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ORIGINAL RESEARCH

Associations between oral behaviors, temporomandibular disorder subtypes and psychological distress in adult women: a retrospective case-control study

Yu Zhong[1], Fang Luo[2], Xinbei Li[2], Shiya Zeng[2], Shuyuan Zhang[3], Jiarui Si[2], Xin Xiong[2,*], Shanbao Fang[1,2,*]

[1]Guangxi Key Laboratory of Oral and Maxillofacial Rehabilitation and Reconstruction, Guangxi Stomatological Virtual Reality Engineering Research Center, College & Hospital of Stomatology, Guangxi Medical University, 530021 Nanning, Guangxi, China
[2]State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases, West China Hospital of Stomatology, Sichuan University, 610041 Chengdu, Sichuan, China
[3]West China Hospital, Sichuan University, 610041 Chengdu, Sichuan, China

***Correspondence**
drxiongxin@scu.edu.cn
(Xin Xiong);
fangshanbao@gxmu.edu.cn
(Shanbao Fang)

Abstract

Oral behaviors and psychological distress are known to be related to temporomandibular disorders (TMDs). However, the relationship between various oral behaviors and specific TMD subgroups in adult women experiencing psychological distress is still unclear. To investigate the relationship between various oral behaviors and different TMD subgroups with different psychological distress states. A total of 210 female TMD patients were divided into 3 subgroups according to their symptoms: pain-related (PT), intra-articular (IT) and combined pain-related and intra-articular (CT). Another 70 participants without TMDs were recruited as the non-TMD (NT) control group. We used reduced Chinese versions of the Oral Behavior Checklist (OBC-Ch 8), including awake (OBC-Ch 6) and sleep-related activities, the 9-item Patient Health Questionnaire (PHQ-9) and the 7-item Generalized Anxiety Disorder Scale (GAD-7) to assess oral behaviors and psychological distress. Differences in OBC scores among TMD subgroups were analyzed using Chi-square, Kruskal-Wallis H and *post hoc* tests, with significance set at $p < 0.05$. Oral behavior subscale scores significantly differed among TMD subgroups ($p < 0.01$). The OBC-Ch 8 scores of PT, IT and CT subjects were significantly higher than the NT group. PT and CT groups also had significantly higher GAD-7 and PHQ-9 scores. Sleep-related OBC scores of the PT, IT and CT groups were higher than those in the NT group, regardless of psychological states ($p < 0.001$). In psychologically distressed subjects, OBC-Ch 8 scores for PT and CT subgroups were significantly higher than those in the NT group. Oral behaviors are differentially associated with various TMD subgroups in female adults, and a correlation exists between individual psychological status and OBC scores.

Keywords

Oral behaviors; Psychological distress; Temporomandibular joint disorders; Bruxism; TMD subgroups

1. Introduction

Temporomandibular disorders (TMDs) are a group of heterogeneous musculoskeletal conditions that involve the temporomandibular joints (TMJs), masticatory muscles and adjacent tissues, with a high prevalence among the general population in the modern world [1, 2]. Multiple etiological factors such as anatomy, trauma, genetic and psychosocial stress have been identified to contribute to the development of TMDs [3, 4].

As a component of the Diagnostic Criteria for TMD (DC/TMD) validation study, the Oral Behavior Checklist (OBC) was developed as a self-administered questionnaire to assess self-reported oral behaviors that are correlated with TMDs [5]. The OBC is the most widely accepted self-reporting tool that can be used to comprehensively assess various types of oral overuse behavior. Further, the OBC also is a good tool for evaluation of memory regarding unconscious oral behaviors [6, 7]. However, according to previous studies, OBC scores have not shown conclusive results related to TMDs. Some researchers have concluded that there is a correlation between painful TMDs and OBC scores [8, 9]. However, other studies have found no significant correlation between TMDs and OBC scores [10, 11]. To better assess patients' oral behaviors, dentists and researchers usually combine self-reported OBC questionnaires with clinical examination including extraoral and intraoral evaluation [12].

Few studies have investigated the relationship between oral behaviors and specific TMD subgroups. Several studies have

shown that some oral behaviors like tooth grinding, clenching, gum chewing and object biting are predictive of TMD risk [13]. Donnarumma *et al.* [14] analyzed OBC responses with exploratory factor analysis and classified OBC items into two groups. The first group included items pertaining to non-functional activities (NFA), such as clenching, grinding and holding. The other group included items pertaining to normal functional activities (FA) of the jaws, such as chewing, talking and yawning. The study explored the relationship between awake-state NFA and various TMD subgroups, and found that NFA scores in the painful TMD subgroup and the painful-dysfunctional TMD subgroup were higher than in the TMD-free control group.

There is general consensus that a biopsychosocial model should be applied to TMDs, and that patients with TMDs should be assessed in a manner that takes into account both physical and psychosocial factors [15]. A significant body of research suggests that psychological factors are strongly implicated in TMDs [16–18]. Several psychological variables can predict increased risk of TMD onset and persistence, including psychosocial stress, somatic symptoms and affective distress. Moreover, psychological characteristics such as anxiety and depression have been found to be related to different symptoms of TMDs [19, 20]. However, Donnarumma *et al.* [21] found that trait anxiety was only weakly related to the frequency of oral behaviors in healthy female individuals.

Bruxism is an umbrella term including various motor activities that may occur while conscious or unconscious. An expert consensus paper further clarified this distinction, and proposed separate definitions for awake bruxism (AB) and sleep bruxism (SB) [22]. The relationship between bruxism and TMD is still controversial and remains unclear. The majority of studies in which bruxism has been correlated with TMDs were conducted by means of a questionnaire or self-reported assessment. These papers have suggested a statistically significant association between bruxism and TMD [23]. Nevertheless, several other studies have identified bruxism based on clinical findings such as tooth wear or electromyographical measures, and the results did not support an association between bruxism and TMDs [24, 25]. Thus, the difference between effects of AB and SB on TMDs is still not clear.

Therefore, it is necessary to explore the relationship between oral behaviors in adult women with various TMD subtypes who are experiencing different psychological distress states. The aims of this study are as follows: (1) To assess the mean score oral behaviors in no TMDs and TMDs subgroups. (2) To study the association between TMD symptoms and bruxism. (3) The distribution of various oral behaviors with or without anxiety and depression in the no TMDs and TMDs subgroups.

In the present study, we take the null hypothesis to be that there is no significant difference in oral behavior scores among TMD subgroups, and that measures of oral behaviors are not correlated with TMD subgroups in women experiencing different types of psychological distress.

2. Materials and methods

2.1 Subjects

The study group consisting of female participants with TMDs was recruited from the Department of Temporomandibular Joint, West China Hospital of Stomatology. Enrollment lasted from 01 February 2022 to 30 March 2023. The healthy, non-TMD volunteers were recruited from the local community through public postings. The study only included female participants, in consideration of the high prevalence of TMDs among females [26]. The inclusion criteria were as follows: (1) age $\geq$18 years old; (2) capable of reading, comprehending and completing the questionnaires. Subjects were excluded from the study if they reported a history of TMD treatment; systemic diseases such as rheumatoid arthritis, tumor or trauma affecting the TMJs; or pharmacotherapy influencing TMD symptoms, including nonsteroidal anti-inflammatory drugs, anxiolytics and antidepressants.

2.2 Questionnaires

All the participants completed questionnaires to assess baseline variables, including a screen for five TMD symptoms (5Ts), abbreviated eight-item version of the Chinese translation of Oral Behaviors Checklist (OBC-Ch 8), 9-item Patient Health Questionnaire (PHQ-9) and 7-item Generalized Anxiety Disorder Scale (GAD-7), all of scales were translated into Chinese.

2.3 TMD subtypes and symptoms

All participants were asked to complete the 5Ts screening questionnaire to distinguish their subtype of TMD. The 5Ts showed excellent validity, sensitivity, reliability and specificity for identifying pain-related and/or intra-articular TMDs [27]. In the current study, clinical examination for Axis I DC/TMD diagnosis was administered by specialists in the Department of TMJ. Based on their questionnaire responses and physical examination, the subjects were categorized into 4 groups:

(1) Pain-Related TMD (PT) Group: pain-related TMD subtype, which included myalgia, arthralgia or headache attributed to TMDs.

(2) Intra-Articular TMD (IT) Group: intra-articular TMD symptoms, which included disc displacement with reduction and intermittent locking; disc displacement without reduction, with or without limited opening; degenerative joint disease or subluxation.

(3) Combined TMD (CT) Group: TMDs with both pain-related and intra-articular characteristics.

(4) Non-TMD (NT) group: Healthy subjects in the control group with no history of TMD diagnosis, matched in age with the other groups.

2.4 Oral behaviors and psychological distress

The participants completed OBC-Ch 8 scale. Eight items including six awake behaviors and two sleep behaviors were chosen to identify and quantify the overuse of the joints and muscles, according to the previous studies [8, 28]. The reliability of the Chinese version of OBC was shown to be good [7]. They answered six items (OBC-Ch 6) about awake oral behaviors, of which four concerned AB specifically, scored on

a 5-point scale (1 = "none of the time" to 5 = "all of the time"). The questionnaire also included two items (OBC 1, 2) about asleep oral behaviors, one of them about SB, scored on a five-point scale (1 = "none of the time", 2 = "less than 1 night per month", 3 = "1 to 3 nights per month", 4 = "1 to 3 nights per week", 5 = "4 to 7 nights per week"). Only in patients reporting frequent bruxism was this behavior considered to be present. Thus, in this study, an OBC value ≥4 on any of the five questions about AB or SB was chosen as the conservative cut-off value for prevalence of AB or SB according to the previous study [29]. Total scores of awake (OBC-Ch 6) and all oral behaviors (OBC-Ch 8) were calculated by summing the OBC items. These items were selected for the study because these oral functional activities might be differentially associated with painful and dysfunctional TMD subtypes [14].

Psychological characteristics of all the subjects were assessed using Chinese versions of the validated PHQ-9 and GAD-7 self-reporting questionnaires. PHQ-9 was used to screen for depression, and items were rated based on the frequency of each symptom during the past two weeks, ranging from 0 (not at all) to 3 (nearly every day), with possible scores ranging from 0 to 27. In this study, the cut-off value for diagnosis of depression was ≥5. GAD-7, which assessed the severity of anxiety, was rated on a Likert scale from 0 (not at all) to 3 (nearly every day), resulting in a range of scores from 0 to 21. The cut-off value for diagnosis of anxiety was set to ≥5 in the present study [20].

2.5 Statistical analysis

The PASS Statistics package version 15.0 (NCSS, Kaysville, UT, USA) was used for sample size calculation. The power analysis determined that a minimum of 180 individuals should be included, with at least 45 participants in each group, for a medium effect size of Cohen's $f = 0.25$, $\alpha = 0.05$ and $1 - \beta = 0.80$.

Continuous variables were described using the mean, standard deviation (SD), median and interquartile range (IQR). Categorical variables were expressed as the number of cases and percentage values. Kolmogorov-Smirnov tests were performed to check the normality of the data. Kruskal-Wallis H test was used for continuous variables with non-normal distribution and grade data. A Chi-square test or Fisher exact probability method was used to investigate categorical variables. Statistical analysis was performed using IBM SPSS v. 26.0 (IBM Corp., Armonk, NY, USA) and a level of $p < 0.05$ was established to determine statistical significance.

3. Results

The characteristics of the participants involved in the study are presented in Table 1. Each group consisted of 70 subjects, for a total of 280 participants with a mean age of 31.29 ± 10.36 included in the study. No significant difference was found in demographic variables (age and level of education) among the four groups (Table 1).

Fig. 1 presents the AB and SB activity of each group. The prevalence of AB in the three TMD subtype groups was higher than in the NT group, though without significant difference (Fig. 1A). The frequency of AB ranged from 20% to 38.6% for the groups in our study. The prevalence of SB was significantly different among the groups ($p < 0.001$, Chi-square text), with the highest prevalence in the CT group (30%), followed by the PT group, IT group and NT group (Fig. 1B).

There was a significant difference in oral behavior scores between the TMD subgroups and the NT group ($p < 0.001$). The total OBC-Ch 8 scores of the TMD subgroups were higher than that of the NT group (2.2 ± 3.0), as shown in Table 2. *Post hoc* pair-wise comparisons revealed that the OBC-Ch 8 scores of the PT group (11.5 ± 4.7), IT group (9.2 ± 5.6) and CT group (10.8 ± 5.2) were significantly higher than that of the NT group (2.6 ± 3.3) (Table 2).

To compare the psychological factors of DC/TMD Axis II, the average scores on the GAD-7 and PHQ-9 were calculated. Table 1 demonstrated that the average GAD-7 and PHQ-9 scores were above the preselected cut-off value only in the PT group (5.2 ± 5.0, 5.5 ± 5.5) and CT group (5.5 ± 4.8, 5.2 ± 4.8). The prevalence of anxiety and depression based on our diagnostic threshold was significantly higher in the TMD subgroups collectively than in the NT group ($p < 0.01$). *Post hoc* pair-wise comparisons indicated that the scores of the PT and CT groups were each significantly higher than that of the NT group (Table 1).

Further, comparison of the psychological characteristics of each TMD subgroup in Tables 3 and 4 revealed that the scores of sleep-related OBC in the three TMD subgroups were each higher than that of the NT group ($p < 0.001$).

As shown in Table 3, the OBC-Ch 6 and OBC-Ch 8 scores of non-anxious subjects (n = 181) were the highest in the PT group (median: 7, 12) and the lowest in the NT group (median: 0, 0). The PT, IT and CT groups had scores that were significantly higher than the NT group, as assessed by *post hoc* pair-wise comparisons ($p < 0.001$). However, among anxious subjects (n = 99), the highest OBC-Ch 6 and OBC-Ch 8 scores were those of the CT group (median: 7, 13). Moreover, the PT group and CT group had significantly higher scores than the NT group, as assessed by *post hoc* pair-wise comparisons of the anxious subjects in each group ($p < 0.001$).

Table 4 shows the OBC scores of participants with and without depression in each group. Significant differences were observed in OBC-Ch 6 (PT, IT, CT > NT) and OBC-Ch 8 (PT, IT, CT > NT) scores across groups in non-depressed participants (n = 175). In depressed participants (n = 105), significant differences were also observed in OBC-Ch 6 (PT > NT) and OBC-Ch 8 (PT, CT > NT).

4. Discussion

In the present study, we aimed to determine the distribution of various oral behaviors and the prevalence of bruxism, as well as the role of psychological distress like anxiety and depression, that may affect patients with various TMD subtypes based on self-reported questionnaires.

TABLE 1. Demographic characteristics of the different TMD groups.

Parameter	NT (n = 70)	PT (n = 70)	IT (n = 70)	CT (n = 70)	Total (n = 280)	*p*-value *Post-hoc*
			Demography			
Age (yr)						
Min–Max	18–55	18–68	18–66	18–62	18–68	0.309[b]
Mean (SD)	31.9 (9.0)	32.1 (11.0)	30.1 (9.5)	31.1 (10.4)	31.3 (10.4)	
Education (%)						
Primary or high school	19 (31.7%)	11 (18.3%)	12 (20.0%)	18 (30.0%)	60 (100.0%)	
Undergraduate	48 (24.1%)	52 (26.1%)	49 (24.6%)	50 (25.1%)	199 (100.0%)	0.136[a]
Graduate student	3 (14.3%)	7 (33.3%)	9 (42.9%)	2 (9.5%)	21 (100.0%)	
			Psychological assessment			
GAD-7 score						
Mean (SD)	2.4 (4.0)	5.2 (5.0)	3.4 (3.7)	5.5 (4.8)	4.1 (4.6)	<0.001[b]*
Median (IQR)	0.0 (4.0)	4.0 (5.0)	2.0 (4.0)	4.0 (7.0)	3.0 (6.0)	PT, CT > NT; IT > CT
Anxiety (%)	16 (22.9%)	31 (44.3%)	20 (28.6%)	32 (45.7%)	99 (35.4%)	0.008[a]* PT, CT > NT
PHQ-9 score						
Mean (SD)	2.7 (3.6)	5.5 (5.5)	3.7 (3.8)	5.2 (4.8)	4.3 (4.6)	<0.001[b]*
Median (IQR)	1.0 (4.0)	4.0 (7.0)	3.0 (5.0)	4.0 (8.0)	3.0 (6.0)	PT, CT > NT
Depression (%)	16 (22.9%)	33 (47.1%)	22 (31.4%)	34 (48.6%)	105 (37.5%)	0.003[a]* PT, CT > NT

[a]*Chi-square test;* [b]*Kruskal-Wallis-test; *Significantly different (GAD-7 score, Anxiety, PHQ-9 score, Depression) among the groups. Abbreviations: NT, no TMD; PT, pain-related TMD; IT, intra-articular TMD; CT, combined TMD; SD, standard deviation; IQR, interquartile range; GAD-7, the 7-item Generalized Anxiety Disorder Scale; PHQ-9, the 9-item Patient Health Questionnaire. Adjusted p value using Bonferroni correction.*

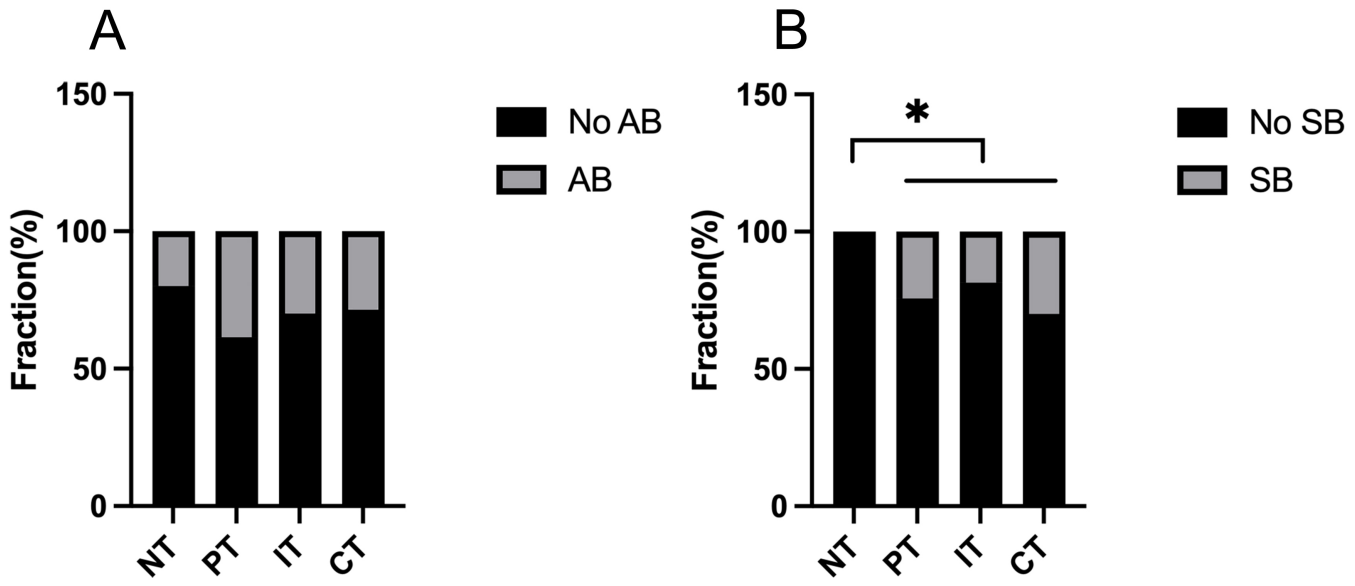

FIGURE 1. The distribution of frequency of bruxism (n = 280). (A) The prevalence of AB and (B) SB in NT, PT, IT and CT groups. NT, no TMD; PT, pain-related TMD; IT, intra-articular TMD; CT, combined TMD; AB, awake bruxism; SB, sleep bruxism. *The prevalence of SB was significantly different among the groups.

TABLE 2. OBC scores in various TMD groups.

Parameter	NT (n = 70)	PT (n = 70)	IT (n = 70)	CT (n = 70)	*p*-value *Post-hoc*
OBC 1. Clench or grind teeth when asleep, based on any information you may have					
Mean (SD)	1.1 (0.3)	2.4 (1.4)	2.3 (1.4)	2.4 (1.6)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	2.0 (2.0)	2.0 (2.0)	2.0 (3.0)	
OBC 2. Sleep in a position that puts pressure on the jaw (for example, on stomach, on the side)					
Mean (SD)	1.2 (0.5)	4.1 (1.1)	3.9 (1.6)	3.9 (1.4)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	4.0 (2.0)	5.0 (2.0)	4.5 (2.0)	
Sleep-related OBC total					
Mean (SD)	0.3 (0.7)	4.5 (1.9)	4.2 (2.5)	4.3 (2.3)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	0.0 (0.0)	4.5 (3.0)	4.0 (3.3)	4.0 (3.0)	
OBC 3. Grind teeth together during waking hours					
Mean (SD)	1.3 (0.8)	1.4 (0.7)	1.2 (0.8)	1.2 (0.6)	0.500
Median (IQR)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	
OBC 4. Clench teeth together during waking hours					
Mean (SD)	2.0 (1.5)	2.5 (1.1)	1.9 (1.0)	2.3 (1.3)	<0.001[b]* PT > NT, IT
Median (IQR)	1.0 (1.0)	2.5 (1.0)	2.0 (2.0)	2.0 (2.0)	
OBC 5. Press, touch or hold teeth together other than while eating (that is, contact between upper and lower teeth)					
Mean (SD)	1.1 (0.3)	2.8 (1.1)	2.5 (1.4)	2.7 (1.2)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	3.0 (2.0)	2.0 (3.0)	3.0 (1.0)	
OBC 6. Hold, tighten or tense muscles without clenching or bringing teeth together					
Mean ± SD	1.2 (0.5)	2.2 (1.0)	1.7 (0.9)	2.0 (1.0)	<0.001[b]* PT, IT, CT > NT; PT > IT
Median (IQR)	1.0 (0.0)	2.0 (2.0)	1.5 (1.0)	2.0 (2.0)	
OBC 7. Hold or jut jaw forward or to the side					
Mean (SD)	1.4 (0.9)	1.9 (0.9)	1.6 (0.8)	2.1 (1.1)	<0.001[b]* PT, CT > NT; PT > IT
Median (IQR)	1.0 (0.0)	2.0 (1.0)	1.0 (1.0)	2.0 (2.0)	
OBC 11. Hold jaw in rigid or tense position, such as to brace or protect the jaw					
Mean ± SD	1.2 (0.5)	2.2 (1.0)	2.0 (1.1)	2.2 (0.9)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	2.0 (2.0)	2.0 (2.0)	2.0 (2.0)	
OBC-Ch 6					
Mean (SD)	2.2 (3.0)	7.0 (3.9)	5.0 (3.9)	6.6 (4.0)	<0.001[b]* PT, IT, CT > NT; PT > IT
Median (IQR)	1.0 (4.0)	7.0 (6.0)	5.0 (6.0)	6.0 (5.0)	
OBC-Ch 8					
Mean (SD)	2.6 (3.3)	11.5 (4.7)	9.2 (5.6)	10.8 (5.2)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (4.0)	12.0 (6.0)	9 .0(8.0)	10.0 (6.0)	

[b]*Kruskal-Wallis-test; *There was a significant difference in oral behavior scores between the TMD subgroups and the NT group. Abbreviations: NT, no TMD; PT, pain-related TMD; IT, intra-articular TMD; CT, combined TMD; OBC, Oral Behavior Checklist; OBC-Ch, Chinese versions of the Oral Behavior Checklist; SD, standard deviation; IQR, interquartile range. Adjusted p value using Bonferroni correction.*

TABLE 3. Oral Behavior Checklist (OBC) scores disaggregated by anxiety status.

Parameter	Anxiety (n = 99)					No anxiety (n = 181)				
	NT (n = 16)	PT (n = 31)	IT (n = 20)	CT (n = 32)	*p*-value *Post-hoc*	NT (n = 54)	PT (n = 39)	IT (n = 50)	CT (n = 38)	*p*-value *Post-hoc*
OBC 1. Clench or grind teeth when asleep, based on any information you may have										
Mean (SD)	1.3 (0.4)	2.3 (1.4)	2.4 (1.2)	2.7 (1.6)	0.007* IT, CT > NT	1.1 (0.3)	2.5 (1.3)	2.3 (1.5)	2.2 (1.6)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (1.0)	2.0 (2.0)	2.0 (2.0)	3.0 (3.0)		1.0 (0.0)	2.0 (3.0)	2.0 (2.0)	1.0 (3.0)	
OBC 2. Sleep in a position that puts pressure on the jaw (for example, on stomach, on the side)										
Mean (SD)	1.5 (0.7)	4.0 (1.2)	3.6 (1.7)	4.3 (1.1)	<0.001[b]* PT, IT, CT > NT	1.2 (0.4)	4.1 (1.1)	4.0 (1.5)	3.6 (1.6)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (1.0)	5.0 (2.0)	5.0 (3.0)	5.0 (1.0)		1.0 (0.0)	4.0 (1.0)	5.0 (2.0)	4.0 (3.0)	
Sleep-related OBC total										
Mean (SD)	0.8 (1.0)	4.4 (2.2)	4.0 (2.5)	5.0 (2.2)	<0.001[b]* PT, IT, CT > NT	0.2 (0.6)	4.6 (1.7)	4.3 (2.5)	3.7 (2.3)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	0.0 (1.8)	4.0 (4.0)	4.0 (4.8)	5.5 (3.5)		0.0 (0.0)	5.0 (3.0)	4.0 (3.0)	4.0 (3.3)	
OBC 3. Grind teeth together during waking hours										
Mean (SD)	1.7 (0.9)	1.4 (0.8)	1.2 (0.4)	1.2 (0.5)	0.043	1.2 (0.7)	1.3 (0.6)	1.3 (0.9)	1.3 (0.6)	0.288
Median (IQR)	1.5 (1.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)		1.0 (0.0)	1.0 (1.0)	1.0 (0.0)	1.0 (0.0)	
OBC 4. Clench teeth together during waking hours										
Mean (SD)	3.2 (1.6)	2.7 (1.2)	2.2 (1.0)	2.6 (1.3)	0.204	1.6 (1.2)	2.4 (1.1)	1.8 (0.9)	2.1 (1.2)	<0.001[b]* PT, CT > NT
Median (IQR)	3.0 (3.0)	3.0 (1.0)	2.0 (2.0)	2.5 (1.0)		1.0 (1.0)	2.0 (1.0)	2.0 (1.0)	2.0 (2.0)	
OBC 5. Press, touch, or hold teeth together other than while eating (that is, contact between upper and lower teeth)										
Mean (SD)	1.2 (0.4)	2.8 (1.1)	2.3 (1.3)	2.8 (1.2)	<0.001[b]* PT, CT > NT	1.1 (0.2)	2.9 (1.2)	2.6 (1.4)	2.6 (1.1)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	3.0 (2.0)	2.0 (2.0)	3.0 (2.0)		1.0 (0.0)	3.0 (2.0)	2.0 (3.0)	3.0 (1.0)	
OBC 6. Hold, tighten, or tense muscles without clenching or bringing teeth together										
Mean ± SD	1.6 (0.8)	2.1 (0.9)	2.0 (1.1)	2.3 (1.0)	0.124	1.1 (0.4)	2.3 (1.0)	1.6 (0.8)	1.8 (1.0)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.5 (1.0)	2.0 (2.0)	2.0 (2.0)	2.0 (2.0)		1.0 (0.0)	2.0 (2.0)	1.0 (1.0)	1.5 (2.0)	

TABLE 3. Continued.

Parameter	Anxiety (n = 99)					No anxiety (n = 181)				
	NT (n = 16)	PT (n = 31)	IT (n = 20)	CT (n = 32)	*p*-value *Post-hoc*	NT (n = 54)	PT (n = 39)	IT (n = 50)	CT (n = 38)	*p*-value *Post-hoc*
OBC 7. Hold or jut jaw forward or to the side										
Mean (SD)	1.8 (0.8)	1.8 (0.9)	1.6 (0.7)	2.3 (1.1)	0.121	1.3 (0.9)	2.0 (0.9)	1.6 (0.9)	1.9 (1.0)	<0.001[b]* PT, CT > NT
Median (IQR)	2.0 (1.0)	2.0 (1.0)	1.5 (1.0)	2.0 (2.0)		1.0 (0.0)	2.0 (2.0)	1.0 (1.0)	2.0 (1.0)	
OBC 11. Hold jaw in rigid or tense position, such as to brace or protect the jaw										
Mean ± SD	1.6 (0.7)	2.1 (1.0)	2.0 (0.9)	2.3 (0.9)	0.054	1.2 (0.4)	2.2 (1.0)	2.0 (1.1)	2.0 (0.9)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (1.0)	2.0 (2.0)	2.0 (2.0)	2.0 (1.0)		1.0 (0.0)	2.0 (2.0)	2.0 (2.0)	2.0 (2.0)	
OBC-Ch 6										
Mean (SD)	5.0 (2.8)	7.0 (3.7)	5.2 (3.9)	7.5 (3.7)	0.041*	1.4 (2.6)	7.1 (4.0)	4.9 (4.0)	5.8 (4.0)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	6.0 (4.0)	7.0 (6.0)	5.5 (6.0)	7.0 (6.0)		0.0 (2.0)	7.0 (5.0)	4.5 (6.0)	5.5 (4.0)	
OBC-Ch 8										
Mean (SD)	5.8 (3.2)	11.3 (5.1)	9.1 (5.4)	12.4 (4.6)	<0.001[b]* PT, CT > NT	1.6 (2.8)	11.6 (4.5)	9.2 (5.7)	9.5 (5.4)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	7.0 (5.0)	12.0 (8.0)	9.0 (7.0)	13.0 (8.0)		0.0 (3.0)	12.0 (5.0)	8.5 (8.0)	9.0 (7.0)	

[b]*Kruskal-Wallis-test; *Significantly different among the groups. Abbreviations: NT, no TMD; PT, pain-related TMD; IT, intra-articular TMD; CT, combined TMD; SD, standard deviation; IQR, interquartile range. Adjusted p value using Bonferroni correction.*

TABLE 4. Oral Behavior Checklist (OBC) scores disaggregated by depression status.

Parameter	Depression (n = 105)					No depression (n = 175)				
	NT (n = 16)	PT (n = 33)	IT (n = 22)	CT (n = 34)	*p*-value *Post-hoc*	NT (n = 54)	PT (n = 37)	IT (n = 48)	CT (n = 36)	*p*-value *Post-hoc*
OBC 1. Clench or grind teeth when asleep, based on any information you may have										
Mean (SD)	1.2 (0.4)	2.6 (1.5)	2.4 (1.3)	2.5 (1.5)	0.004* PT, IT, CT > NT	1.1 (0.3)	2.2 (1.2)	2.3 (1.5)	2.4 (1.6)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	2.0 (3.0)	2.0 (2.0)	2.0 (3.0)		1.0 (0.0)	2.0 (2.0)	2.0 (2.0)	1.0 (3.0)	
OBC 2. Sleep in a position that puts pressure on the jaw (for example, on stomach, on the side)										
Mean (SD)	1.3 (0.4)	4.2 (1.1)	3.6 (1.7)	4.2 (1.2)	<0.001[b]* PT, IT, CT > NT	1.2 (0.5)	3.9 (1.2)	4.0 (1.5)	3.6 (1.5)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (1.0)	5.0 (1.0)	4.5 (3.0)	5.0 (1.0)		1.0 (0.0)	4.0 (2.0)	5.0 (2.0)	4.0 (3.0)	
Sleep-related OBC total										
Mean (SD)	0.4 (0.7)	4.8 (2.1)	4.0 (2.4)	4.6 (2.3)	<0.001[b]* PT, IT, CT > NT	0.3 (0.7)	4.2 (1.8)	4.3 (2.6)	4.0 (2.4)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	0.0 (1.0)	5.0 (2.0)	4.0 (4.3)	4.0 (3.0)		0.0 (0.0)	4.0 (3.0)	4.0 (3.0)	4.0 (4.0)	
OBC 3. Grind teeth together during waking hours										
Mean (SD)	1.7 (0.9)	1.3 (0.7)	1.1 (0.3)	1.2 (0.5)	0.013* IT, CT > NT	1.2 (0.7)	1.4 (0.7)	1.3 (0.9)	1.3 (0.6)	0.261
Median (IQR)	1.5 (1.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)		1.0 (0.0)	1.0 (1.0)	1.0 (0.0)	1.0 (0.0)	
OBC 4. Clench teeth together during waking hours										
Mean (SD)	2.9 (1.7)	2.7 (1.1)	2.2 (1.0)	2.4 (1.3)	0.267	1.7 (1.3)	2.4 (1.1)	1.8 (1.0)	2.3 (1.2)	<0.001[b]* PT, CT > NT
Median (IQR)	2.5 (4.0)	3.0 (2.0)	2.0 (2.0)	2.0 (2.0)		1.0 (1.0)	2.0 (2.0)	1.5 (1.0)	2.0 (2.0)	
OBC 5. Press, touch, or hold teeth together other than while eating (that is, contact between upper and lower teeth)										
Mean (SD)	1.2 (0.4)	2.9 (1.2)	2.1 (1.1)	2.7 (1.0)	<0.001[b]* PT, CT > NT	1.1 (0.2)	2.8 (1.1)	2.7 (1.5)	2.8 (1.3)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (0.0)	3.0 (2.0)	2.0 (2.0)	3.0 (1.0)		1.0 (0.0)	3.0 (2.0)	2.5 (3.0)	3.0 (2.0)	
OBC 6. Hold, tighten, or tense muscles without clenching or bringing teeth together										
Mean ± SD	1.4 (0.5)	2.2 (1.0)	1.8 (0.8)	2.2 (1.0)	0.007* PT, CT > NT	1.2 (0.5)	2.3 (1.0)	1.7 (0.9)	1.8 (1.0)	<0.001[b]* PT, IT, CT > NT; PT > IT
Median (IQR)	1.0 (1.0)	2.0 (2.0)	2.0 (1.0)	2.0 (2.0)		1.0 (0.0)	2.0 (2.0)	1.0 (1.0)	1.5 (2.0)	

TABLE 4. Continued.

Parameter	Depression (n = 105)					No depression (n = 175)				
	NT (n = 16)	PT (n = 33)	IT (n = 22)	CT (n = 34)	*p*-value *Post-hoc*	NT (n = 54)	PT (n = 37)	IT (n = 48)	CT (n = 36)	*p*-value *Post-hoc*
OBC 7. Hold or jut jaw forward or to the side										
Mean (SD)	1.6 (0.7)	1.9 (0.9)	1.8 (1.0)	2.3 (1.1)	0.127	1.3 (0.9)	1.9 (0.9)	1.5 (0.7)	1.9 (1.0)	<0.001[b]* PT, CT > NT
Median (IQR)	1.5 (1.0)	2.0 (1.0)	2.0 (1.0)	2.0 (2.0)		1.0 (0.0)	2.0 (2.0)	1.0 (1.0)	2.0 (2.0)	
OBC 11. Hold jaw in rigid or tense position, such as to brace or protect the jaw										
Mean ± SD	1.4 (0.6)	2.4 (1.1)	1.9 (0.8)	2.4 (1.0)	0.001* PT, CT > NT	1.2 (0.5)	2.0 (1.0)	2.1 (1.2)	1.9 (0.9)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	1.0 (1.0)	3.0 (2.0)	2.0 (1.0)	2.0 (1.0)		1.0 (0.0)	2.0 (2.0)	2.0 (2.0)	2.0 (2.0)	
OBC-Ch 6										
Mean (SD)	4.2 (3.1)	7.3 (3.9)	4.8 (3.0)	7.1 (3.7)	0.004* PT > NT	1.6 (2.8)	6.8 (3.9)	5.1 (4.3)	6.0 (4.1)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	5.0 (6.0)	8.0 (6.0)	5.5 (4.0)	7.0 (6.0)		0.0 (3.0)	7.0 (5.0)	5.0 (7.0)	6.0 (7.0)	
OBC-Ch 8										
Mean (SD)	4.6 (3.4)	12.1 (4.9)	8.8 (4.2)	11.7 (4.9)	<0.001[b]* PT, CT > NT	1.9 (3.1)	10.9 (4.5)	9.4 (6.2)	10 (5.5)	<0.001[b]* PT, IT, CT > NT
Median (IQR)	5.0 (7.0)	14.0 (7.0)	9.0 (6.0)	12.0 (6.0)		0.0 (3.0)	11.0 (5.0)	8.5 (9.0)	9.0 (6.0)	

[b]*Kruskal-Wallis-test; *Significantly different among the groups. Abbreviations: NT, no TMD; PT, pain-related TMD; IT, intra-articular TMD; CT, combined TMD; SD, standard deviation; IQR, interquartile range. Adjusted p value using Bonferroni correction.*

In this study, we utilized self-reporting measures combined with physical examination to reinforce the accurate diagnosis of TMD subtypes. The 5Ts screening questionnaire is a validated tool for the identification of individual TMD status. In addition, we specifically assessed awake and asleep oral behaviors based on the OBC, which has also been validated in previous studies [7, 30].

Several studies have indicated that various oral behaviors are possible contributors to TMDs [8, 31]. The prolonged loading caused by oral activities have been associated with dysfunction of the masticatory muscles and a high stress distribution in the disc, leading to TMDs [32]. Previous studies have found a variety of associations, or lack thereof, between awake and sleep-related oral behaviors and specific TMD subtypes [11]. In the present study, we analyzed participants' responses to OBC items focused on oral behaviors, including both awake and sleep-related oral activities, to comprehensively investigate the distribution of oral behaviors in different TMD subgroups. The results showed significant differences in OBC-Ch 8, OBC-Ch 6 and asleep oral behavior scores among the three subtypes of TMDs studied here and the control group without TMDs. Intergroup comparisons revealed that participants with TMDs had significantly higher scores than controls in the NT group, similar to previous studies [30, 33]. Overall, scores tended to be higher in the current study, which may be due to the sample with only female participants enrolled.

The OBC scores were higher in the PT group and CT group among the different TMD subgroups evaluated in this study, which is in line with the findings of previous studies [33, 34]. The scores on assessments of awake and sleep-related oral behaviors in the IT group were lower than those of the PT group and CT group, again in agreement with previous studies [14, 35]. Sun *et al.* [28] found that the PT patient have higher frequency oral behaviors than those without PT subjects in general participants with the same OBC scale. Indeed, participants with dysfunctional TMDs showed a lower frequency of oral behaviors compared to those with painful TMDs. Frequent oral behaviors are a known risk factor for painful TMDs [36]. Chow *et al.* [6] reported that participants with facial pain have more frequent oral behaviors than those without facial pain. Barbosa *et al.* [8] studied young university students and found that those with higher levels of overuse of oral behaviors had a stronger association with painful TMDs compared to students with fewer and less-frequent behaviors, and the level of overuse of oral behaviors exhibited a dose-response relationship with the severity of TMD-associated facial pain. Moreover, Keela *et al.* [9] investigated the OBC scores associated with various types of pain in TMDs. They reported that high OBC scores were associated with chronic painful TMDs, and suggested that managing oral behaviors during TMD treatment is warranted. However, Lövgren *et al.* [10] evaluated the association between oral behaviors and functional jaw disturbances, and they reported no significant association between the frequency of oral behaviors and a positive screening for functional jaw disturbances. The differences in these results might be due to differing validity of OBC items, which may be influenced by social or cultural factors that vary in different regions [21].

A considerable amount of research has established that age is one of the factors contributing to differences in the distribution of TMD subgroups. In this study, adult subjects were included with a mean age of 31.29 ± 10.36, which was different from the research by Adrian *et al.* [30]. The participants in their study were younger university students with a mean age of 22.7 ± 1.1, which could have contributed to the difference in results. Moreover, Michelotti *et al.* [33] found that female patients have a significant risk of myofascial pain, while the risk of developing disc displacement decreases with their age.

Bruxism, long considered a disorder or pathology, is now thought to be a motor activity that may be a potential risk factor for some diseases and may even have possible physiological or protective relevance [37]. The association of TMDs with self-reported frequent AB and SB with is a controversial topic. In this study, TMD patients were significantly more likely than participants in the NT group to report SB, whereas we found no significant differences in AB across groups. Su *et al.* [38] found that self-reported AB and SB are both associated with lower oral health-related quality of life in TMD patients. Similar to previous reported findings, in our study the prevalence of AB was about 30% in our sample of female adults [39], and the AB distribution was not statistically different between TMD subtypes or in NT controls. The differing degrees of SB prevalence in our results were in line with previous studies which indicated that SB is associated with TMDs [40]. Nevertheless, several studies have suggested that it is not possible to draw definitive conclusions about whether there may be a cause-effect relationship between SB and TMDs. The apparent differences in bruxism rates might indicate that self-reporting of sleep bruxism is unreliable, and varying findings in the literature could also be due to the heterogeneity of study designs [41]. Thus, it has been recommended to assess oral conditions related to the spectrum of bruxism activities using measures other than self-reporting, such as electromyographic (EMG) or polysomnographic (PSG) instrumental measures [42].

Psychological disorders such as anxiety and depression have been correlated with the development of TMDs and inherent comorbidity [43]. Zlendić *et al.* [11] observed differences in psychological variables (anxiety and depression) between their control group and patients with TMDs, especially in the higher pain intensity TMD group. Nevertheless, Yao *et al.* [44]. investigated the mental health of patients with reversible anterior disc displacement, and they found that the measures of anxiety and depression were not significantly different in these patients compared to the control group. Adding nuance to this picture, oral behaviors and psychological distress have been differentially associated with particular TMD symptoms. Thus, it might be necessary to assess the distribution of psychological stress (anxiety and depression) and oral behaviors among different TMD subgroups.

Since psychosocial factors are known to be related to both oral behaviors and pain intensity, they deserve to be the focus of further research in the future. More precise and detailed research projects will clarify the potentially bidirectional relationships between oral behaviors, pain, and psychosocial factors. According to our findings in the present study, anxiety and depression were significantly more prevalent in the PT group and CT groups, both TMD subtypes that involve a pain

component, than in the NT group or the non-painful IT group. Our results indicated that oral behavior scores for both awake and asleep activities and global scores of OBC-Ch 8 were higher in individuals suffering from anxiety and depression, consistent with previous studies [6, 45]. Furthermore, individuals diagnosed with anxiety or depression in the NT group had higher oral behavior scores than others in the NT group. Therefore, assessments of patients' individual psychological status to identify anxiety and depression is recommended before treatment of TMDs.

Most TMDs have a good prognosis. However, in some specific TMD patients with disease that involves a serious Axis-I or Axis-II component, clinical experts suggest multidisciplinary treatment by dental and medical specialists, such as orofacial pain specialists, TMJ surgeons, psychologists and psychiatrists [46]. This approach may particularly be particularly important for patients for whom a painful TMD is associated with anxiety and/or depression.

The TMD diagnoses of patients in our study were confirmed through self-reported questionnaires and physical examination, ensuring highly reliable classification. However, this study still has certain limitations. First, this was a case-control study of patients recruited from one clinical center, with only female participants. We did not interrogate or speculate on cause-effect relationships in this study. Moreover, the female sample size in the study was limited and the results may not represent the general population. Further study should include a larger sample size representing a broader spectrum of genders and ages. The use of standardized tools is encouraged to assess bruxism, and instrumental measures like PSG data during a sleep study might be utilized for more accurate assessment of various oral behaviors as well as definition of sleep bruxism. In addition, the 5Ts scale, although concise and easy to implement, cannot reflect the severity of TMDs. A more comprehensive clinical examination including imaging data and more detailed questionnaires may be required in future studies to accurately assess the relationship between oral behaviors, psychological stress and TMDs.

5. Conclusions

In this study, we found that TMD patients present significantly higher frequency of oral behaviors than healthy subjects. This was especially true of patients experiencing painful TMDs and psychological distress. Clinicians should pay attention to special oral behaviors in patients with TMDs. Interventions for oral behaviors in patients with pain, especially pain combined with psychological distress, may have additional benefits. Further prospective researches are necessary to clarify causal mechanisms and effects of oral behaviors on TMDs outcomes.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

YZ—data collection, study design, manuscript writing and revisions. XX and SBF—development of research idea, study design, revision of manuscript. FL and SYZe—interpretation of the results, critical review of the manuscript. YZ and XBL—statistical analysis, creating figures and tables. SYZh—manuscript writing and revision. JRS—study conception and design, manuscript revision.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institution Ethical Boards of West China Hospital of Stomatology, Sichuan University (No. WCHSIRB-CT-2021-431). All participants provided fully informed consent prior to the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Xin Xiong is serving as one of the Editorial Board members of this journal. We declare that Xin Xiong had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to MP.

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