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ORIGINAL RESEARCH

The Association Between Specific Oral Behaviors and the Number of Temporomandibular Disorder Symptoms in the General Population: A Cross-Sectional Study

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Objective: This study aimed to thoroughly explore the relationship between individual oral behavior and the differing numbers of temporomandibular disorder (TMD) symptom in the general population.

Methods: A total of 565 participants were recruited and completed a questionnaire containing demographic characteristics, eight specific oral behaviors, and five major TMD symptoms (5Ts) checklist. Multivariate linear regression analysis was performed to assess the relationship between individual oral behavior and the number of TMD symptoms, after controlling for confounders.

Results: The prevalence of TMD symptoms was up to 38.2% in the general population, with 64.6% of the participants engaging in one or more oral behaviors. Female participants showed a stronger positive association with most oral behaviors than males. Moreover, wake oral behaviors exhibited a higher correlation coefficient value with TMD symptom number than sleep oral behaviors. Among the eight oral behaviors, bruxism in sleep exhibited no significant correlation with the of TMD symptom number ($P>0.05$). Seven other specific oral behaviors were significantly correlated with the number of TMD symptoms by multivariate linear regression analysis ($P<0.01$). The associations between the seven oral behaviors and TMD symptom number remained significant in sleep posture pressuring jaw (β: 0.165, 95% CI: 0.080–0.250), bruxism in awake (β: 0.341, 95% CI: 0.132–0.550), teeth clenching (β: 0.422, 95% CI: 0.264–0.580), pressing, holding, or touching teeth together (β: 0.282, 95% CI: 0.169–0.395), holding or tightening muscles without clenching (β: 0.447, 95% CI0.304–0.589), holding jaw forward or to the side (β: 0.694, 95% CI0.526–0.861), and holding jaw in rigid or tense position (β: 0.571, 95% CI0.418, 0.724) after adjustment for demographic factors ($P<0.01$).

Conclusion: There was a positive association between seven specific oral behaviors and TMD symptom number. Individuals with higher frequency of specific oral behaviors are more likely to suffer from more TMD symptoms. Sleep bruxism exhibited no association with TMD symptoms and symptom number.

Keywords: oral behaviors, temporomandibular disorders, TMD symptom number, cross-sectional study

Introduction

Temporomandibular disorders (TMD) contain a series of conditions affecting the temporomandibular joint (TMJ), the masticatory muscles and associated hard and soft tissues. TMD is reported as the second most common musculoskeletal disorder causing pain and disability, impacting approximately 7–23% of the population.[1,2] TMD symptoms are more prevalent in females and tend to peak between the aged of 20 to 40 years.[3] Common symptoms of TMD encompass orofacial pain in the facial and periauricular

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areas, temporal headaches, TMJ noises, jaw opening and closed locking.[4] As one of the most common symptoms and major initial manifestations of TMD in clinical practice, painful symptoms are generally characterized by discomfort in the joint and masticatory muscles, impairing the life quality.[5] TMD-related pain radiates intermittently or chronically into surrounding regions and is usually accompanied by other TMD symptoms. The etiology of TMD is multifactorial, encompassing biophysical, psychological, and social environment factors.[6–8] Biophysical factors are mainly ascribed to dysfunction or structural lesions of the intra-joints and related tissues. The secretion of inflammatory factors in the peripheral joint, secondary to excessive mechanical force, exacerbates progression of TMD.[9] In addition, psychosocial factors such as anxiety, depression, and other emotional states have long been a hot topic in TMD research. It's widely accepted that TMD symptoms, especially orofacial pain and headaches, are strongly correlated with negative psychological conditions, including depression, stress and anxiety.[10,11] Moreover, pain intensity and duration were positively correlated with stress scores in cross-section research.[12] Various prospective studies have reported that psychological conditions are risk factors for the onset and perpetuation of TMDs as well.[13] Some scholars categorize temporomandibular disorders (TMD) into two main types: pain-related TMDs, which include conditions like joint pain or headaches, and intra-articular TMDs, which involve symptoms such as joint sounds or limited mouth opening.[1] In addition, patients with temporomandibular disorders (TMD) may experience symptoms that overlap with other chronic pain conditions, such as headaches, fibromyalgia, and neurological disorders. This is likely attributed to central sensitization, particularly manifesting as allodynia and hyperalgesia.[14]

Oral behaviors primarily originate from abnormal activity of the masticatory muscles beyond the normal functions of speaking, chewing, and swallowing.[15,16] Oral behaviors include, for example, clenching teeth, holding the jaw in a rigid position, and so forth.[17,18] Some oral habits, such as nail biting, grinding, and bruxism in awake, have been reported to be related to emotional stress and anxiety and further stimulate TMD development,[19] implicating a strong association between oral behavior and TMD. The research objects of previous studies have focused on patients in dental clinics and hospitals. Related research focusing on the general population was scale. Despite existing studies, there is evidence that individuals with oral behaviors are susceptible to Temporomandibular Joint Disorders (TMDs). However, the related researches focusing on a more detailed classification of the varying TMD symptom number and multiple oral behaviors is warranted.

This study aimed to determine the relationship between the number of TMD symptom and oral behaviors in the general population. The null hypothesis was proposed that there is no association between the number of TMD symptom and any oral behavior in the general population.

Materials and Methods

Clinical Ethical Approval and Participants

This cross-sectional study was approved by the Ethics Committee of West China Hospital of Stomatology (Approval no. WCHSIRB-D-2022-118) and carried out in the general population through questionnaires from June 2023 to August 2023. Written informed consent was obtained from the participants for a clinical questionnaire survey of their personal basic information and disease conditions. The inclusion criteria were as follows: (a) ability to comprehend and complete the questionnaire and (b) proficiency in reading electronic devices. (c) Participants aged >18 years. (d) the presence or absence of any TMD symptom lasting 30 days at least. The exclusion criteria were as follows: (a) history of medication to relieve TMD symptoms and (b) inability to complete the questionnaire properly.

The G*power software was used to determine the sample size with a medium effect size of 0.15, α of 0.05, and confidence level of 95%, with a minimum sample size of 326 subjects. Ultimately, 565 voluntary participants participated in this study, which greatly exceeds the minimum sample size.

Data Collection

Data were obtained from a questionnaire, comprising three distinct sections, which was provided in the Supplementary Material. Demographic data of the voluntary participants were gathered in the first section, including sex, age, educational level, dental treatment history, and systemic disease history. Educational levels were classified into 1,2 and 3, representing high school or below, college, and postgraduate or above, respectively.

The second section consisted of an oral behavior checklist.[20,21] Eight typical behaviors were adapted to assess overuse of joints and muscles, including two oral behaviors during sleep: (1) bruxism in sleep; (2) sleep posture pressuring jaw and 6 oral behaviors in awake: (3) bruxism in awake, (4) teeth clench, (5) pressing, holding, or touching teeth together, (6) holding or tightening muscles without clenching, (7) holding jaw forward or to the side, and (8) holding jaw in rigid or tense position. After qualitative questioning, each item was subsequently ranked on a five-point scale, ranging from 0 to 4. A score of 3 or above is indicative of being symptom-positive.

The third section examined TMD symptoms as described in a previous study.[22] Five typical TMD symptoms (5Ts) were used as screening tools because of their high specificity (100%) and sensitivity (96.1%). The 5Ts consisted of 2 pain-related and 3 pain-unrelated symptoms: (1) TMD/facial pain: pain in the facial and preauricular area, (2) headache, pain in the temple area, (3) TMJ Noises: joint noise in jaw movement; (4) TMJ closed-locking: jaw locking or catching during opening movement; and (5) TMJ open-locking: jaw locking or catching in closed movement. Following the administration of the 5Ts questionnaire, a further count was conducted of TMD symptoms.

Statistical Analysis

Statistical analyses were conducted using R package Windows software and Empower Stats software (set at 0.05) to determine statistical significance. Continuous variables are displayed as mean ± standard deviation and were evaluated using the Kruskal–Wallis U post hoc test. Categorical data are presented as frequencies and were determined using the R×C chi-square test. Spearman's rank correlation test was used to assess the correlations between oral behaviors and the number of TMD symptoms. The correlation coefficient values were subsequently classified as weak (0.1–0.3), moderate (0.3–0.6), and strong (0.6–0.9) associations, respectively. Multivariate linear regression was used to comprehensively evaluate the association between different oral behaviors and TMD symptom number after adjusting for demographic confounders, including age, sex, history of systemic diseases, and history of dental treatments.

Results

A total of 565 valid questionnaires were ultimately included and divided into six groups according to the number of TMD symptom, ranging from 0 to 5. The study cohort was composed of 56.2% females and 43.7% males, with an average age of 32.19 ±13.41 years. The majority of the participants (77.34%) who had graduated from college accounts for 77.34%. Table 1 illustrates

Table 1 Distribution Among Different Groups of Symptoms (N=565)

Variable	NS	1S	2S	3S	4S	5S	P
No (%)	349 (61.8)	78 (13.8)	55 (9.7)	37 (6.5)	15 (2.7)	31 (5.5)	
Age							0.149a
Mean (SD)	32.1 (12.0)	34.3 (13.1)	34.3 (11.7)	37.8 (13.6)	38.4 (21.2)	32.8 (10.7)	
Median (IQR)	30.0 (20.0)	30.5 (25.8)	32.0 (15.5)	40.0 (23.0)	29.0 (27.0)	30.0 (16.5)	
Sex (%)							0.121b
Male	156 (44.7)	34 (43.6)	27 (49.1)	8 (21.6)	8 (53.3)	14 (45.2)	
Female	193 (55.3)	44 (56.4)	28 (50.9)	29 (78.4)	7 (46.7)	17 (54.8)	
Education (%)							0.402b
1	68 (19.5)	9 (11.5)	6 (10.9)	7 (18.9)	3 (20.0)	6 (19.4)	
2	265 (75.9)	66 (84.6)	44 (80.0)	29 (78.4)	11 (73.3)	22 (71.0)	
3	16 (4.6)	3 (3.8)	5 (9.1)	1 (2.7)	1 (6.7)	3 (9.7)	
Systemic Diseases (%)							<0.001**b
Yes	60 (17.2)	30 (38.5)	29 (52.7)	20 (54.1)	9 (60.0)	8 (25.8)	4S,3S,2S,1S>NS
No	289 (82.8)	48 (61.5)	26 (47.3)	17 (45.9)	6 (40.0)	23 (74.2)	
Dental Treatment (%)							<0.001**b
Yes	151 (43.3)	42 (53.8)	37 (67.3)	29 (78.4)	12 (80.0)	16 (51.6)	3S,2S>NS
No	198 (56.7)	36 (46.2)	18 (32.7)	8 (21.6)	3 (20.0)	15 (48.4)	

Notes: NS: no symptom. 1S:1 symptom. 2S: 2 symptoms. 3S: 3 symptoms. 4S: 4 symptoms. 5S: 5 symptoms. No (%) indicates the distribution of the sample according to the number of TMD symptoms in the total sample. IQR, interquartile range; Education 1,2,3 representing high school or below, college, and postgraduate or above, respectively; TMD, temporomandibular disorder; SD, standard deviation. a Kruskal–Wallis *U*-test. b, Chi-square test. **P< 0.01.

the distribution of characteristics based on the varying number of TMD symptoms. The proportions of groups with differing symptom numbers were exhibited as follows: NS (no symptom) (61.8%), 1S (13.8%), 2S (9.7%),3S (6.5%), 4S (2.7), and 5S (5.5%). No significant differences were observed in sex, age, or education level among the groups with different numbers of symptoms ($P < 0.05$). Conversely, systemic disease and dental treatment were significantly associated with different numbers of TMD symptoms ($P<0.05$). In particular, participants in the 1S (38.5%),2S (52.7%),3S (54.1%),4S (60%) subgroups occupied higher percentage of systemic diseases than those in the NS subgroup (17.2%), except for 5S (25.8%) ($P<0.05$). Similarly, dental treatment resulted in a higher proportion of participants with one or more TMD symptoms ($P < 0.05$).

Figure 1 illustrated the distribution of TMD symptoms, either as single occurrences or in combinations from any of the five types among all respondents. For 5 individual TMD symptom, painful symptoms including TMD/facial pain (37.18%), headache (30.76%) exhibited higher frequency compared to intra-joint symptoms including TMJ noises (20.51%) TMJ open- (6.41%) and closed locking (5.13%). In combined types of multiple symptoms, the types with painful symptoms (94.89%) including headache or TMD/facial pain occupied a notable higher percentage than types (5.11%) without painful symptoms.

As indicated in Figure 2, the cohort exhibiting TMD symptoms generally reported a higher proportion of patients exhibiting oral behaviors than the NS group. Moreover, the 4S group exhibited the lowest proportion of no oral behavior (32.0%) and the highest proportion of oral behavior (SI Table 1).

To estimate the statistical differences in detail, we analyzed the association between the frequency of eight oral behaviors (OBs) and the number of TMD symptoms using the Spearman correlation test. Eight oral behaviors were subsequently categorized as sleep and wake OBs. As illustrated in Figure 3, all eight oral behaviors exhibited a positive correlation with the number of TMD symptoms. The p value of the Spearman correlation coefficients was shown in SI Table 2. Among eight OBs, TMD symptom number displayed weak correlations with "bruxism in Sleep" (r=0.14), "sleep posture pressuring jaw" (r=0.24), "bruxism in awake" (r=0.17) and "teeth clench" (r=0.26). TMD symptom number indicated moderate correlations with "pressing, holding or touching teeth together" (r=0.32), "holding or tightening muscles without clenching" (r=0.32), "holding jaw forward or to the side" (r=0.35) and "holding jaw in rigid or tense position" (r=0.32). OBs in the awake (r=0.44) showed moderate correlations with symptom number of TMDs, whereas

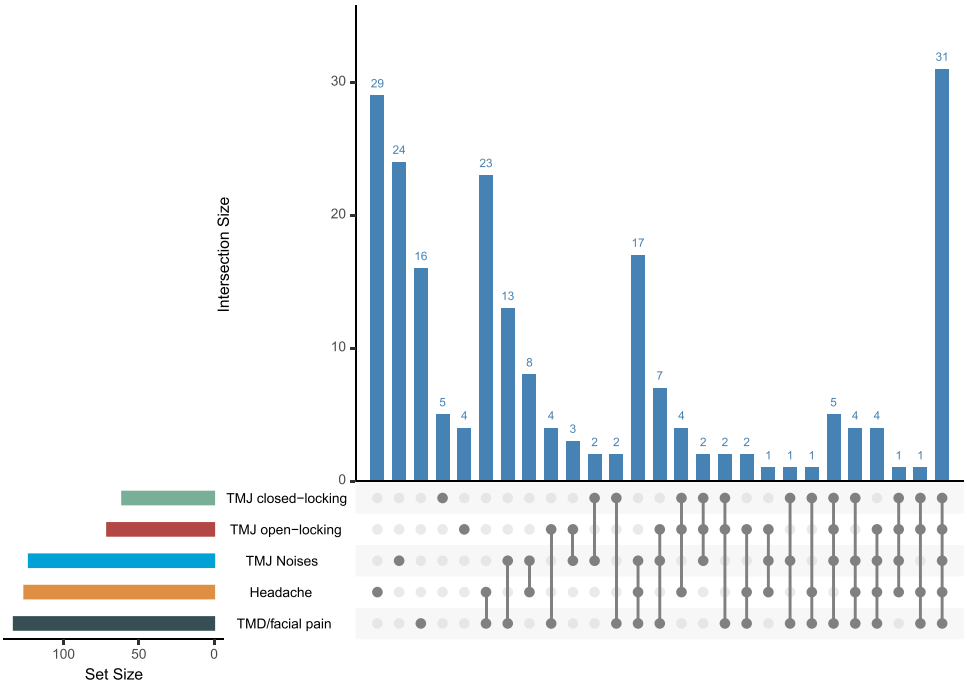

Figure 1 Upset plot.

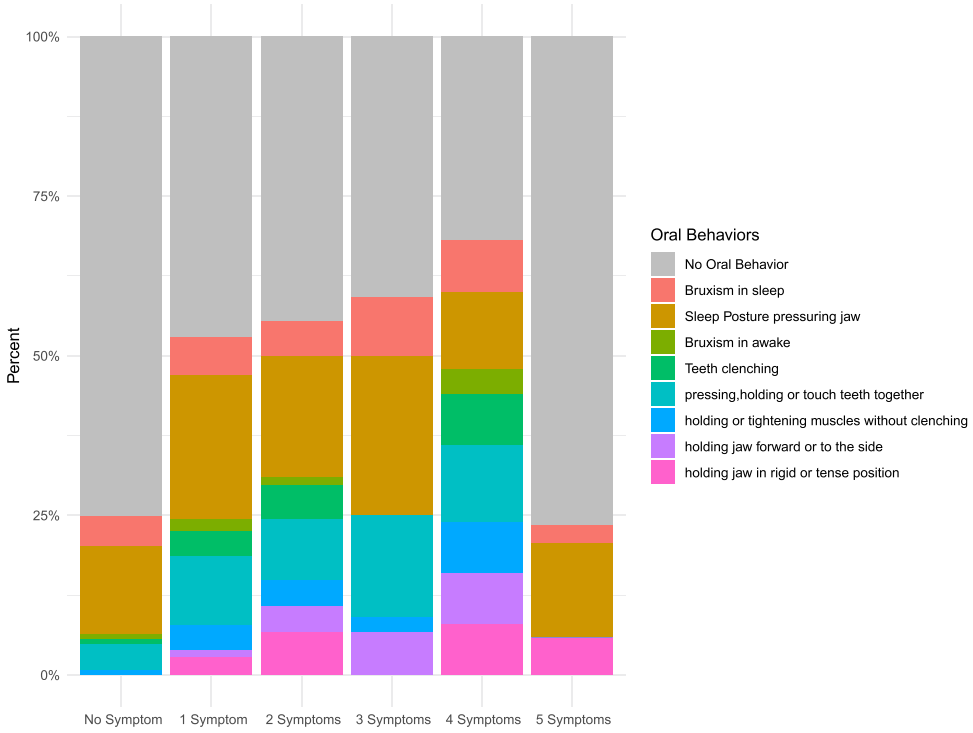

Figure 2 Proportions of oral behaviors among different groups of symptoms.

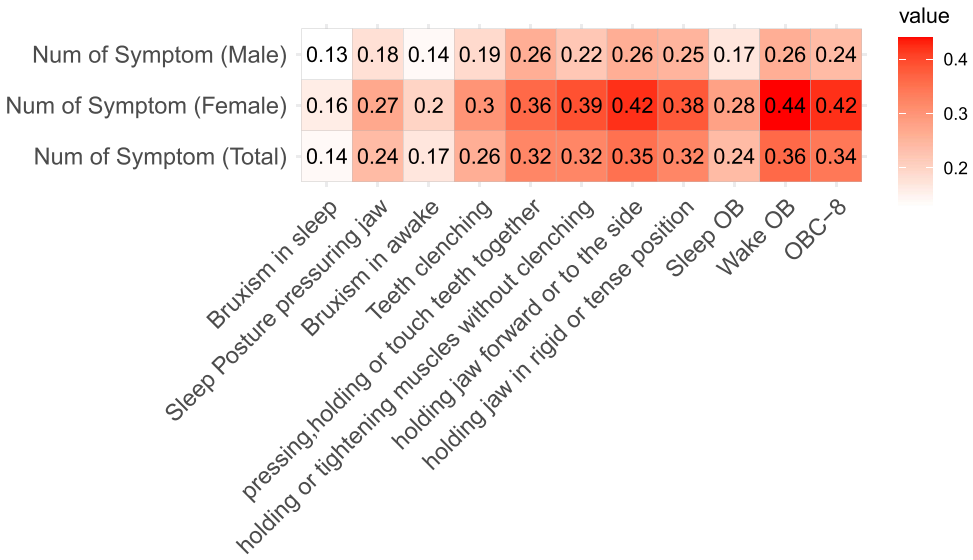

Figure 3 Spearman correlation coefficients heatmap. Abbreviations: OB, oral behavior; Num of Symptom, number of symptoms.

OBs in sleep displayed weak correlations (r=0.28). Notably, female participants with each oral behavior generally exhibited a higher positive correlation coefficient with the number of symptoms compared with males.

Table 2 and Table 3 show the mean and median of the oral behavior checklist scores and the findings of the statistical comparison based on TMD symptom numbers, individually and collectively. As shown in Table 2, no significant correlation of sleep bruxism was observed with the number of TMD symptoms. Additionally, seven other oral behaviors, including Sleep Posture pressuring jaw (1S, 2S, 3S, 4S > NS), bruxism in awake (3S > NS), Teeth Clenching (1S, 2S, 3S, 4S, 5S > NS), pressing, holding, or touching teeth together (1S, 2S, 3S, 4S > NS), holding or tightening muscles without

Table 2 Oral Behaviors Checklist Scores in Groups with Different TMD Symptom Number

Variables	NS	1S	2S	3S	4S	5S	P Post hoc Test
Bruxism in sleep Mean (SD)	0.4 (0.9)	0.5 (0.9)	0.6 (1.0)	0.5 (1.0)	0.8 (1.3)	0.5 (0.8)	0.072 Non-significant
Sleep Posture pressuring jaw Mean (SD)	0.8 (1.3)	1.4 (1.6)	1.3 (1.4)	1.7 (1.5)	1.7 (1.2)	1.0 (1.2)	**<0.001***** **1S,2S,3S,4S>NS**
Bruxism in awake Mean (SD)	0.1 (0.5)	0.2 (0.6)	0.3 (0.7)	0.4 (0.6)	0.5 (1.1)	0.3 (0.7)	**0.004**** **3s>ns**
Teeth Clenching Mean (SD)	0.2 (0.5)	0.5 (0.9)	0.6 (1.0)	0.5 (0.7)	1.2 (1.3)	0.5 (0.8)	**<0.001***** **1S,2S,3S,4S,5S>NS;** **4S>1S**
Pressing, holding or touching teeth together Mean (SD)	0.4 (0.9)	1.1 (1.2)	1.0 (1.1)	1.2 (1.2)	1.4 (1.5)	0.7 (0.8)	**<0.001***** **1S,2S,3S,4S>NS**
Holding or tightening muscles without clenching Mean (SD)	0.3 (0.6)	0.7 (1.0)	0.8 (1.0)	0.7 (0.9)	1.3 (1.3)	0.7 (0.8)	**<0.001***** **1S,2S,3S,4S,5S>NS**
Holding jaw forward or to the side Mean (SD)	0.2 (0.5)	0.4 (0.7)	0.6 (0.9)	0.8 (1.0)	1.2 (1.3)	0.6 (0.8)	**<0.001***** **1S,2S,3S,4S,5S>NS;** **3S,4S>1S**
Holding jaw in rigid or tense position Mean (SD)	0.2 (0.5)	0.6 (0.8)	0.8 (1.0)	0.7 (0.7)	1.3 (1.1)	0.7 (1.0)	**<0.001***** **1S,2S,3S,4S,5S>NS;** **4S>1S**

Notes: NS: no symptom. 1S:1 symptom. 2S: 2 symptoms. 3S: 3 symptoms. 4S: 4 symptoms. 5S: 5 symptoms. NS: no symptom. S: Symptom (s). Results of Kruskal–Wallis test with Bonferroni correction. **P< 0.01, ***P< 0.001. The bold indicates significant difference.

Table 3 Oral Behaviors Checklist Scores Among Different Subgroups

Variables	NS	1S	2S	3S	4S	5S	P Post hoc Test
OBC Total Score							<0.001*** 1S,2S,3S,4S>NS
Median (IQR)	0.0 (4.0)	4.0 (7.0)	5.0 (7.5)	7.0 (7.0)	11.0 (12.5)	3.0 (8.0)	
Mean (SD)	2.6 (4.0)	5.3 (5.4)	6.0 (5.9)	6.6 (4.6)	9.3 (8.2)	5.0 (5.6)	
Sleep OBC Score							<0.001*** 1S,2S,3S,4S>NS
Median (IQR)	0.0 (2.0)	1.5 (4.0)	1.0 (3.0)	2.0 (3.0)	2.0 (2.5)	1.0 (2.5)	
Mean (SD)	1.2 (1.9)	1.9 (2.1)	1.9 (2.1)	2.2 (1.9)	2.5 (2.0)	1.5 (1.8)	
Awake OBC Score							<0.001*** 1S,2S,3S,4S,5S>NS
Median (IQR)	0.0 (2.0)	2.5 (5.0)	3.0 (5.0)	4.0 (4.0)	8.0 (10.5)	0.0 (6.0)	
Mean (SD)	1.4 (2.8)	3.4 (4.1)	4.1 (4.6)	4.4 (3.6)	6.8 (6.7)	3.5 (4.3)	
Average OBC-8							<0.001*** 1S,2S,3S,4S>NS
Median (IQR)	0.0 (0.5)	0.5 (0.9)	0.6 (0.9)	0.9 (0.8)	1.4 (1.6)	0.4 (1.0)	

(*Continued*)

Table 3 (Continued).

Variables	NS	1S	2S	3S	4S	5S	P Post hoc Test
Mean (SD)	0.3 (0.5)	0.7 (0.7)	0.8 (0.7)	0.8 (0.6)	1.2 (1.0)	0.6 (0.7)	
Average Sleep OBC							<0.001*** 1S,2S,3S,4S>NS
Median (IQR)	0.0 (1.0)	0.8 (2.0)	0.5 (1.5)	1.0 (1.5)	1.0 (1.3)	0.5 (1.2)	
Mean (SD)	0.6 (1.0)	1.0 (1.0)	1.0 (1.0)	1.1 (0.9)	1.2 (1.0)	0.7 (0.9)	
Average Awake OBC							<0.001*** 1S,2S,3S,4S,5S>NS
Median (IQR)	0.0 (0.3)	0.4 (0.8)	0.5 (0.8)	0.7 (0.7)	1.3 (1.8)	0.0 (1.0)	
Mean (SD)	0.2 (0.5)	0.6 (0.7)	0.7 (0.8)	0.7 (0.6)	1.1 (1.1)	0.6 (0.7)	

Notes: OBC: Oral behavior checklist. NS: no symptom. 1S:1 symptom. 2S: 2 symptoms. 3S: 3 symptoms. 4S: 4 symptoms. 5S: 5 symptoms. Median (IQR). NS: no symptom. S: Symptom (s). Results of Kruskal–Wallis test with Bonferroni correction. ***P< 0.001.

clenching (1S, 2S, 3S, 4S, 5S > NS), holding the jaw forward or to the side (1S, 2S, 3S, 4S, 5S > NS), and holding the jaw in a rigid or tense position (1S, 2S, 3S, 4S, 5S > NS), reported significantly higher scores with more symptom numbers (Table 2). Likewise, both oral sleep behaviors and awake behaviors exhibited a significant positive correlation with the total number of TMD symptoms and average scores (Table 3).

In Table 4, the univariate linear regression analysis revealed positive correlations between the number of TMD symptoms and seven behaviors, including sleep posture pressuring jaw (β: 0.153; 95% CI 0.069–0.237), bruxism in awake (β: 0.349; 95% CI0.142–0.555), teeth clenching (β: 0.438; 95% CI 0.281, 0.596), pressing, holding, or touching teeth together (β: 0.295; 95% CI0.183, 0.407), holding or tightening muscles without clenching (β: 0.458; 95% CI0.316, 0.600), holding the jaw forward or to the side (β: 0.699; 95% CI0.532, 0.866), and holding the jaw in a rigid or tense position (β: 0.563; 95% CI0.409, 0.716). Interestingly, after adjusting for the II model of demographic factors, a significant positive association with the number of TMD symptoms persisted in seven oral behaviors.

Table 4 Multiple Linear Regression Analysis

Variable	Unadjusted	Adjust I	Adjust II
Bruxism in sleep	0.121 (−0.006, 0.248)	0.114 (−0.013, 0.242)	0.076 (−0.049, 0.201)
Sleep Posture pressuring jaw	**0.153*** (0.069, 0.237)**	**0.165*** (0.080, 0.250)**	**0.118** (0.033, 0.203)**
Bruxism in awake	**0.349*** (0.142, 0.555)**	**0.341** (0.132, 0.550)**	**0.256* (0.049, 0.463)**
Teeth clenching	**0.438*** (0.281, 0.596)**	**0.422*** (0.264, 0.580)**	**0.363*** (0.206, 0.519)**
Pressing, holding or touch teeth together	**0.295*** (0.183, 0.407)**	**0.282*** (0.169, 0.395)**	**0.220*** (0.106, 0.334)**
Holding or tightening muscles without clenching	**0.458*** (0.316, 0.600)**	**0.447*** (0.304, 0.589)**	**0.378*** (0.235, 0.521)**
Holding jaw forward or to the side	**0.699*** (0.532, 0.866)**	**0.694*** (0.526, 0.861)**	**0.607*** (0.437, 0.778)**
Holding jaw in rigid or tense position	**0.563*** (0.409, 0.716)**	**0.571*** (0.418, 0.724)**	**0.496*** (0.341, 0.651)**

Notes: Results presented as β (95% CI) P value. CI: confidence interval. Adjustment I: Age, sex, and education. Adjust II: Age, sex, education, no systemic and no dental treatment. **P< 0.01, ***P< 0.001. The bold indicates significant difference.

Discussion

This cross-sectional study aimed to investigate the potential relationships between differing number of TMD symptoms and oral behaviors, with a particular focus on examining the prevalence of specific oral behaviors. The results indicated a significant positive relationship between oral behavior and the number of TMD symptoms. Among the specific subtypes of oral behaviors, a significant positive association was observed between TMD symptom number and seven of the eight oral behaviors, including sleep posture pressuring jaw, bruxism in awake, teeth clenching, pressing, holding or touching teeth together, holding or tightening muscles without clenching, holding jaw forward or to the side and holding jaw in rigid or tense position. Consequently, the null hypothesis was rejected.

It is generally believed that TMD is more prevalent in females than males.[23] In contrast to the majority of previous studies, no significant difference was found in the distribution of symptoms (p=0.121) in this study (Table 1). The participants with differing TMD symptom numbers exhibited similar constituents among males and females. The prevalence in previous results may be due to neuropsychological or physiological differences, such as more estrogenic hormone,[24] lower pain thresholds, and greater psychological stress in females than in males. Such inconsistencies for the latter results in this study may be ascribed to differences in the respondent stratification. In this study, the subcategories based on symptom numbers varying from 1 to 5 did not exhibit a discernible difference in sex distribution specifically.

TMDs is the second most prevalent musculoskeletal condition,[25] and according to a systematic review, indicating an increase in prevalence over time. Existing literature suggests a correlation between TMD and specific neurodegenerative disorders, such as Parkinson's disease, which is characterized as muscle rigidity and static tremor.[26] It may be inferred that the potential relationship between TMDs and oral behaviors containing habits in chewing and static conditions, is caused by masticatory muscle dysfunction.[26]

An interesting finding was observed among female subjects in this study. Despite no significant difference was found in the sex distribution among the different numbers of TMD symptoms. Compared to males, female participants exhibited a higher positive correlation coefficient with the number of TMD symptoms in every specific oral behavior. Various studies have pointed out that a bidirectional relationship between TMD and psychosomatic factors including anxiety, stress, and depression, is thought to exist and that multiple psychological variables can serve as predictors of TMD.[27,28] Psychosocial disorders play a crucial role in the development of TMD[29–31] Meanwhile, more females suffer from anxiety disorders than males.[32] Anxiety sensitivity has been associated with a reduced pain threshold in both experimental and clinical-based investigations.[33]

Furthermore, the oral behavior of "holding or tightening muscles without clenching" mandibles displayed the universally highest positive correlation with TMD symptom number in both males and females (r=0.42 β: 0.699). This implies a crucial role of mandibular reposition induced by uncoordinated contractions of the masticatory muscles in TMD development. A potential reason for this phenomenon might be that the overload force generated during the mandibular forward movement exacted on the total joint, and the consequent pain could be induced by excessive pressure. The joint space was compressed, and joint disc displacement unsuitably aggravated the TMJ-related pain and other symptoms, creating a vicious cycle.[34] Previous studies have proved that TMDs are considered muscle pain caused by abnormal contraction, ischemia, and asymmetrical activity of masticatory muscles.[35]

Bruxism, an oral behavior of habitual grinding teeth, is typically considered as a potential cause of TMJ microtrauma. This may further lead to an exacerbation of inflammatory processes and the development of pain potentially aggravating inflammation.[36,37] Bruxism includes bruxism during sleep and in awake. It is noteworthy that the tendencies of sleep and awake bruxism exhibited contrast in this study, as evidenced by the results of the multiple linear regression analysis. Different from awake bruxism, sleep bruxism displayed no positive correlation with the number of TMD symptoms. Some researchers hold that the incidence of TMDs is associated only with sleep bruxism, while in other studies, TMDs incidence was associated only with awake or mixed bruxism.[38–41] The mechanisms underlying sleep and awake bruxism were different. This difference may be explained by the fact that, compared with awake bruxism, sleep bruxism can also indirectly affect TMD symptoms by impairing sleep quality, psychological stress or other oral behavior in sleep-like sleep posture, unconsciously.

To the best of our knowledge, this study represents the first evaluation of the correlation between specific oral behaviors and the number of TMD symptoms in the general population based on a considerable sample size, offering notable insights into TMD screening and diagnosis through oral behaviors. Early detection of certain oral behaviors acts as an auxiliary diagnostic indicator in TMD management and prevention. A clear correlation between specific oral behaviors and TMD symptoms is of considerable clinical value, enabling comprehensive monitoring of TMD in patients. For clinicians lacking expertise in TMJ, it can be challenging to predict TMJ conditions and gain a comprehensive understanding of TMD. In particular, the utilization of specific oral behaviors by orthodontists and prosthodontist can facilitate the monitoring and management of TMD conditions in an effective manner.

Despite these insights, this cross-sectional study had some limitations. Firstly, this was a cross-sectional study based on the general population. Therefore, the causal relationship between TMD symptoms and oral behavior could not be determined. Prospective longitudinal studies could aid into completely determining causal relationships and addressing this shortcoming. In addition, TMDs encompass a variety of symptoms, with a recognized distinction between pain-related TMDs and intra-articular TMDs. We have utilized five major TMD symptoms for their high specificity and sensitivity, without further classification. The relationship between TMD classifications and individual oral behaviors is intriguing and could be explored in future research. Moreover, owing to the limitations of the questionnaire, subjective bias from self-reporting is unavoidable. Discrepancies may occur between a patient's subjective perception and the objective observations by clinicians. For example, a patient might report TMD noises that are not detectable by the diagnosing clinician. These observations are intriguing and warrant further investigation.

Conclusions

This cross-sectional study demonstrated the significant associations between seven specific oral behaviors and TMD symptom number in the general population. Individuals with higher frequency of specific oral behaviors was likely to suffer from more TMD symptoms. No significant association was found between sleep bruxism and TMD symptom number.

Data Sharing Statement

The data used to support the findings of this study were available at our university clinic.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of West China Hospital of Stomatology (approval no. WCHSIRB-D-2022-118). Consent was obtained from all study subjects. Written informed consent was obtained from all study subjects.

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Disclosure

The authors declare that they have no conflicts of interest.

References

1. Schiffman E, Ohrbach R, Truelove E. et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group. *J Oral Facial Pain Headache*. 2014;28(1):6–27. doi:10.11607/jop.1151
2. List T, Jensen RH. Temporomandibular disorders: old ideas and new concepts. *Cephalalgia*. 2017;37(7):692–704. doi:10.1177/0333102416686302
3. Slade GD, Fillingim RB, Sanders AE, et al. Summary of findings from the OPPERA prospective cohort study of incidence of first-onset temporomandibular disorder: implications and future directions. *J Pain*. 2013;14(12):T116–T124. doi:10.1016/j.jpain.2013.09.010
4. Ujin yap A, Cao Y, Zhang M-J, et al. Age-related differences in diagnostic categories, psychological states and oral health-related quality of life of adult temporomandibular disorder patients. *J Oral Rehabil*. 2021;48(4):361–368. doi:10.1111/joor.13121

5. Osiewicz M, Manfredini D, Biesiada G, et al. Prevalence of Function-Dependent Temporomandibular Joint and Masticatory Muscle Pain, and Predictors of Temporomandibular Disorders among Patients with Lyme Disease. *J Clin Med*. 2019;8(7):929. doi:10.3390/jcm8070929
6. Kmeid E, Nacouzi M, Hallit S, et al. Prevalence of temporomandibular joint disorder in the Lebanese population, and its association with depression, anxiety, and stress. *Head Face Med*. 2020;16(1):19. doi:10.1186/s13005-020-00234-2
7. Farré-Guasch E, Aliberas JT, Spada NF, et al. The role of inflammatory markers in Temporomandibular Myalgia: a systematic review. *Jpn Dent Sci Rev*. 2023;59:281–288. doi:10.1016/j.jdsr.2023.08.006
8. Durham J, Newton-John TRO, Zakrzewska JM. Temporomandibular disorders. *BMJ*. 2015;350:h1154. doi:10.1136/bmj.h1154
9. Son C, Park YK, Park JW. Long-term evaluation of temporomandibular disorders in association with cytokine and autoantibody status in young women. *Cytokine*. 2021;144:155551. doi:10.1016/j.cyto.2021.155551
10. Knuutila J, Kivipuro J, Näpänkangas R, et al. Association of temporomandibular disorders with pain sensitivity: a cohort study. *Eur J Pain*. 2022;26 (1):143–153. doi:10.1002/ejp.1844
11. Zhu R, Zhang L, Zheng Y-H, et al. Association between Stigma and Pain in Patients with Temporomandibular Disorders. *Int J Clin Pract*. 2022;2022:2803540. doi:10.1155/2022/2803540
12. Fillingim RB, Ohrbach R, Greenspan JD, et al. Potential psychosocial risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *J Pain*. 2011;12(11):T46–T60. doi:10.1016/j.jpain.2011.08.007
13. Chen H, Comnick C, Norman GJ, et al. Triad multisystem phenotype with high risk for developing temporomandibular disorders-characteristics and potential pathophysiology results from the Orofacial Pain: prospective Evaluation and Risk Assessment dataset. *Pain*. 2023;164(5):1027–1038. doi:10.1097/j.pain.0000000000002797
14. Ferrillo M, Migliario M, Marotta N, et al. Temporomandibular disorders and neck pain in primary headache patients: a retrospective machine learning study. *Acta Odontol Scand*. 2023;81(2):151–157. doi:10.1080/00016357.2022.2105945
15. Mehdipour A, Aghaali M, Janatifar Z, et al. Prevalence of Oral Parafunctional Habits in Children and Related Factors: an Observational Cross-sectional Study. *Int J Clin Pediat Dent*. 2023;16(2):308–311. doi:10.5005/jp-journals-10005-2520
16. Ohrbach R, Fillingim RB, Mulkey F, et al. Clinical findings and pain symptoms as potential risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *J Pain*. 2011;12(11):T27–T45. doi:10.1016/j.jpain.2011.09.001
17. Abe S, Kawano F, Matsuka Y, et al. Relationship between Oral Parafunctional and Postural Habits and the Symptoms of Temporomandibular Disorders: a Survey-Based Cross-Sectional Cohort Study Using Propensity Score Matching Analysis. *J Clin Med*. 2022;11(21):6396. doi:10.3390/jcm11216396
18. Markiewicz MR, Ohrbach R, McCall WD. Oral behaviors checklist: reliability of performance in targeted waking-state behaviors. *J Orofacial Pain*. 2006;20(4):306–316.
19. Almutairi AF, Albesher N, Aljohani M, et al. Association of oral parafunctional habits with anxiety and the Big-Five Personality Traits in the Saudi adult population. *Saudi Dent J*. 2021;33(2):90–98. doi:10.1016/j.sdentj.2020.01.003
20. Barbosa C, Manso MC, Reis T, et al. Are oral overuse behaviours associated with painful temporomandibular disorders? A cross-sectional study in Portuguese university students. *J Oral Rehabil*. 2021;48(10):1099–1108. doi:10.1111/joor.13226
21. Donnarumma V, Ohrbach R, Simeon V, et al. Association between waking-state oral behaviours, according to the oral behaviors checklist, and TMD subgroups. *J Oral Rehabil*. 2021;48(9):996–1003. doi:10.1111/joor.13221
22. Yap AU, Zhang M-J, Zhang X-H, et al. Viability of the quintessential 5 temporomandibular disorder symptoms as a TMD screener. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2022;133(6):643–649. doi:10.1016/j.oooo.2021.11.009
23. Gauer RL, Semidey MJ. Diagnosis and treatment of temporomandibular disorders. *Am Family Phys*. 2015;91(6):378–386.
24. Sena M, Mesquita K, Santos FRR, et al. Prevalence of temporomandibular dysfunction in children and adolescents. *Revista Paulista Pediatria*. 2013;31(4):538–545. doi:10.1590/S0103-05822013000400018
25. Jin LJ, Lamster IB, Greenspan JS, et al. Global burden of oral diseases: emerging concepts, management and interplay with systemic health. *Oral Dis*. 2016;22(7):609–619. doi:10.1111/odi.12428
26. Minervini G, Franco R, Marrapodi MM, et al. Prevalence of temporomandibular disorders in subjects affected by Parkinson disease: a systematic review and metanalysis. *J Oral Rehabil*. 2023;50(9):877–885. doi:10.1111/joor.13496
27. Liou Y-J, Bai Y-M, Tsai S-J, et al. Bidirectional Associations of Temporomandibular Joint Disorders with Major Depressive and Anxiety Disorders. *J Evid Dent Pract*. 2023;23(2):101860. doi:10.1016/j.jebdp.2023.101860
28. Dos Santos EA, Peinado BRR, Frazão DR, et al. Association between temporomandibular disorders and anxiety: a systematic review. *Front Psychiatr*. 2022;13:990430. doi:10.3389/fpsyt.2022.990430
29. Seweryn P, Orzeszek SM, Waliszewska-Prosół M, et al. Relationship between pain severity, satisfaction with life and the quality of sleep in Polish adults with temporomandibular disorders. *Dent Med Prob*. 2023;60(4):609–617. doi:10.17219/dmp/171894
30. Simoen L, Van den Berghe L, Jacquet W, et al. Depression and anxiety levels in patients with temporomandibular disorders: comparison with the general population. *Clinical Invest*. 2020;24(11):3939–3945. doi:10.1007/s00784-020-03260-1
31. Wieckiewicz M, Jenca A, Seweryn P, et al. Determination of pain intensity, pain-related disability, anxiety, depression, and perceived stress in Polish adults with temporomandibular disorders: a prospective cohort study. *Front Integrat Neurosci*. 2022;16:1026781. doi:10.3389/fnint.2022.1026781
32. Jamet C, Dubertret C, Le Strat Y, et al. Age of onset of major depressive episode and association with lifetime psychiatric disorders, health-related quality of life and impact of gender: a cross sectional and retrospective cohort study. *J Affective Disorders*. 2024;363:300–309. doi:10.1016/j.jad.2024.07.017
33. Pihut ME, Kostrzewa-Janicka J, Orczykowska M, et al. Initial assessment of the psycho-emotional state of patients with temporomandibular disorders: a pilot study. *Dent Med Prob*. 2024;61(1):153–159. doi:10.17219/dmp/178325
34. Chisnoiu AM, Picos AM, Popa S, et al. Factors involved in the etiology of temporomandibular disorders - a literature review. *Clujul Med*. 2015;88 (4):473–478. doi:10.15386/cjmed-485
35. Sarlani E, Grace EG, Reynolds MA, et al. Evidence for up-regulated central nociceptive processing in patients with masticatory myofascial pain. *J Orofacial Pain*. 2004;18(1):41–55.
36. Zhong J, Gao X, Hu S, et al. A worldwide bibliometric analysis of the research trends and hotspots of bruxism in adults during 1991–2021. *J Oral Rehabil*. 2024;51(1):5–14. doi:10.1111/joor.13577

37. Lekaviciute R, Kriauciunas A. Relationship Between Occlusal Factors and Temporomandibular Disorders: a Systematic Literature Review. *Cureus*. 2024;16(2):e54130. doi:10.7759/cureus.54130
38. Fernandes G, Siqueira J, Gonçalves DADG, Camparis CM. Godoi Gonçalves DAd, et al: association between painful temporomandibular disorders, sleep bruxism and tinnitus. *Braz Oral Res*. 2014;28(1):1–7. doi:10.1590/1807-3107BOR-2014.vol28.0003
39. Blanco Aguilera A, Gonzalez Lopez L, Blanco Aguilera E, et al. Relationship between self-reported sleep bruxism and pain in patients with temporomandibular disorders. *J Oral Rehabil*. 2014;41(8):564–572. doi:10.1111/joor.12172
40. Berger M, Szalewski L, Szkutnik J, et al. Different association between specific manifestations of bruxism and temporomandibular disorder pain. *Neurologia I Neurochirurgia Polska*. 2017;51(1):7–11. doi:10.1016/j.pjnns.2016.08.008
41. van Selms MKA, Thymi M, Lobbezoo F. Psychological distress and the belief that oral behaviours put a strain on the masticatory system in relation to the self-report of awake bruxism: four scenarios. *J Oral Rehabil*. 2024;51(1):170–180. doi:10.1111/joor.13460