Oro-facial activities in sleep bruxism patients and in normal subjects: a controlled polygraphic and audio–video study

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SUMMARY To our knowledge, the large spectrum of sleep motor activities (SMA) present in the head and neck region has not yet been systematically estimated in normal and sleep bruxism (SB) subjects. We hypothesized that in the absence of audio-video signal recordings, normal and SB subjects would present a high level of SMA that might confound the scoring specificity of SB. A retrospective analysis of several SMA, including oro-facial activities (OFA) and rhythmic masticatory muscle activities (RMMA), was made from polygraphic and audio-video recordings of 21 normal subjects and 25 SB patients. Sleep motor activities were scored, blind to subject status, from the second night of sleep recordings. Discrimination of OFA included the following types of activities: lip sucking, head movements, chewinglike movements, swallowing, head rubbing and scratching, eve opening and blinking. These were differentiated from RMMA and tooth grinding. The frequency of SMA per hour of sleep was lower in normal subjects in comparison with SB patients (P < 0.001). Up to 85% of all SMA in normal subjects were related to OFA while 30% of SMA in SB patients were related to OFA scoring (P < 0.001). The frequency of RMMA was seven times higher in SB patients than in normal subjects (P < 0.001). Several SMA can be observed in normal and SB subjects. In the absence of audio-video signal recordings, the discrimination of various types of OFA is difficult to achieve and may lead to erroneous estimation of SB-related activities.

KEYWORDS: sleep bruxism, sleep movement, rhythmic masticatory muscle activity, swallowing, orofacial activity, tooth grinding, sleep recording

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Introduction

Several studies investigating sleep bruxism (SB) patients have been published during the last few years as a consequence of the growing interest in sleep physiology and related disorders. In these studies, different kinds of sleep motor activities (SMA) in the head and neck region have been observed in sleep laboratories (1, 2). For example, tooth grinding, tooth tapping and oromandibular myoclonus are included in sleep movement disorders but they are observed

parallel to the usual oro-facial motor activities (OFA) such as coughing, face rubbing, head scratching, lip movements, yawning, sleep talking, swallowing, tics such as grunting, grimacing, excessive lip and tongue movements such as thrust or protrusion etc (1–8). According to the most recent revision of the International Classification of Sleep Disorders, SB is now defined as a sleep-related movement disorder characterized by grinding or clenching of the teeth (9, 10). Therefore, the main challenge in studying SMA during sleep is to assess the specificity of the movement and to

classify it as either a usual or an unusual activity, i.e. a sleep-related movement disorder (1, 6, 10).

Repetitive jaw muscle activity can be observed during the sleep of both normal subjects and SB patients (1, 11). To our knowledge, chewing automatism was the first name used in sleep medicine to describe RJM activity in the absence of clear feeding behaviour (12, 13). In dentistry, repetitive and brief contractions of jaw closing muscles during sleep are either named 'rhythmic jaw movement (RJM)' or 'rhythmic masticatory muscle activity (RMMA)' (2, 3, 14, 15). In fact, we noted that close to 40% of all OFA in SB patients are not similar to RJM or RMMA and that 60% of normal subjects also present RMMA at a frequency of one episode per hour of sleep in comparison to four or more per hour in more severe SB patients (2, 11, 15).

The gold standard method for discriminating and scoring movement disorders during sleep is based on the use of audio-video polygraphic recordings (2, 6-8, 10, 14-18). Using this methodology, SB is quite recognizable by the presence of RJM activity, e.g. RMMA, with a co-contraction of jaw opening and closing muscles. More precisely, on electromyographic traces, SB is mainly associated with phasic and mixed bursting patterns, i.e. three phasic bursts repeated at a 1 Hz frequency with or without a sustained tonic contraction of both masseter and temporalis muscles (1-3, 15, 17, 19-21). Use of video further helps to discriminate SB-related movements from other types of SMA, as described above, while audio is mandatory to discriminate SB-tooth grinding sounds from those associated with tooth tapping, snoring, talking, or grunting (1, 5-7). Moreover, not all RMMA episodes are observed with concurrent grinding sounds on audio-video polygraphic recordings; only approximately 1/3 of RMMA episodes in SB patients occur with grinding (2, 22). Video is also useful in discriminating body movements that have been associated with 60-90% of RMMA episodes in control subjects and in SB patients (2, 8, 14, 17, 19, 21).

The aim of this retrospective analysis was to identify and quantify the spectrum and frequency of SMA, OFA and RMMA during the sleep of normal subjects and SB patients. We hypothesize that in the absence of audio– video signal recordings, normal subjects and SB patients will present a high level of OFA that may reduce our capacity to discriminate SB-related RMMA from other usual or atypical OFA.

Materials and methods

Study design and subjects

A retrospective comparative analysis of sleep and motor activity data collected in a sleep laboratory was performed with 25 SB-tooth grinding patients [17 female patients and eight male patients; ages (mean \pm s.e.m.) 24.5 ± 0.8 years; range 20–35 yrs] matched to 21 normal subjects (10 female patients and 11 male patients; mean age 23.6 \pm 0.8 years; range 19–35 years). As seen in Table 1, no difference was observed in age or gender distribution. Furthermore, we matched subjects from each group for sleep variables (see Table 1 for sleep duration and sleep stage distribution). The analyses, as described below, were carried out blind to subject status, i.e. normal subjects or SB patients.

Sleep bruxism patients were first selected based upon a history of tooth-grinding occurring more than three times a week for the preceding 3 months, report of orofacial jaw muscle fatigue or tenderness (but no pain) in the morning and the presence of tooth wear or masseter muscle hypertrophy upon voluntary clenching (2, 15). Normal subjects were selected on the basis of the absence of a history of tooth-grinding during sleep and of any of the clinical evidence of SB mentioned above. None of the SB patients or normal subjects had any history or signs of sleep [e.g. snoring, apnoea, periodic leg movement syndrome (PLMS) or insomnia] or medical (e.g. psychiatric, neurological or movement) disorders or pain, and none was taking any medication (1, 2, 21). All subjects participated after providing informed consent according to a protocol that was

 Table 1. Characteristics (age and gender) and sleep variables of normal subjects and SB patients

	Normal subjects $(n = 21)$	SB patients $(n = 25)$	P-value
Age (mean \pm s.e.)	$23{\cdot}6\pm0{\cdot}8$	$24{\cdot}5\pm0{\cdot}8$	0.45
Gender (% women, men)	48% w,	68% w,	0.23
	52% m	32% m	
Total sleep time (min)	$447{\cdot}4~\pm~8{\cdot}2$	$443{\cdot}0\pm6{\cdot}7$	0.68
Stage 1 (%)	6.8 ± 0.5	5.5 ± 0.6	0.11
Stage 2 (%)	$58\cdot2\pm2\cdot0$	$62{\cdot}7\pm1{\cdot}6$	0.08
Stage 3 and 4 (%)	13.5 ± 1.3	$9{\cdot}6\pm1{\cdot}6$	0.02
Stage REM (%)	$21{\cdot}5\pm1{\cdot}0$	$22{\cdot}2\pm0{\cdot}9$	0.61

SB, sleep bruxism; REM, rapid eye movement. Data presented as mean \pm s.e.

reviewed and approved by the Institutional Review Board of the Hôpital du Sacré-Coeur de Montréal.

Sleep and SMA recordings

Polygraphic recordings were made for each participant during two consecutive nights. The first night allowed for adaptation to the sleep laboratory. The second night was used for diagnosis of SB and to rule out other sleep disorders (e.g. insomnia, breathing disorder, PLMS and RBD). Surface electrodes were used for the polygraphic recordings, which included two electroencephalograms (EEG; C₃A₂, O₂A₁), bilateral electro-oculograms (EOGs), an electrocardiogram (EKG) and electromyograms (EMGs) from chin/suprahyoid, bilateral masseter, sternocleidomastoid and anterior tibialis muscle. Further description of the method is provided elsewhere (2, 15). To assess respiratory function, nasal airflow was measured with a thermistor sensor (Thermocouple*). Laryngeal movement was recorded with a piezoelectric sensor (Opti-flex sensors[†]) in order to assess swallowing events, as previously described (22). All signals were recorded at a sample frequency of 128 Hz by means of analysis software.[‡] Simultaneously, audio-video polygraphic recordings were made in a sound-attenuated room for visual scoring of SMA plus other body movements and oropharyngeal sounds. The data were stored on optical disk for subsequent off-line analysis. Only young adults were recruited to minimize the influence of age on EEG and SB-RMMA variables (23, 24).

Sleep scoring

The sleep stages were scored from polygraphic traces by an independent sleep technologist, according to the standard method of Rechstschaffen and Kales (25) but using 20-second instead of 30-second pages. The sleep duration (in minutes) and percentage of time spent in each sleep stage were estimated.

Definition of terms used for sleep motor activities

Sleep motor activities were defined as the spectrum of all activities scored in the head and neck region

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including OFA and RMMA as described below. As described elsewhere, RMMA is recognized by the type of jaw muscle contraction patterns: phasic (at least three rhythmic contractions lasting more than 0.25 s) or tonic (sustained activity lasting more than 2 s) or mixed (phasic and tonic-sustained) types of electromyographic episodes (14, 15, 22). Rhythmic masticatory muscle activity can be observed in the absence or presence of tooth grinding and in the latter case, it corresponds to SB. Oro-facial activities are defined as all motor activities not including the above-mentioned RMMA characteristics. The list of all the OFA scored is given below in this paper. All type of SMA events separated by 3 s of low muscle tone (i.e. nearly silence electromyographic activity) were scored as a new episode.

SMA and OFA scoring

The frequency (number of episodes per hour) of total SMA, OFA and RMMA was also estimated. The frequency of OFA episodes per hour was expressed in percentage for each sleep stage (non-REM stages 1, 2, 3 and 4 and REM stage). To assess time effect throughout the night for OFA, the total sleep time of each subject was further divided into thirds: the first third (dominance of stages 3 and 4), a mid-sleep period and the last third (dominance of REM sleep).

The SB episodes, including RMMA (with or without tooth grinding) were identified, scored and isolated from oro-facial and body activities by an electrophysiology technician and one of the authors (KCD) using audio–video and polygraphic recordings, as previously described elsewhere (2, 7, 15, 26). The inter-rater reliability was excellent, as shown by the intra-class correlation coefficient of 0.91 [95% confidence interval (CI) 0.83–0.95].

Very rapid jerk-like contractions associated with EMG bursts in jaw and neck muscles shorter than 0.25 s were classified as fragmentary myoclonus (5, 7). Using both the EMG and audio–video signals, OFA such as lip sucking, head movements (lateral and up or down), large and brief chewing-like movement different from RMMA (no alternating rhythm between opening and closing jaw muscle), swallowing, rubbing or scratching the head with hands or fingers (this included eyes, nose, face, neck and chin areas), eye opening and blinking movements were specifically scored. Two sub-analysis were considered: (i) OFA

with oropharyngeal sounds such as sleep talking, yawning, tooth tapping, grunting, throat clearing, snoring and tongue clicking; (ii) OFA with and without body movements. In addition to polygraphic and audio–video recordings, we indirectly identified swallowing events by recording laryngeal movements with a non-invasive sensor, according to the description above. By using this method, swallowing events during sleep could be recognized with a high inter-observer scoring agreement as previously reported (22). Again, similarly to RMMA, the 3-s criterion was used to separate OFA episodes.

Statistics

Statistical analysis was performed on sleep and orofacial motor activities parameters. The normality of data distribution was verified using the Shapiro–Wilk test. Two sample *t*-tests and Mann–Whitney *U*-tests were used depending on data distribution to assess the statistical difference between normal subjects and SB patients.

Results

Total number of SMA, OFA and RMMA

The total number of SMA per hour of sleep (including OFA + RMMA) was 37.7% lower in normal subjects in comparison with SB patients (*P* < 0.001; Table 2). By contrast, the frequency of OFA alone was 37.5% higher in normal subjects in comparison with SB patients (*P* = 0.02; Table 2). The expression of the difference of OFA only in percentages between the groups (i.e. EMG episodes without RMMA characterizing SB-tooth

 Table 2.
 SMA, OFA and RMMA in normal subjects and SB patients

	Normal subjects	SB patients	P-value
SMA per hour of sleep	6.6 ± 0.7	10.6 ± 0.9	<0.001
OFA per hour of sleep	5.6 ± 0.6	3.5 ± 0.6	<0.02
OFA/SMA (%)	$84{\cdot}9\pm2{\cdot}4$	30.2 ± 2.9	<0.001
RMMA per hour of sleep	1.0 ± 0.2	$7{\cdot}1\pm0{\cdot}4$	<0.001

SB, sleep bruxism; SMA, sleep motor activity; OFA, oro-facial activity; RMMA, rhythmic masticatory muscle activity. SMA = sum of OFA + RMMA, with and without tooth grinding. Tooth grinding was only present in SB patients. OFA does not include RMMA or tooth grinding. See Table 4 for description. Data presented as mean \pm s.e. grinding) revealed that OFA constituted close to 85% of all SMA in normal subjects and 30% in SB patients (P < 0.001). The frequency of RMMA was seven times higher in SB patients than in normal subjects (P < 0.001).

OFA by sleep stage and 1/3 of sleep duration

The analysis of OFA distribution over sleep stages shows that around 69% and 58% of OFA events occurred in light non-REM sleep stages 1 and 2 for normal subjects and SB patients, respectively (no statistical significant difference; Table 3). A trend towards more OFA was observed in normal subjects in deep sleep stages 3 and 4 in comparison with SB patients (P = 0.06). By contrast, slightly more OFA were scored during REM sleep for SB patients (P = 0.05; Table 3). The analysis of total sleep time divided in 1/3 periods failed to show a significant variation in the distribution of OFA between early, middle and late sleep periods (Table 3).

Various types of OFA

As seen on Table 4, the most frequent OFA scored in normal subjects was head rubbing and scratching (2·3 times more frequent than in SB patients; P < 0.001). Head movements were higher in prevalence in both groups but not statistically significant between the groups. Oro-facial motor activity with other body movements were 2·2 times more frequent in normal subjects in comparison with SB patients (P < 0.001).

Sleep bruxism patients presented much more lip sucking (3.9 times more frequent than in normal

Table 3. Distribution of OFA by sleep stages and throughout three sleep periods divided into thirds of total sleep duration for normal subjects and SB patients

	Normal subjects	SB patients	P-value		
OFA distribution by sleep stages $(\%)^{\dagger}$					
Stage 1	17.1 (2.6-38.1)	13.7 (0-42.9)	0.14		
Stage 2	52.2 (16.0-87.5)	44.4 (13.6-75.0)	0.52		
Stage 3 and 4	5.9 (0-28.0)	1.9 (0-47.8)	0.06		
Stage REM	23.2 (4.2-61.3)	33.3 (7.7-75.0)	0.05		
OFA by third of sleep duration $(\%)^{\dagger}$					
First	$28{\cdot}3\pm2{\cdot}7$	31.9 ± 3.2	0.40		
Second	38.8 ± 2.3	35·6 ± 3·8	0.20		
Third	32.9 ± 3.1	32.5 ± 3.0	0.93		

⁺Median values (minimum–maximum) are shown when the data distribution was not normal. Otherwise, mean \pm s.e. is shown.

Table 4. Percentages of oro-facialepisodes containing different types ofOFA during sleep

Oro-facial episodes (%)	Normal subjects	SB patients	<i>P</i> -value
Lip sucking	8.2 ± 1.7	32.6 ± 4.7	<0.001
Head movement	33.5 ± 3.3	28.8 ± 3.5	0.33
Chewing-like (excluding RMMA)	18.7 ± 3.8	$28{\cdot}6\pm4{\cdot}7$	0.12
Swallowing	18.4 ± 3.1	$18\cdot2\pm3\cdot4$	0.96
Head rubbing and scratching	32.9 ± 3.9	14.3 ± 2.1	<0.001
Eye opening and blinking	5.9 (0-17.9)	7.7 (0-45.8)	0.25
OFA with oropharyngeal sound	2.9 (0-47.8)	1.3 (0-50.0)	0.60
OFA with other body movements	47.7 ± 4.3	21.3 ± 3.2	<0.001

OFA, oro-facial activity; RMMA, rhythmic masticatory muscle activity; SB, sleep bruxism. Note: total is larger than 100% because of concomitant OFA.

subjects; P < 0.001). In a decreasing order and without statistical significance, SB patients had more frequent head movements followed by chewing-like activity (excluding RMMA), swallowing, eye opening and blinking and OFA with oropharyngeal sound.

Discussion

To the best of our knowledge, this is the first study systematically identifying, calculating and comparing SMA (including OFA + RMMA) between SB patients and normal subjects. The most important finding of the present report is that about 30% of SMA encountered in SB patients are related to OFA and therefore, in the absence of audio–video scoring, it seems that the use of electromyographic signals alone may clearly carry a risk of overestimating bruxism activity in SB. The concomitant OFA included lip sucking, head movements, chewing-like movements excluding RMMA, swallowing, rubbing and scratching head with fingers or hands, eye opening and blinking. Interestingly, 85% of all SMA in normal subjects were scored as OFA and not as RMMA.

Methodological issues

Quantification of SMA and discrimination between OFA and RMMA are possible with sleep laboratory or ambulatory recordings (1). We recognize that sleep laboratory recordings, using audio–video in parallel with electromyography, are costly and have limited applicability in natural subject environment. However, investigators using ambulatory recording need to acknowledge the lower discrimination capacity of their scoring because of the risk of adding various types of SMA–OFA not specific to SB (1, 2, 6, 7, 15, 27). The use of ambulatory

electromyography will gain in specificity and precision by adding audio-video system or body sensors to recognize various types of body movement and OFA from SB (28, 29). An example of this is the body sensors in the mattress that have been used in the past and that seem to help in the discrimination of some non-specific episodes (7, 16). Body movements and swallowing or sleep talking can also be excluded from RMMA-SB scoring with audio-video and swallowing movement sensor (1, 4, 6). Recently, a new ambulatory device was offered on the market (BiteStrip[§]). A good correlation between OFA recorded with the device and the polygraphic recordings was reported. However, the lack of a specific discrimination between OFA and SB, and the absence of audiovideo simultaneous recordings probably limit the value of this monitoring method (30).

Sound specificity is also another issue in recording and scoring SB. Tooth grinding and snoring are easily discriminated from each other by the use of audiovideo and polygraphic signals. Several oral and pharyngeal sounds can be observed during sleep such as coughing, sighing, tongue clicking, grunting, tooth tapping and even temporomandibular clicking (5–7). Tooth tapping can be easily mistaken for tooth grinding. In a previous publication, we reported that 10% of our SB patients do in fact present tooth tapping during sleep with a clear pattern of muscle contraction on electromyographic tracings, the oromandibular myoclonus. The oromandibular myoclonus is a brief (0.25 s or less) contraction of jaw and neck muscles that can be repeated in cluster or observed as an isolated event during all sleep stages (5). It is important to discriminate tooth tapping from SB because it may be a sign of sleeprelated epileptic activity (5, 6, 27).

[§]Scientific Laboratory Products, Tel Aviv, Israel.

A recent history of tooth grinding sounds is probably the most reliable criterion for justifying SB recording in the sleep laboratory (1, 4, 9, 11). Reports of tooth grinding by a sleep partner seem to be much more reliable than a dentist's observation of tooth wear, as tooth wear may have happened months or years before (1, 4).

Again, both ambulatory monitoring and polygraphic recordings in a natural environment or in a sleep laboratory are the methods used to score motor activities associated with SB. Nevertheless, in the absence of audio–video recordings, it may be difficult to distinguish SB-related motor activities from other oro-facial activities as the OFA scored in this study during sleep (1, 6, 7). Before using SB scoring to draw conclusions about the aetiology or physiopathology or the efficacy of treatment in randomized-controlled trials, investigators need to establish the specificity of the method used to discriminate various types of SMA–OFA (1, 31).

Specificity issues

Previous reports have already identified various types of OFA during sleep, such as swallowing, sleep talking, and oromandibular myoclonus, as described above, as well as coughing and chewing-like movements (1, 5, 7, 8, 12-14, 22, 27). Based from the extrapolation of one of our previous studies (not designed to systematically estimate OFA during sleep), about 40% of OFA in SB patients and 60% of OFA in normal subjects are not typical of RMMA-SB episodes in jaw muscles (20). In the present study, values are lower for SB patients (30%) and higher for normal subjects (85%). This may be explained by the study analysis design, which was specifically addressing such issues in a systematic and blind quantitative manner using standardized scoring criteria (2, 11). Moreover, it seems plausible that the differences in scoring methods may explain discrepancies between the various published studies on SB (2, 7, 8, 14, 15, 17, 19, 22, 28, 32).

As mentioned above, in sleep medicine, the presence of rhythmic oromandibular movements has been named chewing automatism. However, it is not known whether chewing automatism is concomitant with tooth grinding or not (12, 13). Sleep bruxism-tooth grinding behaviour was first observed to be associated with a rhythm in jaw muscle activity in 1968 by Reding and colleagues; a finding that was later supported by scoring criteria using either the terms of phasic episode or RJM or RMMA in SB patients (2, 3, 14, 15, 20). Rhythmic masticatory muscle activity is defined as three or more repetitive jaw muscle bursts and can be seen as phasic (rhythmic) or mixed (phasic and tonic-sustained) types of electromyographic episodes, regardless of the presence of tooth grinding. In patients with a history of frequent and recent tooth grinding, in comparison with observations made in normal subjects, phasic and mixed RMMA episodes constitute close to 90% of SB episodes, they are three to six times more frequent and their muscle burst amplitude is 40% higher (14, 15, 22). Furthermore, we observed that 60% of normal subjects do present RMMA but at a low frequency of about one episode per hour of sleep (15, 22). The presence of RMMA, in the absence of tooth grinding in normal subjects, has also been observed in other studies (14, 33).

Conclusion

In conclusion, several types of SMA were identified during the sleep in both groups of subjects. As expected, the most frequent type of SMA in SB patients was RMMA. However, based on statistical significance, the most frequent type of OFA observed in SB patients was lip sucking while in normal subjects, it was head rubbing and scratching. As 30% of SMA in SB patients are related to OFA and 85% of SMA in normal subjects are related to OFA, these findings suggest that precise scoring of SMA-OFA needs to be carried out with audio-video and electromyographic signals to improve discrimination between the subject groups. Such procedure is strongly advised in validating new diagnostic tools or algorithms and in planning randomized-controlled study design to test the efficacy and safety of medication or oral appliance for sleep OFA-related disorders.

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