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ORIGINAL RESEARCH

The Association Between Insomnia and Temporomandibular Disorders in Orthodontic Patients

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Objective: This cross-sectional study aimed to investigate the association between insomnia and the presence of temporomandibular disorders (TMD) and its subtypes in orthodontic patients.

Methods: A total of 648 adult orthodontic patients (158 males and 490 females, median age 26) were included and completed a questionnaire containing sociodemographic information, insomnia severity index (ISI), the five major temporomandibular disorder symptoms (5Ts) checklist, and self-reported sleep bruxism. Presence of insomnia and TMD of the included patients was determined according to the diagnostic criteria, and statistical analyses were conducted as appropriate to compare ISI-related scores between TMD and non-TMD participants. Further, multivariable regressions were performed to detect the potential correlation between insomnia and TMD in orthodontic patients.

Results: Orthodontic patients with TMD scored significantly higher in both the individual items and the total sum of ISI than those without TMD. More patients were bothered by insomnia in the TMD group than the non-TMD counterparts (26.6% vs 16.7%, p=0.003). After adjusting for confounding variables, insomnia was found to be significantly correlated with TMD in orthodontic patients (OR=1.677, 95% CI 1.128, 2.511). Subgroup analysis of TMD subtypes showed a significant positive association of insomnia with pain-related TMD (OR=2.007, 95% CI 1.331, 3.015).

Conclusion: Insomnia was associated with a higher prevalence of pain-related TMD rather than intra-articular TMD in orthodontic patients.

Keywords: temporomandibular disorders, pain, insomnia, orthodontic treatment

Introduction

Temporomandibular disorders (TMDs) are a group of problems affecting the masticatory musculature, temporomandibular joints (TMJs), and/or associated structures, which manifest as noises, pain, and dysfunction of the jaw. The prevalence of TMD in children and adults vary between 7% and 30% and the incidence is about 4% per annum, which has raised more and more concern.[1,2] However, the development of TMD is now considered multifactorial, involving various factors such as biological, behavioral, environmental, social, emotional, and cognitive factors, either individually or in combination.[3] Based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), TMD can be generally categorized into two types: pain-related TMD (PT) and intra-articular TMD (IT).[4] A patient could suffer from multiple subtypes of TMDs at the same time.

Insomnia, defined as sleep continuity disturbance associated with daytime complaints related to sleepiness, fatigue, somatic symptoms (for example, head or body aches), mood disturbance, compromised cognitive or occupational

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function, concerns about sleep, or dissatisfaction with sleep, is one of the most common sleep disturbances.[5] It occurs in approximately 50% of the patients with chronic pain and is prevalent among TMD individuals.[5] Evidence has shown a two-way link between insomnia and some symptoms of TMD, such as mental stress, TMJ pain, and sleep bruxism (SB).[6–8] One hypothesis is that insomnia serves as a major predictor for the onset of TMDs and influences the development and maintenance of chronic TMJ pain.[9] Moreover, several studies suggest that insomnia is associated with SB and individuals with SB are more likely to report insomnia symptoms than those without.[8,10,11] On the other hand, some researchers have claimed that insomnia could be a consequence of TMJ pain.[12]

To date, although the correlation between TMD and orthodontic treatment has not been completely revealed, it is still found that the prevalence of TMD in prospective orthodontic patients varied between 21.1% and 73.3%, which surpasses the rates observed in the general population.[13] It is generally agreed that some special considerations should be given to the therapeutic strategy of orthodontic patients with TMD due to the potential pathological changes in TMJ and the corresponding influences on stomatognathic system.[14,15] Besides, previous studies have pointed out that TMD might be detrimental to the psychological status of patients, which probably meddles in the experience and satisfaction of orthodontic patients.[16] Consequently, to avoid the possible adverse effects on both physical and mental health of orthodontic patients, it is quite essential for orthodontists to develop a more comprehensive and rational treatment protocol for TMD patients by recognizing and evaluating the preexisting TMD problem in time.[16,17]

As an annoying disturbance to patients, insomnia is often self-reported at the initial appointment and hence could provide some early suggestions ahead of the subsequent clinical examinations, which might improve the diagnostic efficiency of orthodontic practice. However, the relationship between insomnia and TMD among orthodontic patients remains unclear. Therefore, the primary focus of this research is to investigate the association between insomnia and TMD, by taking different subtypes of TMD into account. Additionally, the relationship between TMD and orthodontic treatment is also explored. Our first hypothesis is that insomnia is positively correlated with TMD among orthodontic patients, and this association is similar for both pain-related TMD (PT) and intra-articular TMD (IT). Secondly, we hypothesize that there is a relationship between TMD and orthodontic treatment at different stages.

Materials and Methods

Patients who attended the orthodontic department of West China Hospital of Stomatology, Sichuan University from May 2022 to August 2022 were recruited for this cross-sectional study. The inclusion criteria were as follows: 1) age greater than or equal to ≥18 years, 2) about to start, undergoing, or having completed orthodontic treatment, and 3) providing informed consent. The exclusion criteria were as follows: 1) history of orofacial trauma or surgery, 2) uncontrolled autoimmune, metabolic, or psychiatric disease.

The sociodemographic information of the patients, including age, sex, and education level was collected. Specifically, the educational level was classified as high school or below, college or university, and postgraduate or above. Insomnia was assessed by the Insomnia Severity Index (ISI). The ISI is a 7-item, 5-point Likert scale used to rate the nature, severity, and impact of insomnia.[18,19] Participants were asked to recall and rate insomnia problems in the last 2 weeks, including difficulty falling asleep, difficulty staying asleep, early awakenings, satisfaction with sleep patterns, noticeability of sleep problems by others, worries about sleep problems, and the interference of sleep with daily functioning. The ISI scores ranged from 0 to 28. Patients were diagnosed with insomnia when scoring over 7 and were identified to be bothered with moderate-to-severe insomnia when scoring more than 14, according to previous studies.[18]

TMD was screened with the 5 Temporomandibular Disorder Symptoms (5Ts) questionnaire, which was validated by previous studies for its capability in screening TMD and its subtypes.[20–22] Participants were asked to respond to the presence of quintessential symptoms of TMD such as orofacial pain, TMJ noise, and joint locking within 30 days. Based on the questionnaire, PT was characterized by the presence of symptoms such as TMJ/facial pain and/or headaches, which probably indicate myalgia, arthralgia, or headaches attributed to TMD. IT was defined by symptoms such as TMJ noises, closed locking, and/or open locking. These symptoms may suggest conditions such as TMJ disc displacement, degenerative joint disorders, or subluxation.[17,18] Considering the possibility of concurrent pain and joint disorders, in this study, patients with TMD were categorized into three groups based on the results: pain-related TMD (PT); intra-articular TMD (IT); and combined TMD (CT, with both symptoms of PT and IT).[19] In addition, self-reported sleep bruxism was

assessed using the first question from The Oral Behavior Checklist:[23,24] "Clench or grind teeth when asleep, based on any information you may have". A frequency of one or more nights per week is indicative of being symptom-positive.

The 20 events per variable criterion was used to determine the sample size, and the minimum acceptable sample size was calculated to be 200. All statistical analyses were conducted in R (version 4.2.2, The R Foundation for Statistical Computing), with the significance level set to 0.05. Shapiro–Wilk test was used to test the normality of the variables. Correlation between variables was measured using the Spearman correlation coefficient. Wilcoxon rank sum test was used for comparison of medians between two groups. Kruskal–Wallis test and Dunn's post hoc test were used for comparison between multiple groups. The *p*-values for all multiple comparisons were adjusted using the Holm–Bonferroni method. Logistic regression was used to explore the relationship of TMD and its subtypes with other variables.

Results

As shown in Table 1, a total of 648 orthodontic patients were enrolled in this study, including 158 males (24.4%) and 490 females (75.6%) with a median age of 26 years. Therein, 331 patients were diagnosed with TMD, including 182 classified as PT and 281 classified as IT. Notably, 131 patients suffered from both PT and IT simultaneously. There was a great balance between the TMD and the non-TMD group in "age", "education level", and "stages of orthodontic treatment". Meanwhile, significant differences were found in "sex" and "sleep bruxism". Specifically, more female participants were diagnosed with TMD (53.67% VS 43.04%, $p = 0.025$) and the habit of sleep bruxism was more likely to be reported in the TMD group (17.2% VS 6.0%, $p < 0.001$). Detailed distribution in the sociodemographic characteristics of the included patients is illustrated in Figure 1.

Additionally, analyses of the ISI scores were conducted, and the results are presented in Table 2. The comparison between the TMD and non-TMD groups showed that the total ISI score of the TMD group 5.2±4.7 was statistically higher (5.2±4.7 VS 3.6±3.8, $p < 0.001$). Moreover, the scores for each item of the ISI questionnaire were significantly different between the two groups ($p < 0.05$). In particular, the differences between the two groups were more pronounced in the items of 'satisfaction with sleep patterns', "the interference of sleep with daily functioning", "noticeability of sleep problems by others", and "worries about sleep problems" ($p < 0.001$). More patients were bothered by insomnia in the TMD group than in the non-TMD counterparts (26.6% VS 16.7%, $p = 0.003$) according to the diagnostic criteria. A more

Table 1 Sociodemographic Characteristics of Included Patients

Variable	Non-TMD	TMD	p-value	Total
N	317 (48.9)	331 (51.1)		648
Age (Mean±SD)	27.1±6.2	26.6±5.9	0.301	26.8±6.1
Sex (%)			0.025*	
Male	90 (28.4)	68 (20.5)		158 (24.4)
Female	227 (71.6)	263 (79.5)		490 (75.6)
Edu (%)			0.101	
High school or below	18 (5.7)	10 (3.0)		28 (4.3)
College or university	236 (74.4)	267 (80.7)		503 (77.6)
Postgraduate or above	63 (19.9)	54 (16.3)		117 (18.1)
Stage of orthodontic treatment (%)			0.975	
Before	131 (41.3)	135 (40.8)		266 (41.0)
During	139 (43.8)	148 (44.7)		287 (44.3)
After	47 (14.8)	48 (14.5)		95 (14.7)
Sleep bruxism (%)	19 (6.0)	57 (17.2)	<0.001***	76 (11.7)
PT				50 (15.11)
IT				149 (45.01)
CT				132 (39.88)

Note: N indicates number of participants. Quantitative data presented by Mean±SD; categorical data presented by frequency (constituent ratio); *$p < 0.05$, ***$p < 0.001$.

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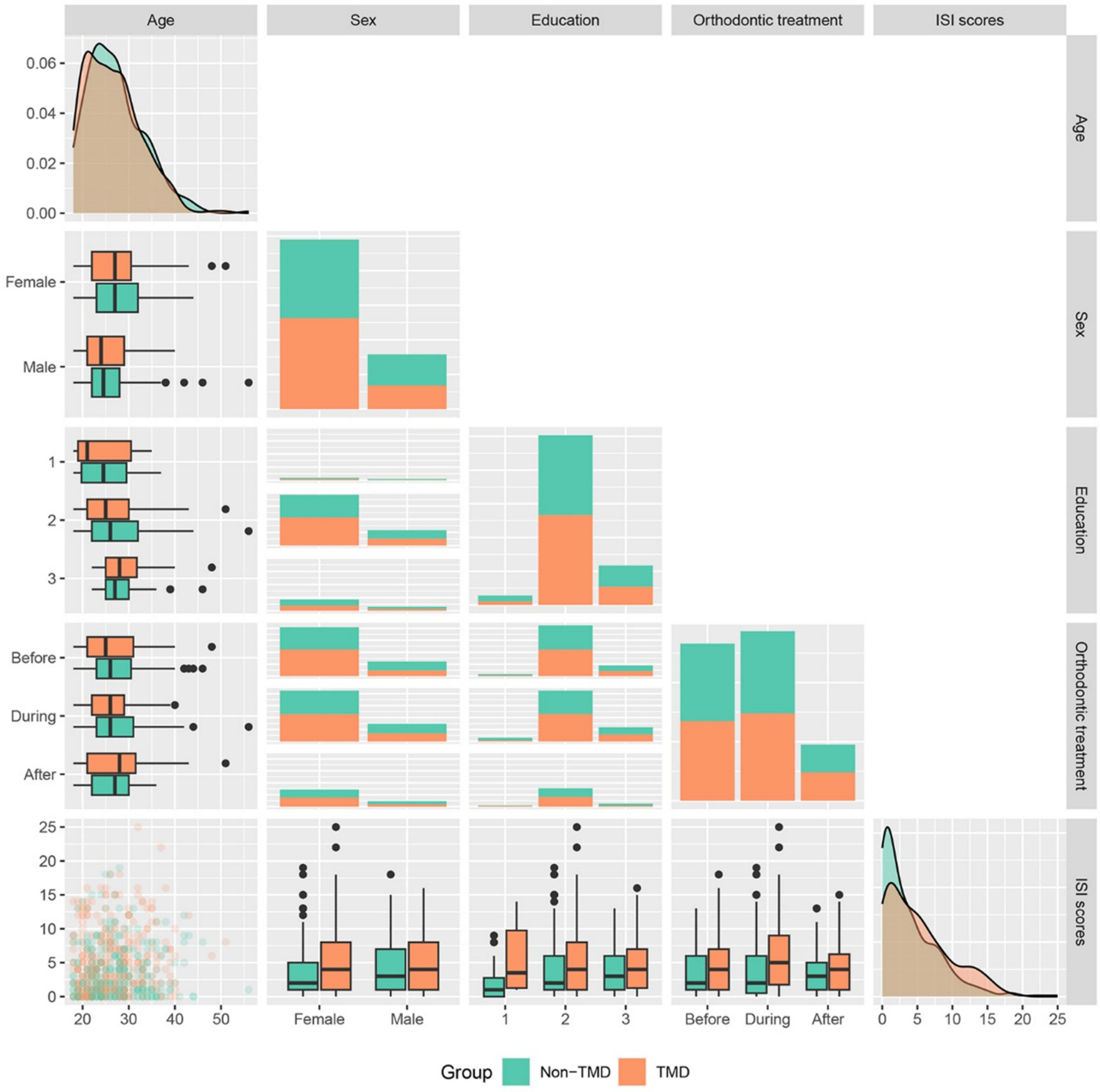

Figure 1 Distributions between age, sex, education level, stage of orthodontic treatment, and ISI score.

detailed classification of insomnia was examined. Although more patients in the TMD group were diagnosed with moderate-to-severe insomnia compared with the non-TMD group, the difference was not statistically significant (4.5% VS 1.9%, $p = 0.094$).

Furthermore, comparisons of the ISI scores between patients of different TMD subtypes were also performed. As shown in Figure 2, the total ISI score of the CT group was significantly higher than those of the IT group and the non-TMD group, but not the PT group. For each item, comparisons (Figure 3) showed that orthodontic patients with CT had significantly higher scores than those without TMD ($p < 0.01$) and those with only IT ($P < 0.05$) in all items except the item of "interference of sleep problem with daily functioning", in which no significant difference was found between the groups of CT and IT.

Table 2 Comparison of ISI Scores and Insomnia Diagnosis of Included Participants

Variable	Non-TMD	TMD	p-value	Total
N	317	331		648
Total score (Mean±SD)	3.6±3.8	5.2±4.7	<0.001***	4.4±4.4
Insomnia diagnosis (%)				
Non-insomnia	264 (83.3)	243 (73.4)	0.003**	507 (78.2)
Insomnia	53 (16.7)	88 (26.6)		141 (21.8)
ISI-1: Falling asleep	0.4 (0.6)	0.5 (0.8)	0.019*	0.5 (0.7)
ISI-2: Staying asleep	0.3 (0.5)	0.4 (0.7)	0.005**	0.3 (0.6)
ISI-3: Early awakening	0.3 (0.6)	0.4 (0.7)	0.047*	0.4 (0.7)
ISI-4: Satisfaction	1.2 (1.0)	1.4 (1.0)	<0.001***	1.3 (1.0)
ISI-5: Interference	0.6 (0.8)	0.9 (0.9)	<0.001***	0.7 (0.9)
ISI-6: Noticeable	0.5 (0.8)	0.8 (0.9)	<0.001***	0.6 (0.8)
ISI-7: Worry	0.5 (0.7)	0.7 (0.9)	<0.001***	0.6 (0.8)
Moderate to Severe Insomnia (%)			0.094	
No	311 (98.1)	316 (95.5)		627 (96.8)
Yes	6 (1.9)	15 (4.5)		21 (3.2)

Note: N indicates number of participants. Quantitative data presented by Mean±SD; categorical data presented by frequency (constituent ratio); *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Furthermore, three multivariate regression models were established by taking different compounding factors into consideration to determine whether insomnia is associated with TMD in orthodontic patients. As presented in Table 3, there was a significantly positive correlation between insomnia and TMD when age, sex, and education level were controlled (OR = 1.856, 95% CI 1.264–2.750). The correlation remained statistically significant when "stage of orthodontic treatment" and "sleep bruxism" were taken into consideration successively (OR = 1.854, 95% CI 1.260–2.750; OR = 1.677, 95% CI 1.128–2.511, respectively). A similar trend was also found between sex and TMD. Besides, sleep bruxism, instead of the stage of orthodontic treatment, was recognized to be significantly correlated with TMD in orthodontic patients (OR = 3.067, 95% CI 1.787–5.475). As for the subgroup analyses (Table 4), it was shown that female (OR = 1.914, 95% CI 1.231–3.047), insomnia (OR = 2.007, 95% CI: 1.331–3.015) and sleep bruxism (OR = 2.413, 95% CI: 1.445–4.018) were associated factors of PT. Besides, sleep bruxism also showed a positive association with IT (OR = 2.712, 95% CI 1.637–4.587), while age may be a protective factor for IT (OR = 0.968, 95% CI: 0.942–0.995).

Discussion

This study aimed to examine the association between insomnia and TMD in orthodontic patients, specifically considering the subtypes of TMD. Overall, the results showed that insomnia was positively associated with TMD. For the TMD subcategory, insomnia was significantly positively associated with PT, but not with IT.

Insomnia, characterized by difficulty falling or staying asleep, or experiencing non-restorative sleep, has been observed to have a potentially bidirectional relationship with TMD.[25] Instead of being a simple result of pain, several studies have previously identified insomnia as a risk factor for the onset and maintenance of TMD, as well as the flare of chronic TMD symptoms.[11,19] One study found that significantly poorer sleep quality evaluated with the Pittsburgh Sleep Quality Index (PSQI) was reported by TMD patients compared with the healthy controls.[26] Here in the current study, our results indicated that orthodontic patients with TMD had significantly higher scores on the ISI scale and were more likely to be diagnosed with insomnia compared with non-TMD participants, which was consistent with the findings of the abovementioned research conducted among general population. However, a cause-effect extrapolation of the association between insomnia and TMD was not allowed due to a limitation of the study type. Although some longitudinal studies have been conducted and reported that patients with primary sleep disorders such as insomnia had a 44% higher risk of developing TMD and the incidence rate was almost twice as high compared with the healthy control,[27,28] more prospective studies are still needed to achieve high-quality evidence.

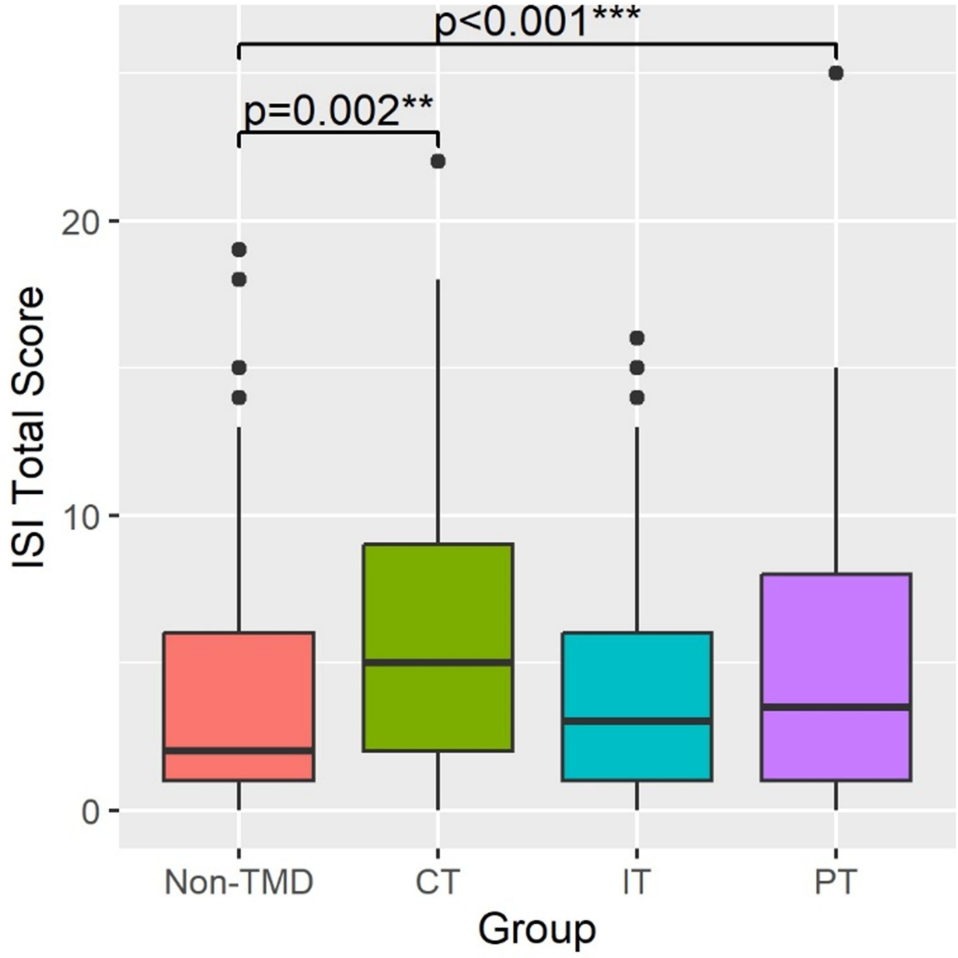

Figure 2 Comparison of ISI scores between groups of PT, IT, CT, and non-TMD. $^{**}p < 0.01$, $^{***}p < 0.001$.

Concerning the subtypes of TMD, the current study found that insomnia was positively associated with PT, but not IT. Similarly, some studies have suggested that sleep disorders might be a risk factor for developing painful TMD.[29] As reported by a cohort study,[28] progressive deterioration of subjective sleep quality was recognized in initially TMD-free adults who developed painful TMD later before the onset of pain symptoms in TMJ. However, it is still inconclusive how insomnia would contribute to the development of pain-related TMD problems. Some researchers proposed that insomnia probably correlated with central sensitivity and pain perception, hence playing an etiologic role in pain disorders.[30] Therefore, it was indicated that effective management of insomnia can critically improve the symptoms of chronic orofacial pain.[31,32] On the other hand, it should also be noted that the presence of pain in TMD patients could strongly impact the sleep quality in turn.[12] For TMD patients under active orthodontic treatment, the condition might be even worse since the causes of pain can be from not only TMD but also the application of orthodontic force and irritation of orthodontic appliances. Taken above, it is advisable for orthodontists to monitor the possible co-occurrence of insomnia and TMD-related symptoms in orthodontic patients.

Our study also indicates a significant association between PT and female, consistent with existing literatures.[11,33] The sex disparities may be attributed to hormonal, cultural, and social factors, elevated work-related stress among women, variations in pain tolerance, and differences in healthcare-seeking behaviors.[34–38] Besides, we found a negative correlation between IT and age. IT, with or without pain, was the primary TMD conditions observed in young adult patients.[39] This may suggest a strong self-remodeling capacity or surrogate capacity of TMJ. With interventions such as conservative or anterior repositioning splint (ARS) therapy, the IT-burdened TMJ in young people shows the ability of reparation and even regeneration with age.[40] The different risk profiles of PT and IT identified from these results

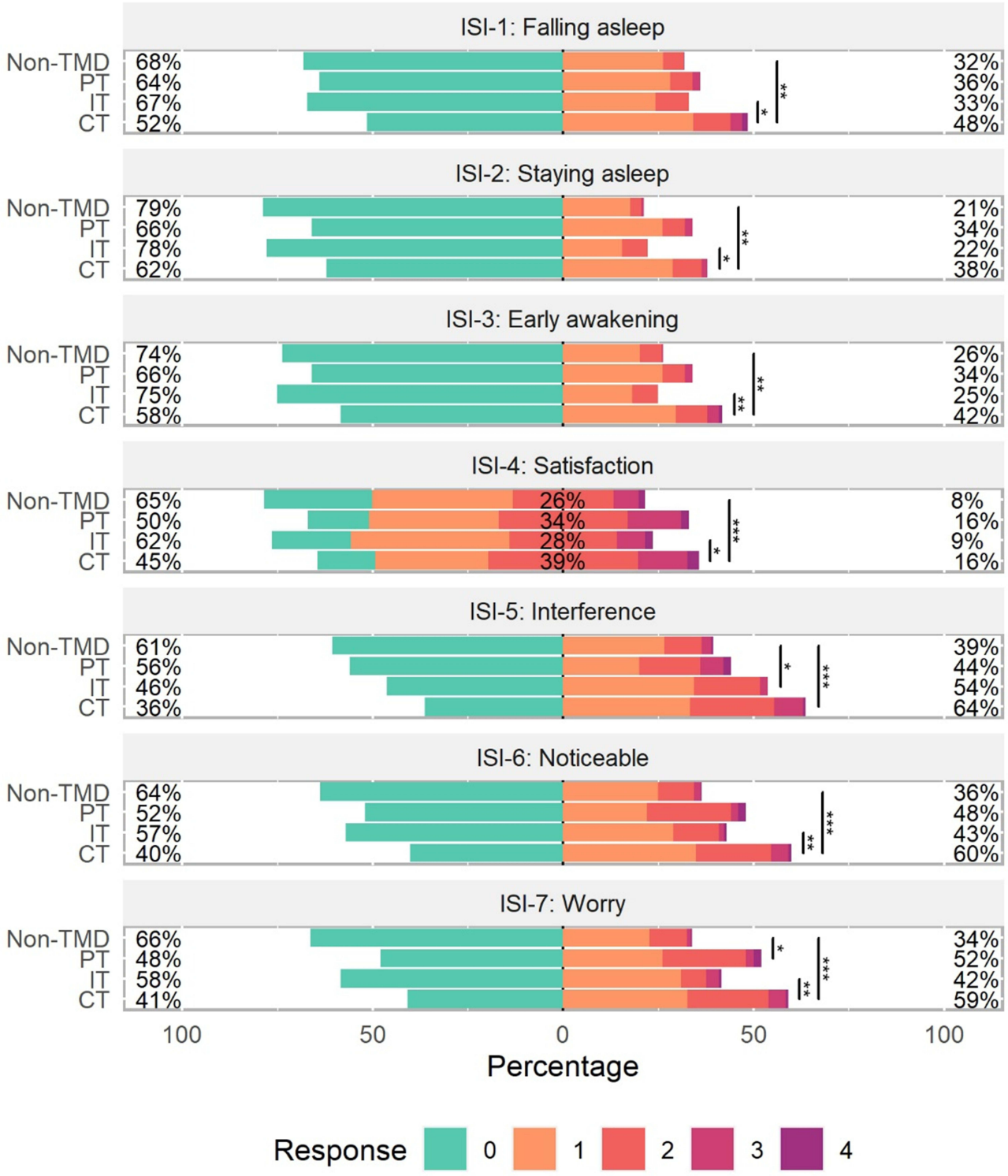

Figure 3 Comparison of ISI scores for each item between patients with different subtypes of TMD. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

probably indicated that orthodontists should pay attention to different demographic factors when screening for diverse TMD subtypes and avoid a one-size-fits-all approach.

Meanwhile, it was suggested in the current study that sleep bruxism was positively associated with TMD, as well as for both the subtypes of PT and IT. Generally, the relationship between sleep bruxism and TMD remains a controversial

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Table 3 Multiple Regression Models for TMD

Variable	Model 1 OR [95% CI]	Model 2 OR [95% CI]	Model 3 OR [95% CI]
Age	0.978 [0.952, 1.005]	0.978 [0.952, 1.005]	0.978 [0.951 1.004]
Sex			
Male	Reference	Reference	Reference
Female	1.589* [1.098, 2.310]	1.591* [1.099, 2.312]	1.641* [1.127, 2.400]
Education level			
High school or below	Reference	Reference	Reference
College or university	2.080 [0.943, 4.846]	2.089 [0.946, 4.873]	1.927 [0.869, 4.510]
Postgraduate or above	1.691 [0.716, 4.187]	1.697 [0.718, 4.207]	1.528 [0.642, 3.806]
Insomnia diagnosis			
Non-insomnia	Reference	Reference	Reference
Insomnia	1.856** [1.264, 2.750]	1.854** [1.260, 2.750]	1.677* [1.128, 2.511]
Stage of orthodontic treatment			
Before	-	Reference	Reference
During	-	1.032 [0.733, 1.452]	1.037 [0.734, 1.466]
After	-	1.036 [0.644, 1.670]	1.045 [0.645, 1.693]
Sleep bruxism	-	-	3.067*** [1.787, 5.475]

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

topic. According to the previous literature, the degree of association between the two is inconclusive and strongly depends on the assessment strategy for sleep bruxism. Specifically, in general, questionnaire studies reported an association between TMD and sleep bruxism, which is consistent with the present results,[41] whilst instrumental studies did not.[42] For instance, a controlled cohort study using PSG found no significant relationship between SB and TMD-related pain.[42] This inconsistency may be attributed to the recall bias of patients when making self-reports on sleep bruxism and the non-uniform diagnostic standards between different assessment strategies. This highlighted the complexity of diagnosing and correlating SB with TMD, particularly when relying on different evaluation methods. Consequently, it might be more favorable if both subjective and objective methods mentioned above could be employed for the diagnosis of sleep bruxism in future studies.

In addition, it was also revealed that the prevalence of TMD was not correlated with the phase of orthodontic treatment in our study. As previously reported, the change of occlusion or condyle position resulting from orthodontic treatment does not significantly impact an individual's susceptibility to TMD, nor does it act as a preventive measure against future development of TMD.[43,44] These findings align with our study results, both of which indicate that TMD may not necessarily be a contraindication of orthodontic treatment if all the therapies are well planned and proficiently delivered. It is now widely accepted in the field of orthodontics that the understanding and management of TMD should shift from the simplistic occlusal and mechanical-based model to a more comprehensive medical and biopsychosocial model.[14] Therefore, adopting this major paradigm shift in clinical approach is always recommendable to all orthodontists, especially those dealing with the orthodontic treatment of patients concomitant with TMD.[14]

Several limitations should be noticed when interpreting the findings of the current study. Firstly, due to its cross-sectional nature, this study is unable to allow a cause-effect extrapolation of the association between insomnia and TMD. Prospective studies such as cohort studies may be favored in the future. Also, more topics still need to be explored in

Table 4 Multiple Regression Models for PT and IT

Variable	PT OR [95% CI]	IT OR [95% CI]
Age	0.999 [0.969, 1.029]	0.968* [0.942, 0.995]
Sex		
Male	Reference	Reference
Female	1.914** [1.231, 3.047]	1.405 [0.964, 2.062]
Education		
High school or below	Reference	Reference
College or university	0.936 [0.405, 2.361]	1.378 [0.624, 3.209]
Postgraduate or above	0.69 [0.270, 1.883]	1.23 [0.518, 3.054]
Insomnia diagnosis		
Non-insomnia	Reference	Reference
Insomnia	2.007*** [1.331, 3.015]	1.425 [0.963, 2.108]
Orthodontic treatment		
Before	Reference	Reference
During	1.291 [0.878, 1.905]	0.993 [0.702, 1.405]
After	1.227 [0.707, 2.093]	0.979 [0.601, 1.587]
Sleep bruxism	2.413*** [1.445, 4.018]	2.712*** [1.637, 4.587]

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

future studies, such as the association of insomnia and orthodontic factors in TMD versus non-TMD populations, which has rarely been directly analyzed so far. In addition, the assessment of sleep bruxism relied on self-report, a commonly utilized method in epidemiological and clinical research due to its simplicity and cost-effectiveness. However, the accuracy of measurements might be sacrificed when compared with more advanced diagnostic strategies, such as electromyography or polysomnography (PSG).[45]

Conclusions

Despite the limitations, several conclusions can still be drawn from the current study as follows.

1. Insomnia was found to be significantly associated with TMD in orthodontic patients.

2. As to the subtypes of TMD, insomnia was recognized to be associated with PT but not IT among orthodontic patients.

3. Female was positively associated with PT, while age negatively correlated with IT. Sleep bruxism was significantly correlated with TMD, including both PT and IT.

4. No correlation was found between the phase of orthodontic treatment and TMD.

Data Sharing Statement

All the clinical data are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Ethical Committee of the State Key Laboratory of Oral Diseases, West China Hospital of Stomatology, Sichuan University (No. WCHSIRB-D-2022-033) and met the ethical principles of the World Medical

Association Declaration of Helsinki (version 2002). Informed consent was obtained from each participant before investigation.

Author Contributions

All authors have made substantial contributions to the reported work, encompassing aspects such as conception, study design, execution, data acquisition, analysis, and interpretation, or in all of these areas. They participated in drafting, revising, or critically reviewing the article; provided final approval for the version to be published; agreed on the journal to which the article has been submitted; and accept responsibility for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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