Relationship Between the Frequency of Sleep Bruxism and the Prevalence of Signs and Symptoms of Temporomandibular Disorders in an Adolescent Population

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Purpose: The relationship between sleep bruxism (SB) and temporomandibular disorders (TMD) is unclear. This study aimed to estimate SB prevalence in an adolescent population and to investigate the relationship between SB frequency and prevalence of TMD signs/symptoms. **Materials and Methods:** First-year students at a high school in Okayama, Japan, were recruited in 2005, with 195 subjects responding. The SB detection device was a miniature disposable device (BiteStrip, SLP) that indicated the total SB events per night on a 4-grade score. The subjects were divided into severe and nonsevere SB groups with SB frequency cutoffs. The subjects were examined for temporomandibular joint (TMJ) noise during mouth opening/closing, tenderness of the masticatory/cervical muscles, and range of TMJ condylar movement. The presence/absence of headache and shoulder stiffness was also determined by the interview. The odds ratio (OR) and confidence interval (CI) were calculated to test the relationship between SB frequency, gender difference, and presence of the TMD signs/symptoms by multiple regression analysis. **Results:** Severe SB (more than 125 events per night) was significantly related to the presence of TMJ clicking (OR: 3.74, CI: 1.22–11.49, P = .02), while gender (male) was not related to the presence of TMJ clicking. Severe SB was not related to headache, though gender (male) was significantly related to headache (OR: 2.52, CI: 1.04–6.11, P = .04) in these subjects. **Conclusion:** These results suggest that the presence of TMJ clicking was closely related to severe SB in an adolescent population. *Int J Prosthodont 2008;21:292–298.*

Temporomandibular disorders (TMD) are defined not as merely a temporomandibular joint (TMJ) problem, but rather as all disturbances associated with the function of the masticatory system.[1] The subtype of TMD with the highest prevalence is the TMJ internal derangement (ID) that is caused by dislocation of the TMJ articular disc. This frequently results in joint pain, joint noise, and limited condylar movement during maximum mouth opening/closing.[2,3]

Previous epidemiologic studies reported that almost half (49.9%) of the subjects who were 20 to 81 years old (n = 4,289) had 1 or more clinical sign/symptom of TMD.[4] The signs/symptoms of a TMJ ID develop from childhood, and their prevalence and severity increase in the adolescent population[5] but then decrease with age. Therefore, the first step in understanding the risk factors for TMD is to investigate the prevalence of the possible risk factors between childhood and adolescence associated with the signs and symptoms of TMD.

Previously, various factors such as malocclusion, external injury, and habit were thought to be related to the incidence of TMD. However, it is still unclear which factor is most closely related to TMD. Sleep bruxism (SB) was suggested to be one of the candidate etiologies of TMD.[6] According to the International Classification of

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Sleep Disorders, SB is a stereotypical mandibular movement characterized by tooth grinding or jaw clenching during sleep.[7,8] This unconscious loading to the TMJ caused by SB is suspected to cause damage to the articular disc or to displace it forward. For example, Tsolka et al[9] indicated that the prevalence of awareness of bruxism was significantly greater in TMD patients than in asymptomatic controls, and other studies also reported that a moderate to strong relationship existed between self-reported SB and the signs and symptoms of TMD.[10–12] In contrast, other studies reported that there is no relationship between presence of bruxism and muscle sensitivity under palpation or joint disturbances.[13,14] One of the major reasons for these contradictory results is assumed to be the low validity of the SB assessment outcomes, such as self-awareness of SB, feeling of masticatory muscle tension and/or stiffness upon awakening, and reports of grinding sounds heard by sleep partner or others.[6,9–14]

Recently, a disposable SB detection device (BiteStrip, SLP) that can record the cumulative number of nocturnal masseter hyperactivity episodes in an individual's home environment was introduced. The gold standard of SB diagnosis was polysomnography (PSG) assessment in the sleep laboratory.[15–18] However, even the PSG data can be affected by the numerous electrodes attached on the subjects' face and body or by environmental bias.[17] Meanwhile, Bitestrip is a miniature device that does not disturb the subjects' usual sleep. In addition, the accuracy of SB event detection of BiteStrip has already been shown to be excellent compared with PSG assessment,[19] which is much more costly than Bitestrip. Thus, Bitestrip makes it possible to measure individual SB frequency easily and objectively, even in an epidemiologic situation.

Therefore, this study was designed to elucidate the prevalence of SB in an adolescent population and to investigate the relationship between SB frequency and prevalence of the signs/symptoms of TMD. The established null hypothesis was that there is no correlation between SB frequency and prevalence of the signs/symptoms of TMD in an adolescent population.

Materials and Methods

Study Population

First-year students (male/female = 173/148; mean age: 15.4 ± 0.5 years) at a high school located near the major urban area in Okayama, Japan, in 2005 were asked to join this survey. In response, 195 subjects (male/female: 86/109; mean age: 15.4 ± 0.5 years) agreed to participate. They received both clinical examinations and SB measurement. The subjects were excluded if they presented with 1 or more of the following conditions: *(1)* using any oral device, *(2)* taking one or more medications, *(3)* having any medically diagnosed sleep disorders, or *(4)* showing compromised mental or physical ability. All subjects signed a consent form. If the subject was under 20 years old, his or her parent's written consent was also obtained.

This study protocol was approved by the Ethical Committee for Human Research of Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences (no. 69), and the Grant-in-Aids for Scientific Research was approved by the Japan Society for the Promotion of Science (nos. 16591949 and 18592122).

SB Detection Device

The device used was a miniature single-use electronic device for SB detection (BiteStrip). It is composed of electromyography (EMG) electrodes and an amplifier to acquire masticatory muscle signals, a central processing unit with real-time software that detects and analyzes the EMG patterns, and a permanent chemical display that indicates the 4-grade score, which interprets the accumulated number of SB for 4.5 hours. This device counts the number of masseter muscle hyperactivities as the number of SB events that exceed the continuous 30% maximum voluntary clenching, and previous reports demonstrated this device had sufficient validity to detect SB events at the same level as PSG assessment (sensitivity: 0.92, specificity: 0.91; Minakuchi et al, personal communication). Furthermore, this device automatically starts to measure the muscle hyperactivity 30 minutes after the skin sensor detects that this device was placed on the cheek. The measurement period was set at 4.5 hours exactly; therefore, the accumulated number of SB events was not affected by variety in the length of the sleeping period. This device indicated the total number of SB events on a 4-grade scale: 0 = fewer than 40 events; 1 = 40 to 74 events; 2 = 75 to 124 events, and 3 = more than 125 events. After receiving all clinical examinations and answering the questionnaire, participants were handed this device directly and instructed in its usage in a home environment using a mirror and an instruction manual over 15 minutes by 2 trained instructors.

Clinical Examination of TMD Signs and Symptoms

All participants received clinical examinations for the signs/symptoms of TMD conducted by 1 of 2 calibrated examiners (CNS and HM). This clinical examination included palpation of the TMJ during maximum mouth opening/closing, range of TMJ condylar movement, and assessment of tenderness of the masticatory muscles.

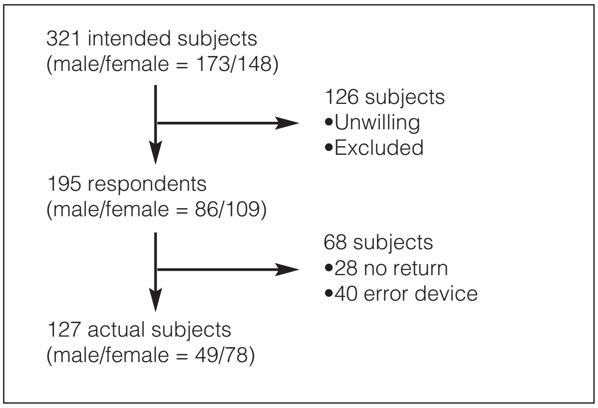

Fig 1 Sampling profile of this study.

The examination of TMJ noise was performed by a bilateral TMJ palpation method during maximum mouth open/close cycles. If there was a palpable click on the left and/or right TMJ that was reproducible on 2 of 3 consecutive mouth open-close cycles, the subject was diagnosed TMJ click positive. Tenderness of the masticatory/cervical muscles was defined as positive when pain was reported by the subjects in response to palpation in 1 or more of the muscle sites listed in the Research Diagnostic Criteria (RDC).[20] This palpation was performed by the examiners' middle finger with 9.8 N of pressure, which was calibrated by a pressure algometer (Pressure Algometer, Wanger Instruments). Range of the TMJ condylar movement was examined concomitantly with TMJ noise examination. An examiner palpated the skin surface outside of the bilateral TMJ condyles during maximum mouth opening and closing. If the TMJ condylar position palpated under the maximum mouth opening did not reach the top of the articular eminence, then the subject was diagnosed to have a positive limited condylar movement, according to the RDC.[20]

In addition to clinical examinations, all subjects were asked to fill out a self-administered questionnaire containing questions on signs/symptoms of TMD, headache, and shoulder stiffness. According to the structured protocol, subjects were also interviewed about their history of headache and shoulder stiffness during the last 1 month in addition to the location, pain quality, pain intensity, pain duration, and frequency. Internal consistency levels between the similar variables of the interview and the questionnaire regarding headache (0.60) and shoulder stiffness (0.43) were checked and evaluated according to the kappa index.[21]

Calibration of the Clinical Examination

Two examiners were calibrated for the examination of TMJ noise, tenderness of the masticatory/cervical muscles, and range of the TMJ condylar movement prior to the initiation of this study. This calibration was performed by means of a set of 16 TMD subjects who were sixth-year students and postgraduate residents of Okayama University Medical and Dental Hospital. Specifically, the examiners separately examined the signs/symptoms without any discussion of the aforementioned criteria. Then, 2 examiners discussed the results of each assessment and made a mutual consensus on the diagnostic criteria. In response, the mean kappa value among these assessments increased from 0.25 before calibration to 0.59 after calibration.[21]

Statistical Analysis

The subjects were divided into 2 groups based on the score of the SB detection device. This device had a 4-grade assessment, thus 3 different cutoffs (1, 2, 3) were used to provide 2×2 tables for risk assessment. Specifically in cutoff 3, the subjects with scores 0, 1, 2 composed the nonsevere SB group, while the subjects with score 3 composed the severe SB group. And the cutoffs 2 and 1 were defined to divide the subjects between scores 1 and 2 and scores 0 and 1, respectively.

Comparisons of the baseline data among the intended subjects, the nonrespondents, the respondents, the actual subjects, and the nonmeasurable subjects were performed using 1-way factorial analysis of variance to test the mean difference of each parameter among these sample sets. The odds ratio (OR) and 95% confidence interval (CI) were calculated to test the relation between SB severity and TMD signs/symptoms by using simple and multiple logistic regression models (StatView 5.0, Abacus Concepts and SPSS 10.0J, SPSS). In the multiple logistic regression models, the presence/absence of TMD signs/symptoms was considered the outcome variable, and SB severity and gender difference were the predictor variables. The significance level of statistical analysis was set at $\alpha = .05$.

Results

Baseline Comparisons Among Intended Subjects, Nonrespondents, Respondents, Actual Subjects, and Nonmeasurable Subjects

Among the 195 respondents, 28 subjects did not return the detection device, and 40 detection devices did not work properly or showed errors. Finally, 127 subjects were treated as actual subjects (Fig 1). Baseline comparisons among the 5 classes of subjects were made

Table 1 Baseline Comparisons Among Intended Subjects, Nonrespondents, Respondents, Actual Subjects, and Nonmeasurable Subjects

	Intended subjects (n = 321)	Nonrespondents (n = 126)	Respondents (n = 195)	Actual subjects (n = 127)	Nonmeasurable subjects (n = 68)	P*
Male						
Height (cm)	169.0 ± 5.9	169.4 ± 5.1	168.7 ± 6.6	168.0 ± 6.5	169.5 ± 6.6	.72
Weight (kg)	58.4 ± 8.7	58.3 ± 8.4	58.7 ± 9.0	58.8 ± 9.6	58.5 ± 8.2	.99
Age (y)	15.4 ± 0.5	15.4 ± 0.5	15.4 ± 0.5	15.4 ± 0.5	15.3 ± 0.5	.91
Female						
Height (cm)	157.6 ± 5.3	158.1 ± 6.0	157.4 ± 5.0	157.8 ± 5.2	156.4 ± 4.3	.71
Weight (kg)	51.3 ± 8.1	49.1 ± 9.3	52.1 ± 7.5	52.9 ± 7.9	50.0 ± 6.0	.11
Age (y)	15.4 ± 0.5	15.4 ± 0.5	15.3 ± 0.5	15.4 ± 0.5	15.3 ± 0.5	.95

*One-way analysis of variance.

Table 2 Distribution of the Sleep Bruxism Scores in Male and Female Subjects

	Score 0	Score 1	Score 2	Score 3
Male	15 (30%)	12 (24%)	8 (18%)	14 (28%)
Female	32 (42%)	19 (24%)	19 (24%)	8 (10%)

Table 3 Prevalence of TMD Signs and Symptoms

Sign/symptom	Prevalence (n)
TMJ clicking	
Male	17% (8/48)
Female	15% (12/78)
Limited mouth opening	
Male	0% (0/48)
Female	12% (9/78)
Headache	
Male	19% (9/48)
Female	36% (27/78)
Shoulder stiffness	
Male	29% (14/48)
Female	49% (38/78)

TMD = temporomandibular disorders; TMJ = temporomandibular joint.

in terms of height, weight, and age. No significant baseline difference was observed in the listed parameters (Table 1).

Distribution of SB Frequency

The distribution of SB scores (0 to 3) in the male and female subjects is shown in Table 2. The results show that 28% of the male subjects showed a score of 3 (more than 125 events), while 10% of the female subjects showed a score of 3. This result indicated that the frequency of severe SB tended to be higher in the male subjects than in the female subjects; however, no overall significant frequency difference was observed between the male and female subjects (Kruskal-Wallis test, $P = .09$).

Prevalence of TMD Signs and Symptoms

The prevalence of TMD signs/symptoms is shown in Table 3. The female subjects showed higher prevalence of headache, shoulder stiffness, and limitation of mouth opening than the male subjects. The prevalence of TMJ clicking was 15% in the female subjects and 17% in the male subjects.

Relationship Between SB Frequency and TMD Signs and Symptoms

The relationship between the SB frequency and prevalence of TMD signs/symptoms is shown in Table 4. Interestingly, the severe SB group (cutoff 3) indicated a 6.67 times higher prevalence of TMJ click (95% CI: 1.31 to 33.95; $P = .02$) and a 4.85 times higher prevalence of headache (95% CI: 1.05 to 22.31; $P = .04$) in the male subjects. Meanwhile, in the female subjects, no significant OR for severe SB was observed. In other words, specifically in the male subjects, the TMJ clicking and headache were more prevalent in the severe SB group than in the nonsevere SB group.

Since the frequency of the severe SB subjects tended to be higher in the male subjects than in the female subjects, a multivariate analysis was conducted to exclude the confounding gender difference on the relationship between SB frequency and TMD signs/symptoms. The results of this multiple logistic regression analysis are shown in Table 5. As an independent factor, the SB frequency was significantly related to the prevalence of TMJ clicking, while no significant correlation was observed between the gender difference and the prevalence of TMJ clicking. In contrast, the gender difference (male) was significantly related to the prevalence of headache, while no significant relationship was detectable between the SB severity and the prevalence of headache in this adolescent population.

Table 4 Relationship Between Sleep Bruxism Frequency and Prevalence of TMD Signs and Symptoms

	Prevalence		Regression analysis		
SB cutoff	Severe	Nonsevere	*P*	95% CI	OR
Male					
TMJ clicking					
1	21% (7)	7% (1)	.24	0.42–33.8	3.77
2	29% (6)	7% (2)	.07	0.89–28.0	5.00
3	38% (5)	9% (3)	.02*	1.31–33.9	6.67
Limited mouth opening					
1	–	–	–	–	
2	–	–	–	–	
3	–	–	–	–	
Headache					
1	21% (7)	13% (2)	.52	0.32–9.65	1.75
2	24% (5)	15% (4)	.43	0.42–7.75	1.80
3	38% (5)	11% (4)	.04*	1.05–22.3	4.85
Shoulder stiffness					
1	24% (8)	40% (6)	.27	0.13–1.77	0.48
2	24% (5)	33% (9)	.47	0.17–2.26	0.63
3	23% (3)	31% (11)	.57	0.15–2.86	0.66
Female					
TMJ clicking					
1	15% (7)	16% (5)	.96	0.28–3.38	0.97
2	11% (3)	18% (9)	.45	0.14–2.37	0.58
3	25% (2)	14% (10)	.43	0.35–11.3	2.00
Limited mouth opening					
1	15% (7)	6% (2)	.24	0.52–13.9	2.69
2	15% (4)	10% (5)	.51	0.39–6.53	1.60
3	13% (1)	11% (8)	.93	0.12–10.2	1.11
Headache					
1	37% (17)	34% (11)	.82	0.44–2.88	1.12
2	41% (11)	33% (17)	.52	0.53–3.60	1.38
3	13% (1)	39% (27)	.18	0.03–1.95	0.23
Shoulder stiffness					
1	48% (22)	50% (16)	.85	0.37–2.26	0.92
2	56% (15)	45% (23)	.38	0.60–3.89	1.52
3	63% (5)	47% (33)	.42	0.41–8.43	1.87

*Statistically significant ($P < .05$).
TMD = temporomandibular disorders; TMJ = temporomandibular joint; SB = sleep bruxism; CI = confidence interval; OR = odds ratio.

Table 5 Multiple Logistic Regression Analysis of Sleep Bruxism Frequency and TMD Signs and Symptoms

Symptom/predictor	*P*	95% CI	OR
TMJ clicking			
Gender (male)	.72	0.42–3.43	1.21
SB frequency	.02*	1.22–11.4	3.74
Headache			
Gender (male)	.04*	1.04–6.11	2.52
SB frequency	.70	0.42–3.69	1.24

*Statistically significant ($P < 0.05$).
TMD = temporomandibular disorders; TMJ = temporomandibular joint; SB = sleep bruxism; CI = confidence interval; OR = odds ratio.

Table 6 Relationship Between Sleep Bruxism Frequency and Tenderness of the TMJ and Masticatory/Cervical Muscles

	Prevalence		Regression analysis		
SB cutoff	Severe	Nonsevere	*P*	95% CI	OR
Male					
TMJ					
1	6% (2)	20% (3)	.16	0.04–1.74	0.26
2	0% (0)	19% (5)	.97	–	–
3	0% (0)	14% (5)	.97	–	–
Digastric					
1	33% (11)	33% (5)	> .99	0.27–3.65	1.00
2	14% (3)	48% (13)	.02*	0.04–0.76	0.18
3	0% (0)	46% (16)	.98	–	–
Masseter					
1	24% (8)	33% (5)	.51	0.17–2.44	0.64
2	19% (4)	33% (9)	.27	0.12–1.82	0.47
3	23% (3)	29% (10)	.70	0.17–3.31	0.75
Temporalis					
1	6% (2)	13% (2)	.41	0.05–3.31	0.42
2	0% (0)	15% (4)	.97	–	–
3	0% (0)	11% (4)	.97	–	–
SLM					
1	9% (3)	7% (1)	.78	0.13–14.6	1.40
2	5% (1)	11% (3)	.44	0.04–4.15	0.40
3	8% (1)	9% (3)	.92	0.08–9.40	0.89
Trapezius					
1	48% (16)	73% (11)	.11	0.09–1.30	0.34
2	43% (9)	67% (18)	.10	0.12–1.22	0.38
3	54% (7)	57% (20)	.84	0.24–3.15	0.88
Female					
TMJ					
1	30% (14)	16% (5)	.14	0.75–7.41	2.36
2	30% (8)	22% (11)	.41	0.53–4.43	1.53
3	25% (2)	24% (17)	.96	0.19–5.64	1.04
Digastric					
1	26% (12)	25% (8)	.91	0.38–2.98	1.06
2	30% (8)	24% (12)	.56	0.48–3.91	1.37
3	38% (3)	24% (17)	.42	0.40–8.66	1.87
Masseter					
1	33% (15)	25% (8)	.47	0.53–3.97	1.45
2	37% (10)	25% (13)	.29	0.63–4.69	1.72
3	38% (3)	29% (20)	.60	0.33–6.88	1.50
Temporalis					
1	11% (5)	6% (2)	.49	0.33–10.0	1.83
2	15% (4)	6% (3)	.20	0.58–13.4	2.78
3	13% (1)	9% (6)	.71	0.16–4.55	1.52
SLM					
1	11% (5)	3% (1)	.24	0.42–34.0	3.78
2	11% (3)	6% (3)	.42	0.38–10.6	2.00
3	25% (2)	6% (4)	.08	0.83–36.4	5.50
Trapezius					
1	74% (34)	69% (22)	.62	0.48–3.49	1.29
2	78% (21)	69% (35)	.40	0.54–4.73	1.60
3	88% (7)	70% (49)	.32	0.35–25.9	3.00

*Statistically significant ($P < .05$).
TMJ = temporomandibular joint; SB = sleep bruxism; CI = confidence interval; OR = odds ratio; SLM = sternocleidomastoideus.

Relationship Between SB Frequency and Tenderness of the TMJ and Masticatory/Cervical Muscles

The relationship between the SB frequency and tenderness of the TMJ and masticatory/cervical muscles is shown in Table 6. In general, the male subjects showed lower prevalence in terms of muscle tenderness than the female subjects, with the exception that both the male and female subjects showed a high prevalence of tenderness of the trapezius muscle. No significant correlation was observed between SB frequency and tenderness of the TMJ and masticatory/cervical muscles, except for the digastric muscle.

Discussion

This study was unique in comparison to prior epidemiologic studies of SB because calibrated examiners, a relatively large number of subjects, and an SB detection device that could measure the bruxism frequency objectively were used. Most of the previous SB research was based on self-estimated questionnaires and/or clinical examinations such as tooth attrition or PSG assessment. The reliability and validity of self-estimated questionnaires and tooth attrition may be low; therefore, the current standard of SB diagnosis has been PSG assessment that measures masticatory muscle activity throughout the night.[15–18] However, PSG assessment also has drawbacks because the subjects must sleep while attached to numeric electrodes on the surface of their face. In addition, the subjects must sleep at a sleep laboratory for the measurement, thereby creating a situation that is far from their usual sleep environment. In consideration of these drawbacks, PSG data may be affected by the measurement environment.[17] On the other hand, the SB detection device used in this study was an all-in-one unit and contained no wire harness and a thin body, meaning subjects could sleep in their home environment with their usual sleep conditions. Further, the SB detection device objectively measured the subjects' SB frequency into 4 grades. This objectivity made the statistics more powerful. For example, it was evident that the odds ratio for TMJ clicking increased when the cutoff SB level was changed from 2 to 3. This would strongly support the relationship between SB frequency and TMJ clicking in a dose-dependent manner.

Of course, this study also contained some limitations. First, the response rate in this sampling was not very high. This could mean that the respondents were more concerned about their TMJ condition and SB than the nonrespondents. Consequently, the frequency of SB and TMD signs and symptoms could be shifted. However, the primary purpose of this study was to test the relationship between SB frequency and the prevalence of TMD signs/symptoms. The assessment of TMD signs/symptoms was done in a blinded fashion because the SB frequency was measured just after the assessment of TMD signs/symptoms. Therefore, the possible sampling bias did not appear to affect the final result of this study.

Second, the SB assessment in this study was performed just once after the clinical assessment. Since the SB severity usually shows daily fluctuation,[16] it is necessary to consider the possibility that the score obtained by the single SB assessment did not always represent the general trend of the subject's SB condition. On the other hand, TMD signs/symptoms are also known to fluctuate daily. To test the temporal relationship between SB frequency and TMJ ID signs/symptoms, it was thought that a single assessment should be valid for this specific purpose.

Third, approximately 20% of the SB detection devices did not work properly and/or showed error indication. This is related not to SB frequency but to improper usage, mechanical defects, and improper settings for electrical skin resistance. This was also supported by the results of the baseline comparison showing that these nonmeasurable subjects would not affect the internal and external validity of the study.

Fourth, some variables used in this study had a low internal consistency (reliability) between the interview and questionnaire. For instance, the kappa values for the assessment of shoulder stiffness were 0.43. Generally, a chronic symptom such as shoulder stiffness can fluctuate a great deal. Therefore, the low reliability of the assessment could affect the results on the relationship between SB frequency and the prevalence of shoulder stiffness.

Fifth, the research design of this study was cross-sectional; therefore, it was impossible to clarify the causality between SB frequency and the incidence of TMD signs/symptoms. A future follow-up study on the TMD signs/symptoms of the subjects will resolve this issue.

Even with these limitations, the findings of this cross-sectional study, especially the statistically significant relationship between SB frequency and the prevalence of the TMJ click, are highly interesting and in full agreement with previous questionnaire-based case-control studies[6,12,22,23] and an electric device–based cross-sectional study.[24] In fact, Molina et al[23] reported that the frequency of TMJ click increased with the severity of subjectively evaluated SB. Carlsson et al[12] also reported a significant relationship between self-reported SB and TMJ noise in a population-based prospective study. In addition, Baba et al[24] reported that male subjects (mean age: 24.7 ± 2.0 years) showed a significant positive correlation between the prevalence of TMJ click and the number of muscle hyperactivity episodes. They included the interesting observation that the mean duration of the masticatory muscle hyperactivity in the male subjects was significantly longer than that of the female subjects. Interestingly, the multiple regression analysis in the current study showed no gender relation to the prevalence of TMJ click. This means that the SB frequency was related to the prevalence of the TMJ clicking in both male and female subjects. It is also obvious that other possible risk factors for the incidence of TMJ clicking, such as malocclusion, poor oral habits, and oral trauma, should be involved in future studies.

Velly et al[22] noted that self-reported tooth clenching/grinding was associated with the prevalence of chronic masticatory myofascial pain (OR = 8.4). Huang et al[6] also reported that self-reported clenching was identified as a risk factor for subjects with myofascial pain (OR = 4.8). On the other hand, Gavish et al[13] observed no association between the presence of SB and the muscle sensitivity to palpation or TMJ disturbance in their adolescent population-based survey. These results seem to be in contradiction, but this could be ascribed to the different nature of the target population. In fact, the TMD and/or myofascial pain patients were focused in the prior cross-sectional study,[6,22] whereas the present subjects and those in the Gavish et al study were not TMD patients, but high school students. Another important point is to differentiate daytime clenching and SB. Many researchers have recently assumed that low-level clenching could be harmful to the orofacial musculature.

Although the female subjects showed higher prevalence of headache in this study, the gender difference (male) was detected as a positive predictor of headache. This contradiction is based on the fact that the relationship between gender (female) and headache was weaker than the relation between SB frequency (heavy confounder of being male) and headache. Since SB frequency was not related to headache in the female subjects, gender difference (male) instead of SB frequency was detected as a significant predictor for headache in this adolescent sample. Of course, the power of the relationship between gender difference and headache is not powerful in the adolescent subjects. Thus, additional research in the future would be necessary to clarify the actual related factors for headache in this age group.

Conclusions

The results indicated that severe SB was associated with the prevalence of TMJ click. This causality could not be concluded in this research; therefore, additional follow-up studies of these subjects are required to evaluate the incidence and perpetuation of TMD signs and symptoms to identify risk factors for the incidence and perpetuation of TMD.

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References

1. Okeson JP. Signs and symptoms of temporomandibular disorders. In: Okeson JP (ed). Management of Temporomandibular Disorders and Occlusion, ed 5. Missouri: Mosby, 2003:191–244.
2. Morrow D, Tallents RH, Katzberg RW, Murphy WC, Hart TC. Relationship of other joint problems and anterior disc position in symptomatic TMD patients and in asymptomatic volunteers. J Orofac Pain 1996;10:15–20.
3. Ribeiro RF, Tallents RH, Katzberg RW, et al. The prevalence of disc displacement in symptomatic and asymptomatic volunteers aged 6 to 25 years. J Orofac Pain 1997;11:37–47.
4. Gesch D, Bernhardt O, Alte D, et al. Prevalence of signs and symptoms of temporomandibular disorders in an urban and rural German population: Results of a population-based Study of Health in Pomerania. Quintessence Int 2004;35:143–150.
5. Nilner M, Kopp S. Distribution by age and sex of functional disturbances and diseases of the stomatognathic system in 7–18 year olds. Swed Dent J 1983;7:191–198.
6. Huang GJ, LeResche L, Critchlow CW, Martin MD, Drangsholt MT. Risk factors for diagnostic subgroups of painful temporomandibular disorders (TMD). J Dent Res 2002;81:284–288.
7. Sleep related bruxism. In: The International Classification of Sleep Disorders: Diagnostic and Coding Manual, ed 2. Westchester, IL: American Academy of Sleep Medicine, 2005:189–192.
8. Lavigne GJ, Minzini C, Kato T. Sleep bruxism. In: Kryger M, Roth T, Dement W (eds). Principles and Practice of Sleep Medicine. Philadelphia: Elsevier, 2005:946–959.
9. Tsolka P, Walter JD, Wilson RF, Preiskel HW. Occlusal variables, bruxism and temporomandibular disorders: A clinical and kinesiographic assessment. J Oral Rehabil 1995;22:849–856.
10. Allen JD, Rivera-Morales WC, Zwemer JD. Occurrence of temporomandibular disorder symptoms in healthy young adults with and without evidence of bruxism. Cranio 1990;8:312–318.
11. Widmalm SE, Christiansen RL, Gunn SM. Oral parafunctions as temporomandibular disorder risk factors in children. Cranio 1995;13:242–246.
12. Carlsson GE, Egermark I, Magnusson T. Predictors of signs and symptoms of temporomandibular disorders: A 20-year follow-up study from childhood to adulthood. Acta Odontol Scand 2002;60:180–185.
13. Gavish A, Halachmi M, Winocur E, Gazit E. Oral habits and their association with signs and symptoms of temporomandibular disorders in adolescent girls. J Oral Rehabil 2000;27:22–32.
14. Choi YS, Choung PH, Moon HS, Kim SG. Temporomandibular disorders in 19-year-old Korean men. J Oral Maxillofac Surg 2002;60:797–803.
15. Lavigne GJ, Rompre PH, Montplaisir JY. Sleep bruxism: Validity of clinical research diagnostic criteria in a controlled polysomnographic study. J Dent Res 1996;75:546–552.
16. Lavigne GJ, Guitard F, Rompre PH, Montplaisir JY. Variability in sleep bruxism activity over time. J Sleep Res 2001;10:237–244.
17. Wruble MK, Lumley MA, McGlynn FD. Sleep-related bruxism and sleep variables: A critical review. J Craniomandib Disord 1989;3:152–158.
18. Miyawaki S, Tanimoto Y, Araki Y, Katayama A, Fujii A, Takano-Yamamoto T. Association between nocturnal bruxism and gastroesophageal reflux. Sleep 2003;26:888–892.
19. Shochat T, Gavish A, Arons E, et al. Validation of the BiteStrip screener for sleep bruxism. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:e32–e39.
20. Dworkin SF, LeResche L. Research Diagnostic Criteria for Temporomandibular Disorders: Review, Criteria, Examinations and Specifications, Critique. J Craniomandib Disord 1992;6:301–355.
21. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174.
22. Velly AM, Gornitsky M, Philippe P. Contributing factors to chronic myofascial pain: A case-control study. Pain 2003;104:491–499.
23. Molina OF, dos Santos J, Nelson SJ, Nowlin T. A clinical study of specific signs and symptoms of CMD in bruxers classified by the degree of severity. Cranio 1999;17:268–279.
24. Baba K, Haketa T, Sasaki Y, Ohyama T, Clark GT. Association between masseter muscle activity levels recorded during sleep and signs and symptoms of temporomandibular disorders in healthy young adults. J Orofac Pain 2005;19:226–231.