Sleep bruxism

Associations and comorbid conditions

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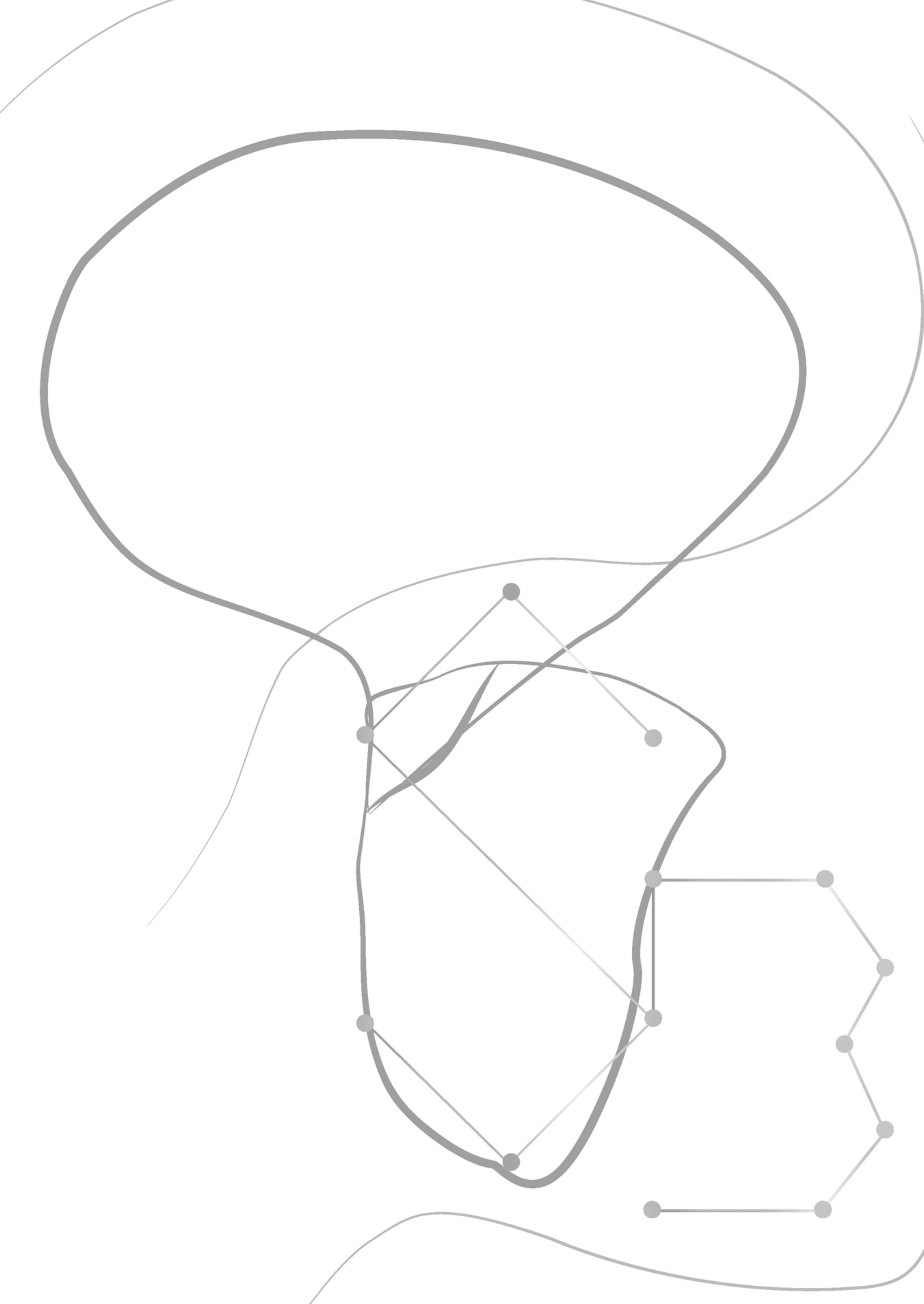

CHAPTER 2

THE ASSOCIATION BETWEEN SLEEP BRUXISM AND AWAKE BRUXISM: POLYSOMNOGRAPHIC AND ELECTROMYOGRAPHIC RECORDINGS IN WOMEN WITH AND WITHOUT MYOFASCIAL PAIN

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ABSTRACT

Background: Sleep bruxism (SB) and awake bruxism (AB) are masticatory muscle activities that are rarely assessed in the same individuals and are thought to be associated with different behaviors.

Objectives: To investigate whether individuals engaging in SB also engage in AB, that occurs during rest and during stress-related activity, and to investigate whether SB and AB are associated with different characteristics.

Methods: Females with myofascial pain (N=122) and non-myofascial pain controls (N=46) were evaluated for SB events and for AB events at rest and AB during stress-related activity, using electromyographic (EMG) recordings and a standardized scoring of bruxism events. The joint distributions between SB and AB events and EMG activity were evaluated, and the characteristic qualities of SB and AB were assessed.

Results: Neither SB event rates nor the EMG activity associated with those events was associated with AB events rates or EMG activity, either at rest or during stress-related activity. On the contrary, event rates and EMG activity when awake and at rest were positively associated with events and activity during stress-related activity. SB was characterized mainly by grinding, while AB was characterized mainly by clenching.

Conclusion: Sleep bruxism and awake bruxism do not tend to occur in the same individuals.

Keywords: awake bruxism, electromyography, muscle activity, polysomnography, sleep bruxism, stress

1. INTRODUCTION

Sleep bruxism (SB) is defined as repetitive masticatory muscle activity (RMMA) during sleep, and awake bruxism (AB) as RMMA during wakefulness.[1] Because different characteristics and consequences may occur for SB and AB, a 2018 international consensus statement[2] recommended specific and separate bruxism definitions for each. Gold standards for SB and AB assessment were considered to be polysomnographic (PSG) and electromyographic (EMG) recording, respectively.[2] Another major recommendation of the consensus statement was that the behaviors not be assessed dichotomously but continuously.

So far, nearly all existing research on the causes and consequences of SB and AB rely on suboptimal, dichotomized measures. For those studies using optimally recommended assessment methods, we know of no existing study that simultaneously assesses the same individuals for both SB and AB.

In this report, we investigate both SB and AB using a polysomnography and EMG-based methodology, respectively. We tested the following hypotheses: (1) individuals engaging in SB also engage similarly in AB which occurs at rest and during stress-related activity, and (2) SB and AB are associated with different subtypes of activity (mainly grinding versus mainly clenching, respectively).

2. METHODS

2.1 Participants

Participants were recruited between May 2008 and June 2011 from among the female patients, who sought treatment at the NYU College of Dentistry (NYUCD), and their acquaintances. Case participants were from the orofacial pain clinic at NYUCD and diagnosed with myofascial TMD according to the Research Diagnostic Criteria for TMD (RDC/TMD).[3] Control participants were from other NYUCD dental clinics and cases' acquaintances. The recruited control participants were matched to the case participants on measures of age, socioeconomic status, race, and Hispanic ethnicity. The potential control participants were not included if they reported having facial pain for more than one week in the last two years and had more than one painful site on masticatory muscle palpation, based on RDC/TMD criteria.[3,4] The potential case and control participants were excluded if they reported having trauma involving the face, acute dental problems, undergoing extensive dental treatment within two days before the RCD/TMD examination, were pregnant, regularly smoked during the sleep period, or experienced regular insomnia, sleep apnea, or neuropathic facial pain.

All participants signed informed consent, and 122 cases and 46 non-myofascial pain controls completed sleep laboratory recordings and stress-related activity.[4,5] This study was approved by the Institutional Review Board at the New York University (NYU) School of Medicine (protocol 07-303).

2.2 Procedure

Polysomnographic recordings were obtained in the New York Sleep Center, and stress-related activity was done at the Bluestone Center for Clinical Research at the New York University College of Dentistry.[4,5]

2.2.1 Polysomnographic recordings (PSG)

PSG was recorded for two consecutive nights. The first night was used for acclimation to the sleep laboratory setting. The PSG recording from second night was generally used in analysis, except that the first-night recording was used in three participants who failed to attend the second night and in seven participants when technical problems prevented second night scoring. The PSG recording lasted approximately from 10.30 PM to 7 AM. The PSG record consisted of a six-channel electroencephalogram, a bilateral electrooculogram, a bilateral submental and an anterior tibialis EMG, a right and left masseter and temporalis EMG, an electrocardiogram, chest and abdominal motion (by means of belts with piezoelectric sensors), body position, airflow by nasal pressure transducer and nasal-oral thermistor, and oximetry.

PSG data were recorded by SomnoStar Pro (Viasys Healthcare, San Diego, CA, USA) and exported to Stellate Harmonie software (Natus, San Carlos, CA, USA) for analysis. Two raters scored jaw muscle activities using the RDC/SB validated by Lavigne and colleagues.[6] The interrater reliability for identification of RMMA episodes by the two raters was excellent (k = 0.89).

2.2.2 Stress-related activity

There was a 120-minute session for stress-related activity, including experimental set-up and four stress-related activities. Participants underwent all stress-related activities once in one session, during the experiment. The experiment started with 5 min of vanilla baseline (VB), that is a non-stressful attention task, followed in random order by four stress-related activities: a cold pressor test, a mental arithmetic test, a speech stressor test, and a reaction time/startle response test.

Vanilla baseline (VB) was an activity in which the participant counted the number of colored squares on the computer screen and keyed the results. The cold pressor test immersed a participant's preferred foot in 10°C water for 2 min. The mental arithmetic test was serial subtractions with high difficulty level for 5 min. There was a math problem with 2-4 digits on the computer screen, and the participant was requested to type a correct answer as fast as possible, with adjustment for skill level to maximize task difficulty. The speech stressor test was 4 min of preparation for a 3-min speech about the participant's opinion on illegal immigration into the United States. Participants were told that the speech would be recorded and judged against speeches made by the other participants. Only data from the preparation period were used in analysis. For the reaction time/startle response test, the participant saw a four-letter word on the computer screen and then answered as quickly as possible whether a letter showing in the latter screen was present or not in that previous word. They were told that, if they answered slower than the average prior participants, they would receive a white noise blast, which was actually administered randomly. The reaction time/startle response test was performed for 3 min. Before starting each task, there was a 5 min recovery period, labelled 'between-task rest period'. Participants were requested not to talk and to avoid large body movement during the experiment. Full details can be found in Janal et al.[5]

Muscle activity during stress-related activity and between-activity rest periods was recorded from right and left masseter and temporalis muscles. To measure surface EMG, Ag/AgCl electrodes were applied to the skin, which was abraded and cleaned with an alcohol hot wipe. The LabView program (MindWare Technologies, Ltd., Westerville, OH, USA) was used to control the experiment; a Bionex 3711-08 amplifier system (MindWare Technologies, Ltd., Westerville, OH, USA) was used to collect EMG signal data; and EMG Analysis Software (v 3.0; MindWare Technologies, Ltd., Westerville, OH, USA) was used to process and export EMG data. A camera with sound recording was focused on the participant at all times, so that talking and other activities could be identified. Prior to export, data were filtered to include signals between 15 and 50 Hz, and periods containing artifacts, defined as signals at least 3x baseline associated with talking, laughing, coughing, yawning, smiling, and rubbing the nose or face (and miscellaneous others), were edited out. Bruxism events were then defined by visual analysis of the EMG signal over time for each task, following the rules developed by Lavigne et al. for the study of sleep bruxism.[6] Moderate levels of reliability from Cohen's Kappa test were shown between two raters judging 61 EMG periods as containing a bruxism event (either grinding or clenching) or not (k= 0.44).[7] Once exported to SPSS, EMG amplitude could be computed for the entire period of the task (EMGtot), or separately for grinding and clenching events. EMGtot for the 2 raters were similar, averaging 1.6 and 1.7 uV (p= .30).

2.3 Outcome Measures

2.3.1 SB event rate

Polysomnography (PSG) with audio and video signal recording included right and left masseter and temporalis electromyogram (EMG). Jaw muscle activity with two folds of amplitude when relaxing was used as a cutoff point for RMMA activity. Scoring of RMMA activity followed the rules established by Lavigne.[6] Phasic episodes were defined as at least three EMG bursts that lasted 0.25-2 s. Tonic episodes were bursts that lasted longer than 2 s. Mixed episodes were combined phasic and tonic episodes which were separated by less than 3 s. An RMMA episode was counted if it was separated by at least 3 s from the previous episode.[6] In this paper, RMMA episode would be called as 'event'. These events are standardized as events per hour of sleep (events/hr) and defined as 'SB event rate'.

2.3.2 AB event rate

Masseter and temporalis activity was measured by surface EMG recording. RMMA activity was measured following the same rules as for sleep bruxism.[6] Background EMG activity was obtained from EMG after subtracting periods with AB activity and movement artefact activity. Event counts were standardized as events/hr to make them comparable with sleep data. Similar to SB events, the standardized events per hour of AB activity was defined as 'AB event rate'.

2.3.3 EMG activity associated with SB and AB events.

Masseter EMG activity of bruxism events during sleep was obtained by subtracting activity unrelated to bruxism events from the total activity during the night. Similarly, EMG activity of AB events was computed by subtracting the background EMG activity from total EMG activity at rest and during stress-related activity.

2.4 Statistical analyses

Characteristic SB and AB and distribution of SB and AB in all participants were investigated by descriptive analysis. Student's t-test and chi-square were used to compare demographic data and distribution of SB and AB between case and control groups. Mann-Whitney U test was used to compare all SB and AB parameters, viz., event rates and EMG activity of SB and AB, between cases and controls, because all parameters were not normally distributed. Spearman's rank correlation coefficient was used to assess agreement between SB rates and AB rates between rest and stress-related activity, and to assess agreement between EMG activity of SB and AB events in all participants (N=168) and in the participants who had at least one SB and AB event (N=51). Significance level was set at P<.05 for all analyses. Data analysis was performed with IBM SPSS (v.28, IBM Corp, Armonk, NY, USA).

3. RESULTS

3.1 Participants

Cases and controls were well matched in their demographic characteristics (age [control mean±SD= 35.7±13.5 y vs case= 37.9±17.3 y; p= .44], race [control= 62.5% white, 10.4% black, 27.1% other vs case= 62.8% white, 15.7% black, 21.5% other; p= .77], Hispanic ethnicity [control= 25.0% vs case= 24.8%; p= .98], and years of education [control mean±SD= 15.7±2.2 y vs case= 15.5±2.3 y; p= .58]). TMD patients reported having pain onset 7 years before the study (median= 84 months, range= 4-605 months) with moderate pain intensity (mean±SD= 5.2±1.7). Total sleep time (TST) was also similar between cases and controls (control mean±SD= 402.3±45.84 min vs case= 386.8±52.49 min; p=.08).

3.2 Occurrence of SB and AB events

Event rates and EMG activity of SB and AB were not different between cases and controls. Using a cut-off of two or more RMMA episodes/h,[8] there were 33 (27%) of 122 cases and 13 (28.3%) of 46 controls who met the criteria for SB, and 34 (27.9%) of 122 cases and 11 (23.9%) of 46 controls who met the criteria for AB during stress-related activity. However, there was no significant association between SB and TMD (p=.875) or between AB and TMD (p=.606). Thus, all parameters were presented in a combined group (n=168). **Figure 1** shows the distribution of SB event rates and AB event rates at rest and stress-related activity. The AB event rate during stress-related activity was quite a bit higher than the SB event rate or the AB event rate at rest. **Tables 1** and **2** show the distribution of SB and AB rates in all participants.

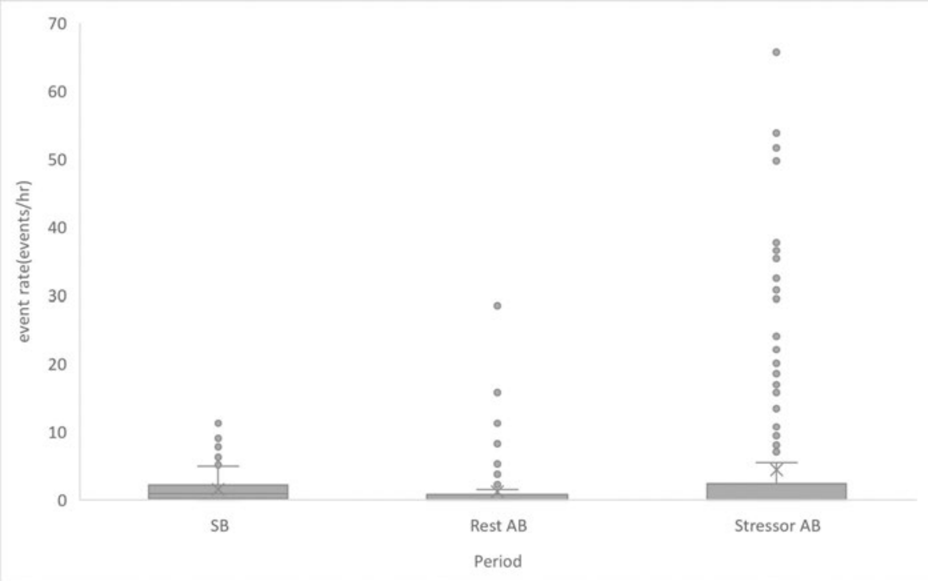

Figure 1 Distribution of SB and AB event rates in all participants (N=168); Rest AB, AB at rest; Stressor AB, AB during stress-related activity.

Table 1 Distribution of SB event rates and AB event rates at rest

		AB at rest (events/hr)				
		0-0.49	**0.5-0.99**	**1-1.99**	**≥2**	**Total**
SB (events/hr)	**0-0.49**	42 25%	7 4.2%	1 0.6%	11 6.5%	61 36.3%
	0.5-0.99	19 11.3%	2 1.2%	2 1.2%	6 3.6%	29 17.3%
	1-1.99	21 12.5%	2 1.2%	2 1.2%	7 4.2%	32 19%
	≥2	33 19.6%	3 1.8%	2 1.2%	8 4.8%	46 27.4%
	Total	115 68.5%	14 8.3%	7 4.2%	32 19%	168 100%

Table 2 Distribution of SB event rates and AB event rates during stress-related activity

		AB during stress-related activity (events/hr)				
		0-0.49	**0.5-0.99**	**1-1.99**	**≥2**	**Total**
SB (events/hr)	**0-0.49**	43 25.6%	1 1.6%	0 0%	17 10.1%	61 36.3%
	0.5-0.99	21 12.5%	0 0%	2 1.2%	6 3.6%	29 17.3%
	1-1.99	22 13.1%	0 0%	0 0%	10 6%	32 19%
	≥2	33 19.6%	1 0.6%	0 0%	12 7.1%	46 27.4%
	Total	119 70.8%	2 1.2%	2 1.2%	45 26.8%	168 100%

Using two or more bruxism events per hour as a threshold,[8] rates of potential clinical significance of 27.4%, 19%, and 26.8% were seen during SB, AB at rest, and AB during stress-related activity, respectively. That is, the majority of participants failed to display clinically significant rates of bruxism, and most of those showed less than 0.5 events/hr.

Table 3 shows that people who had ≥ 2 AB events/hr at rest also tended to have an ≥ 2 AB events/hr during stress-related activity. These individuals accounted for 16.1% of those 26.8% who showed ≥ 2 AB events/hr during the stress tasks. There was a strong positive correlation between the presence of AB at rest and during stress-related activity (r_s = 0.63, p<.001) (**Table 3)**.

Table 3 Distribution of AB event rates at rest and during stress-related activity.

		AB during stress-related activity (events/hr)			r_s
		<2	**≥2**	**Total**	
AB at rest (events/hr)	**<2**	118 70.2%	18 10.7%	136 81%	0.63**
	≥2	5 3%	27 16.1%	32 19%	
	Total	123 73.2%	45 26.8%	168 100%	

Note: There was a strong positive correlation between the presence of AB at rest and during stress-related activity. r_s= correlation coefficient, ** p<.001

3.3 Association between awake and sleep bruxism rates and masseter muscle activity

In further analysis, we consider both grinding and clenching events in two conditions. First, all participants (N=168) and, second, participants with at least one event during sleep and daytime periods (n=51) to prevent undue influence from the majority of participants who did not brux or had only an AB event or a SB event.

AB event rates at rest and during stress-related activity were strongly related (N=168, $r_s = 0.88$, $p<.001$; N=51, $r_s = 0.57$, $p< .001$), but event rates during the sleep period were unrelated to either awake period (N=168, r_s= -0.03 and -0.01, respectively; N=51, r_s= 0.01 and 0.13, respectively). Thus, those who brux the most during stress-related activity also brux the most when off-task. However, those who brux more than others during sleep do not have a greater tendency to brux more than others when assessed during an awake session.

Tables 4 and **5** show the relationship between masseter muscle activity during sleep and wake periods in all participants and in participants with at least one SB and AB event. There was no association between sleep and wake EMG activity. On the contrary, muscle activity of AB events at rest and during stress-related activity was positively associated.

Table 4 Correlation between masseter muscle activity (uVrms) during SB and AB events in all participants (N=168)

N=168	EMG SB	EMG AB at rest	EMG AB during stress-related activity
EMG SB	1.000		
EMG AB at rest	0.047	1.000	
EMG AB during stress-related activity	0.028	0.451**	1.000

** p< .001

Table 5 Correlation between masseter muscle activity (uVrms) during SB and AB events in participants who bruxed at least once (N=51)

N=51	EMG SB	EMG AB at rest	EMG AB during stress-related activity
EMG SB	1.000		
EMG AB at rest	0.078	1.000	
EMG AB during stress-related activity	0.011	0.609**	1.000

** p< .001

3.4 Characteristics of SB and AB

Grinding events predominated among participants showing SB, making up 97.7% of all sleep events. By contrast, clenching events predominated among those showing any AB, making up 86.4% of all awake events.

4. DISCUSSION

The present study explored the association between awake and sleep bruxism measured by bruxism events (grinding and clenching) and masseter muscle activity (surface EMG). Neither SB and AB event rates nor bruxism-related muscle activity support an association between SB and AB. The results showed that tooth grinding was the main characteristic for SB, and tooth clenching was the main characteristic for AB.

The present study showed that about 72.6% of this sample exhibited SB less than two events/hr during sleep, and half of this group exhibited SB rate ranging 0.5-1.99 event/hr. According to Rompre et al.,[8] individuals with these rates are categorized as non-bruxers. Importantly, while 46 participants showed ≥2 events during sleep and 32 showed ≥2 AB events at rest, only 8 (4.8%) showed both (**Table 1**). Similarly, while 45 showed ≥2 AB events during stress-related activity, only 12 (7.1%) showed ≥2 events during sleep and during stress-related activity (**Table 2**). However, many still had some SB events. Similarly, 81% and 73.2% of participants had AB at rest and during stress-related activity less than two events/hr, respectively. The proportion of participants who had more than two AB events/hr during stress-related activity was higher than the proportion of participants who had AB at rest. While we did not assess perceived stress during these activities, Pierce et al.[9] found a positive association between EMG activity during SB and self-reported stress in some individuals only, suggesting that participants might have different coping mechanisms.[9] This association requires further exploration.

In secondary analyses, we explored the relationship between EMG activity during the occurrence of bruxism events. Similar to event rates, women characterized by high levels of EMG activity during sleep were not also generally characterized by high levels of EMG activity during stress-related activity or at rest. Similar results were obtained when measuring masseter EMG activity in overall participants and in participants who had at least one SB and AB event (**Tables 4** and **5**). That is, those with the highest levels of EMG activity during sleep were generally different from those showing the highest levels of activation during the awake stress-related activity. This result showed that increased EMG activity during sleep is not correlated with EMG activity during awake periods. Conversely, a twin cohort study found a genetic correlation between self-reported AB and SB,[10] although self-report is not considered as valid as PSG or instrumental evidence.[11] On the contrary, EMG activity of AB during stress-related activity was associated with EMG activity of AB at rest.

Do the correlation between AB at rest and during stress-related activity and their event rates reflect a general tendency to engage in AB regardless of stress? Event rates and EMG activity during the two waking assessment conditions were highly correlated, supporting the conclusion that awake bruxers tend to have AB events with or without stress and suggesting a trait-like tendency/habit of AB. Nevertheless, about 11% of AB events (of the about 27% total) during stress-related activity occurred in women without such events at rest (**Table 3**). In addition, some outliers in AB during stress-related activity showed higher numbers of events than AB at rest (**Figure 1**). Thus, awake bruxers may show more AB events during stress conditions than at rest. Stress has a role as a contributing factor for AB.[12-15] Tooth clenching induced by guided music listening increased when listening to stressful music.[16] However, the changes in tooth clenching after listening to stressful music were different between high and low parafunctional groups.[17] AB would play a part in stress coping that may differ between individuals.[9,18] In addition, high-stress conditions can increase muscle tension.[19] On the contrary, experimental jaw bracing and thrusting increased stress in healthy adult participants.[20] The relationship between resting-related AB and stress-related activity AB provides fertile ground for further investigation.

Our findings showed similar levels of AB and/or SB in TMD-cases and controls. This result agrees with a study of Camparis et al.,[21] who showed a similar number of SB episodes in sleep bruxers with and without TMD pain. In addition, the intensity of SB was independent of TMD pain intensity.[22] Likewise, the study of Ramanan et al. showed a similar number of AB episodes between TMD-pain cases and controls.[23] However, they found a longer period of low-level clenching in TMD cases than in controls.[23] On the contrary, some studies found an association between TMD pain and EMG or PSG-confirmed SB.[24,25] For example, Rossetti et al. found that PSG-confirmed SB and self-reported daytime clenching were more common in those with myofascial pain.[25] Wei et al. found that the duration of SB events was longer in patients with TMJ disc displacement and pain than in pain-free controls.[26] Hence, the association between SB, AB, and TMD should be further investigated.

In this study, the most common specific characteristics occurring during SB and AB are different. Like us, Bracci et al.[27] also reported more clenching than grinding when awake in a young adult samples using an ecological momentary assessment tool- BruxApp®.[27] Similar to us, Rossetti et al. reported prominent grinding during sleep.[25] In addition, Lavigne et al. reported that phasic episodes were the most SB episodes.[6] Together, these data add to the suggestions of different types of specific bruxism characteristic when asleep and awake.

This study showed a lower number of SB and AB event rates compared to previous studies. There were differences in populations and methodologies between our study and other studies. The different instruments and thresholds used in this and other studies would determine the difference in the number of SB and AB episodes.[28] Our target population did not consist of sleep or awake bruxers, while some studies investigated in sleep bruxer and non-bruxer groups.[6,8] Some authors used different EMG activity thresholds, for example, over 10% of maximum voluntary contraction (MVC)[29] or 20% of MVC,[6] while we used jaw-muscle activity with two folds of amplitude when relaxing as a cut-off point for RMMA activity. Thus, methodological differences between this and other studies cannot be ruled out as an explanation for differences in reported AB and SB event rates.

The strength of this study is that we used gold-standard EMG and PSG assessment of muscle activity during wakefulness and sleep.[2] Bruxism events were scored reliably according to published criteria.[6,8] Importantly, to the best of our knowledge, this is the largest study to examine instrumentally-assessed bruxism during sleep and awake periods in the same individuals.

This study has some limitations. First, we studied women only, so results may not be generalizable to men. Second, AB event during stress were obtained from experiments. At this time, the external validity of experimentally evoked bruxism has an uncertain relationship to bruxism in daily life.

5. CONCLUSIONS

This study showed that sleep bruxism, primarily grinding activity, and awake bruxism, primarily clenching activity, do not typically characterize the same individuals. There was little support for the hypothesis that those who brux during sleep also brux when awake. On the contrary, resting and stress-associated awake bruxism events did tend to occur in the same individuals, suggesting a characteristic behavior.

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Conflict of Interest Statement: None

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