	.059	0.28
Bruxism	0.135	1.15	1.08–1.21	< .001	
Optimism	−0.051	0.95	0.90–1.00	.051	
Bruxism × optimism	−0.011	0.99	0.98–1.00	.110	0.29
Bruxism	0.125	1.13	1.08–1.19	< .001	
Stress	0.162	1.18	0.97–1.42	.094	
Bruxism × stress	0.027	1.03	0.98–1.08	.259	0.27
Bruxism	0.126	1.14	1.07–1.20	< .001	
Psychological treatment	0.442	1.56	1.01–2.39	.044	
Bruxism × psychological treatment	0.016	1.02	0.91–1.13	.780	0.26

A bold regression coefficient (b) in step 2 (analysis of confounders) indicates that the regression coefficient for bruxism changed by more than 10% compared to its coefficient in the single logistic regression model (step 1). *Note:* Each model included in step 3 was adjusted for gender. CI = confidence interval; OR = odds ratio.

was absent for age. Therefore, the subsequent multiple regression analyses in step 3 were adjusted for gender and not for age. According to the tests for moderation, none of the interactions between any of the six potential moderator variables and bruxism was significant. Only the model that tested the effect of the interaction between anxiety and bruxism on TMD pain was close to the predefined threshold for significance, with a *P* value of .059. The percentage of explained variance was highest (36%) for the model that included gender, bruxism, somatic symptoms, and the interaction between the latter two variables, and was lowest (26%) for the model investigating the effect of psychological treatment.

Discussion

The purported relationship between bruxism and the presence of pain-related TMD has been investigated extensively, as it is clinically plausible that these phenomena are causally related since clenching and grinding of the teeth may lead to overloading of the masticatory structures and thus to TMD pain. Since psychological factors may play a profound role in the presence of bruxism activities as well,[30–32] the present study investigated whether TMD pain is the product of an interaction between psychological factors and bruxism; ie, the study examined if the association between bruxism and the clinical presence of TMD pain was moderated by psychological distress. The main finding of the study was that the effect of bruxism on TMD pain in patients who experienced considerable psychological distress was equal to the effect in those with lower levels of distress. None of the six interaction terms (ie, none of the interactions between any psychological variable and bruxism) showed significant regression with the clinical presence of TMD pain (*P* values ranged between .059 and .833). To date, only experimental studies have provided evidence that the association between jaw motor function and pain in the orofacial area can be moderated by psychological factors; for example, the level of pain catastrophizing appears to be of direct influence on the effect of experimentally induced jaw muscle pain on jaw movement.[33] Likewise, it is known from Brandini et al that psychological factors manifesting in depression and stress may play a moderating role in the association between facial pain and jaw motor function.[34] Since clinical studies on pain-related TMD involve a multitude of factors that cannot be controlled for, it remains a challenge to bridge the gap between well-controlled experimental pain models and clinical practice.

A second finding of the current study was that patients with clinically diagnosed TMD pain reported significantly higher levels of bruxism activities compared to patients without any pain in the orofacial area. According to the odds ratio (OR) found in this single logistic regression, a one-unit change in bruxism score would imply that the odds of being part of the case group were 1.132 larger than the odds of being part of the control group. At first glance, this coefficient may not seem to be indicative of a high risk; however, a more clinically relevant change of five units would result in an OR of 1.859 (viz, the exponential constant e of five times the corresponding b value [0.124]). When this model was adjusted for gender, the OR for a five-unit increase became slightly higher (1.994). In other words, independent of the patient's gender, a score of five points higher on the four questions relating to bruxism was related to an increased OR of almost 2 for being diagnosed with TMD pain.

Another finding was that bruxism intensity in patients diagnosed with TMD pain appeared to be associated with a variety of psychological factors. According to the Spearman correlations, a higher sum score for bruxism was related to higher scores for depression, somatic symptoms, anxiety, and stress. Moreover, patients with low scores on the optimism scale reported more bruxism. Comparable associations were noticed in other studies[30,31,35]; however, it should be borne in mind that such associations are findings from studies that adopt a self-report diagnosis of bruxism, and evidence for the association between psychosocial disorders and bruxism rarely comes from studies using instrumental techniques (eg, polysomnographic or electromyographic recordings).[15] In addition, it has also been noted that studies that rely entirely on self-evaluation for the diagnosis of bruxism seem to more often produce positive relationships with orofacial pain than those using instrumental recording techniques.[10] Perhaps the observation that associations between bruxism and a variety of other factors seem to occur more frequently in studies based on self-reports might be due to potential bias at the diagnostic level. Some of the persons interviewed may have preconceived ideas about the subject of bruxism; for instance, patients who seek help for orofacial pain in the morning might consider this pain as a criterion for self-recognized sleep-related bruxism.[31] Likewise, when under stress, the awareness of bruxism behavior might be higher. Future associative studies on bruxism should address this concern to minimize any bias.

Another aspect that should be highlighted is the fact that the present study did not solely focus on the awareness of tooth grinding behavior during sleep, but also aimed to include awake clenching and other parafunctional activities indicative of bruxism (ie, pressing, touching or holding the teeth together other than while eating). This was done because the self-report of sleep bruxism (ie, reports of tooth grinding during sleep) is known for its risk of overscoring or underscoring the condition. To assess these activities, 4 of the 21 questions of the OBC21 were selected that especially focus on oral behaviors embedded in the definition of bruxism (viz, a repetitive masticatory muscle activity characterized by teeth clenching or grinding and/or by bracing or thrusting of the mandible).[36] A previous study has revealed an excellent test-retest reliability of the OBC, and a good concurrent validity between single items of the OBC and comparable items (identical or differing somewhat) of another oral parafunctions questionnaire.[19]

Even though there is general consensus that multiple and diverse risk factors are associated with an increased risk of pain-related TMD, little is known about how these factors may interact. A recent report therefore proposed a new conceptual model to capture the complexity of TMD pain called stochastic variation.[37] The stochastic variation model aims to think in complex multivariate models rather than simple univariate models for TMD pain. A key element of this model involves the random variation of meaningful factors that determine whether a person becomes a pain patient. Depending on the person, risk factors can have different potencies that vary from neutral to extremely potent. If these factors just occur randomly in a given period of time, then they would basically just be representing "noise" in the system. However, if there were interactions between the risk factors and if they had additive effects, then there could be outcomes that for some patients would oscillate in a nonpainful state and in others would generate pain ranging from brief to persistent.[37] Even though none of the interaction terms in the present study had a significant effect on the relationship between bruxism and TMD pain, more research is needed to understand if and how these factors interact.

Conclusions

The current study has revealed that patients with TMD pain reported significantly more bruxism compared to patients without any report of orofacial pain and that a variety of psychological factors were associated with bruxism intensity. Nonetheless, these psychological factors appeared to have no influence on the strength of the relationship between bruxism and TMD pain. It can therefore be concluded that the clinical presence of TMD pain was not the result of an interaction between psychological factors and self-reported bruxism activities.

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