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Frequency of awake bruxism behaviours in the natural environment. A 7-day, multiple-point observation of real-time report in healthy young adults

A. Bracci[1] | G. Djukic[2] | L. Favero[1] | L. Salmaso[3] | L. Guarda-Nardini[4] | D. Manfredini[1,5]

[1]School of Dentistry, University of Padova, Padova, Italy
[2]Institute of Clinical Physiology, National Research Council, Pisa, Italy
[3]Department of Management and Engineering, University of Padova, Padova, Italy
[4]Department of Dentistry and Maxillofacial Surgery, Hospital of Treviso, Treviso, Italy
[5]School of Dentistry, University of Siena, Siena, Italy

Correspondence
Daniele Manfredini, School of Dentistry, University of Padova, Padova, Italy.
Email: daniele.manfredini@tin.it

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Summary

The aim of this study was to assess awake bruxism (AB) behaviours in a sample of healthy young adults using a smartphone-based application for a real-time report (ie, ecological momentary assessment [EMA], also called experience sampling method [ESM]). Forty-six dental students used a smartphone application that sent 15 alerts at random intervals during the day for 1 week to collect AB self-reports. They had to answer on time by tapping on the display icon that refers to their current condition of jaw muscles: relaxed; teeth contact; teeth clenching; teeth grinding; jaw clenching without teeth contact (ie, bracing). The average frequency of relaxed jaw muscles, as a percentage of answers over the 7 days, was 71.7%. Teeth contact (14.5%) and jaw clenching (10.0%) were the most frequent AB behaviours. No significant gender differences were detected. Interindividual differences were quite relevant, but the overall frequency was in general only moderately variable from day-to-day. Coefficient of variation (CV) was low for the condition “relaxed jaw muscles” (0.44). At the individual level, teeth contact was the most prevalent behaviour, with a 39.1%-52.2% proportion of subjects reporting it at least once a day. During a 7-day observation period, the frequency of real-time report of AB behaviours in a sample of healthy young adults was 28.3%. The low daily variability in the average frequency value for the relaxed jaw muscles condition suggests that EMA may be a reliable strategy to get deeper into the epidemiology of oral behaviours. This investigation introduced EMA principles to the study of AB and provided data on the frequency of AB behaviours in young adults that could be compared to populations with risk/associated factors and possible clinical consequences.

KEYWORDS
awake bruxism, bruxism, diagnosis, ecological momentary assessment, smartphone

1 | INTRODUCTION

Bruxism is a debated topic in dentistry, as several investigations have tried to get deeper into its aetiology and possible consequences.[1-3] Recently, a panel of experts has provided a consensus paper that, along with providing an updated definition, also suggested that knowledge on several bruxism issues may be improved with a better assessment of its presence.[4] Over the years, several different approaches have been proposed to “diagnose” bruxism, including the use of measurement devices (ie, polysomnography [PSG], electromyography [EMG]) as well as the adoption of clinical or self-reported/questionnaire-based protocols.[5,6] The differences in the diagnostic strategies may affect results of the literature on bruxism epidemiology, which report wide prevalence ranges for both adults and children/adolescents.[7,8]

To refine current knowledge, researches should distinguish between the various forms of bruxism, both concerning the circadian manifestation (eg, sleep [SB] vs awake bruxism [AB]) and the type of masticatory muscle activity (MMA). The consensus panel also reported that the different diagnostic approaches have different levels of diagnostic accuracy and recommended the adoption of a diagnostic grading system, as for neuropathic pain.[9] To this aim, it should be remarked that self-reported approaches are suitable for the detection of "possible" SB or AB, while an integrated clinical assessment leads to a "probable" diagnosis. "Definite" SB assessment should be based on self-report, a clinical examination, plus PSG tracking, preferably along with audio/video (AV) recordings, while "definite" AB should require self-report, clinical examination and EMG recordings.[4] Due to the difficulties to perform hour-long EMG recordings of jaw muscles' activity during wakefulness, definite AB assessment could be also based on the so-called ecological momentary assessment (EMA). Such procedure is also referred to as experience sampling method (ESM) and requires a real-time report of the condition under study (eg, AB behaviours).[10]

Until now, available data on AB prevalence were derived from retrospective self-reports at a single observation point.[8] Such an approach may potentially lead to an imperfect estimate due to the absence of information on the frequency as well as to the patients' forced recall of their oral conditions during the time span covered by the report, which is usually very generic and refers to wide periods (eg, days, weeks, months). Thus, collecting real-time data at multiple recording points during the day, close in time with the experience in the natural environment, as provided with EMA approaches, could be the most suitable strategy to approximate a definite depiction of the epidemiology of AB behaviours and improve on previous work on the topic. In turn, it could help getting deeper into the debated issues concerning the aetiology and clinical consequences.[11,12]

Ecological momentary assessment has been already proven reliable in the research setting to assess a variety of oral behaviours,[13] even including the role of jaw muscle tension as a predictor for facial pain.[14] Nonetheless, EMA-based data on AB are fragmental and limited to a few investigations on selected behaviours, such as teeth clenching and teeth contacting habits.[15-17] Thus, current knowledge on AB/EMA has some shortcomings, such as the lack of information on the prevalence of mandible bracing (ie, the analogous of clenching without the teeth in contact, viz., "jaw clenching"), which was introduced as part of the bruxism activities in the consensus definition.[4] In addition, there is a need to gather comprehensive data on healthy individuals that could be used as a standpoint for future comparison with selected populations with specific diseases or risk factors.

Based on that, it could be useful to assess the frequency of all conditions (ie, teeth clenching, jaw clenching, teeth grinding, teeth contacting habits) that are potentially part of the spectrum of AB behaviours in a natural environment. To pursue that goal, smartphone technology provides an ideal platform for the adoption of EMA-based on-time evaluations at multiple daily recording points over multiple-day spans. This investigation was thus designed to assess the frequency of the above AB behaviours over 1 week in a sample of healthy young adults by the adoption of a dedicated smartphone application.

2 | METHODS

The sample consisted of all undergraduate dental students attending the final 2 years of the School of Dentistry, University of Padova, Italy, and performing clinical training at the Section of Dentistry and Maxillofacial Surgery, Hospital of Treviso, Italy, underwent an assessment of their AB behaviours. Participants should have been in good general health as the only criterion for admission to the study, along with the availability of a smartphone. This criterion provided the absence of temporomandibular disorders (TMD pain) and/or any documented psychiatric, neurological or systemic (eg, rheumatological, hormonal) diseases.

All participants received a code pass to download an application for their smartphone, called BruxApp® (BruxApp team, Pontedera, Italy). Two training sessions with the leading investigator (A.B.) and the study supervisor (D.M.) were performed as part of the practical training provided by the dental school curriculum portfolio. The sessions aimed to provide information on the study and how to use the application. In short, BruxApp sends alert sounds at random hours during the day to collect data on self-reported AB. The individual must answer on real time by tapping on the display icon that refers to the current condition of his/her jaw muscles: relaxed jaw muscles; teeth contact; teeth clenching; teeth grinding; jaw clenching without teeth contact (ie, bracing). For any further details on the software, readers are referred to the original publication.[17]

The above conditions were selected because of their relevance as behaviours that are part of the AB spectrum. During the information sessions, they were defined as follows:

1. Relaxed jaw muscles: condition of perceived relax of jaw muscles, with mandibles kept apart;
2. Teeth contact: condition of slight teeth contact like the teeth contact that the subject perceives when a 40 μ articulating paper (Bausch Occlusionspapier®; Bausch KG, Koln, Germany) is put between the dental arches and he/she is asked to slightly keep the teeth in contact to retain it on site. In short, this condition is defined as light touching of teeth when the mouth is closed;
3. Teeth clenching: all conditions in which teeth contacts are more marked than the above and jaw muscles are kept tense;

TABLE 1 Frequency data[a] expressed in percentage of positive observations (mean values, range, 95% confidence intervals and coefficient of variation) for the different AB behaviours over the 7-d observation period

Activity	Mean frequency (SD)[a]	Range	95% CI	Daily mean frequency D1	D2	D3	D4	D5	D6	D7	CV[b]
Relaxed jaw muscles	71.7 (24.3)	5.8-100	64.3-78.4	69.3 (30.7)	72.4 (30.5)	68.6 (31.2)	72.4 (31.4)	73.1 (28.4)	72.9 (34.4)	74.5 (34.3)	0.44
Teeth contact	14.5 (14.7)	0-47.4	10.5-18.9	14.9 (20.0)	11.1 (17.7)	15.4 (20.5)	14.4 (21.8)	14.7 (21.4)	14.7 (21.6)	14.5 (21.1)	1.25
Jaw clenching/ bracing	10.0 (11.5)	0-42.7	6.4-13.2	11.9 (18.6)	12.4 (21.5)	13.0 (20.9)	10.1 (20.5)	8.7 (15.0)	8.9 (19.1)	7.7 (16.2)	1.81
Teeth clenching	3.7 (4.9)	0-19.7	1.5-5.3	3.9 (8.0)	3.9 (7.7)	3.0 (7.9)	2.8 (5.5)	3.5 (8.2)	3.5 (9.8)	3.3 (7.6)	3.27
Teeth grinding	0.1 (0.5)	0-3.1	0-0.2	0	0.2 (2.1)	0	0.3 (2.8)	0.1 (0.7)	0	0	n.a.

AB, awake bruxism; CI, confidence intervals; CV, coefficient of variation; SD, standard deviation

[a]Mean frequency value is the number of positive responses for each specific behaviour per reporting period. For instance, a mean of 71.7% for the condition "Relaxed jaw muscles" can be interpreted as equivalent to the report of 71.7% "Relaxed jaw muscles" per 100 reporting alerts, indicating that, on average, each subject answered "Relaxed jaw muscles" to 71.7% of the alerts, generalising from the random EMA sampling, with a minimum of 5.8% by at least 1 subject and a maximum of 1000% by at least 1 subject.[13]

[b]Coefficient of variation (CV) is expressed as the ratio between SD and mean values of frequency data over the 7 recordings day for each condition.

4. Teeth grinding: condition in which the opposite teeth are gnashed or ground, independently by intensity and direction of antagonist teeth contacts;
5. Jaw clenching (without teeth contact): condition of jaw muscle stiffness or tension like teeth clenching, but with teeth kept apart (ie, bracing).

After the explanation, the students were trained to recognise the different conditions. The study protocol started the day after the second training session. Participants were taught to answer the alert by tapping on the display within 5 minutes from the alert sound. After that period, answers could not be stored in the software, and an error message appeared on the display. Also, they were asked to discard the alert if coming while performing functional activities, such as eating or talking. The software was programmed to send 15 alerts/d at random intervals, to limit expectation bias (eg, risk that individuals may modify their behaviours based on the alert expectation, if set at predetermined intervals). Recording time was set from 9.00 to 12.00 and from 15.00 to 19.00 daily, to reduce the possibility that alert sounds were randomly generated by the application during lunch times.

Data were recorded over a 1-week period, and a minimum of 70% of valid answers (ie, provided within 5 minutes from the alert and not discarded by the individual because occurring during functional activities) was required. In case of failure to reach the minimum percentage of valid answers, the software generated an error message and automatically set an additional recording day to complete the 7-day protocol. After the observation period, the software generated an anonymous pre-formatted excel file that participants should send researchers via email.

A descriptive evaluation of the frequency of each condition (ie, relaxed muscles; teeth contact; teeth clenching; teeth grinding; jaw clenching), calculated as a percentage with respect to the answered alerts, was performed in all individuals. The frequencies were calculated daily on an individual basis, and individual frequencies were used to calculate an average of the study population on a daily basis. At the end of the 7-day observation period, the mean frequency of each condition was assessed both for each subject and the study population. Data were reported as mean values of the 7-day span per each condition according to the strategy of reporting EMA data described by Kaplan and Ohrbach (13—see Table 1 for an example description). For each condition, a coefficient of variation (CV; ie, ratio between SD and mean values over the 7 recording days) of frequency data was assessed.

Between-gender comparison was performed using *t* test for unpaired data, with significance level set at $P < .05$.

In addition, as a second analysis, the prevalence values of each behaviour on a subject level, that is the proportion of subjects indicating the behaviour at least 1 time, were assessed on a daily basis.

All statistical procedures were performed with the software SPSS 21.0 (IBM, Milan, Italy).

The study protocol was approved by the Treviso Hospital's IRB (code #344-CES-AULSS9), and each participant gave written consent to take part in the study.

TABLE 2 Prevalence data expressed as the proportion of individuals that reported the behaviours at least once a day

Activity	Daily prevalence (95% CI)						
	D1	D2	D3	D4	D5	D6	D7
Teeth contact	52.2 (39.1-65.2)	43.5 (30.4-56.5)	45.7 (30.4-60.9)	43.5 (30.4-56.5)	50.0 (37.0-63.0)	45.7 (32.6-60.9)	39.1 (26.1-54.3)
Jaw clenching/bracing	37.0 (23.9-52.2)	39.1 (26.1-54.3)	41.3 (26.1-56.5)	28.3 (17.4-41.3)	23.9 (13.0-39.1)	23.9 (10.9-37.0)	21.7 (10.9-32.6)
Teeth clenching	19.6 (8.7-32.6)	23.9 (13.0-37.0)	15.2 (6.5-26.1)	8.7 (2.2-17.4)	13.0 (4.3-23.9)	8.7 (2.2-17.4)	10.9 (2.2-19.6)
Teeth grinding	0	2.2 (0-6.5)	0	4.3 (0-10.9)	2.2 (0-6.5)	0	0

3 | RESULTS

Of the 50 students attending the final 2 years of the dental school (25 per year), 4 were not eligible for the study, because having a history of TMD pain (N = 3), or being affected by systemic rheumatic disease (ie, rheumatoid arthritis [N = 1]).

Within the final sample of 46 participants (26 females; mean age 24.2 ± 1.7 years) taking part to the study protocol, 5 individuals reported a failed recording day each, thus, requiring a 1-day extension of the observation period. All the other participants did not report any failed recording days. The average response rate to the alerts was 82.1 ± 9.2% (range 71.4-94.3).

On average, the frequency of the various AB behaviours over the 7 days was as follows: relaxed jaw muscles, 71.7%; teeth contact, 14.5%; jaw clenching without teeth contact, 10.0%; teeth clenching, 2.7%; teeth grinding, 0.1% (Table 1). Gender-related frequency was assessed to test for possible differences in the frequency of AB behaviours, but all comparisons were not significant, with *P*-values ranging from .129 to .754.

Coefficient of variation of the frequency of each condition at the study group level over the 7 days was low for the condition "relaxed jaw muscles" (0.44), while it was higher for the behaviours "teeth contact" (1.25), "jaw clenching" (1.81) and "teeth clenching" (3.27). Any specific patterns of reduction or increase over time were shown. The only exception was a progressive reduction in the jaw clenching frequency, which decreased from 11.9% to 7.7% (Table 1).

As the proportion of subjects reporting the different behaviours at least 1 time during the observation period, data showed that teeth grinding was the least prevalent condition, with a peak of 4.3% of individuals reporting it at least once on day 4 (range over the 7 days: 0%-4.3%). Teeth contact was the most prevalent behaviour, with a 52.2% prevalence of individuals reporting it on day 1 (range over the 7 days: 39.1%-52.2%) (Table 2).

4 | DISCUSSION

This report provided information on the frequency of AB behaviours by the adoption of the so-called EMA approach, which was first introduced in the psychological research settings to maximise the validity of self-reporting the outcome variable under investigation/assessment (eg, symptoms, affect, behaviour, feeling, cognition) close in time to experience.[18] Such an approach may allow a better understanding of the epidemiological features of many diseases, by studying the natural course and fluctuations of signs, symptoms and exposure to aetiological factors. Besides, EMA can take advantage of recent progress in smartphone technology, as data collection for both clinical and research purposes can be conducted using a tool that is already a part of daily life for a large percentage of the population.[19,20]

In the current investigation, a smartphone application has been used to assess the frequency of AB behaviours. Results show that, in a population of healthy young adults, the average frequency of the different AB behaviours (ie, teeth contact; teeth clenching; teeth grinding; jaw clenching) over a 7-day observation period is 28.3%. Teeth contact habits and jaw clenching were the most frequently reported conditions, with an average prevalence of 14.5% and 10.0%, respectively. At the patient level, the most prevalent behaviour was teeth contact, which was reported at least once a day by a minimum of 39.1% of individuals and a maximum of 52.2 of individuals on a daily basis.

These data were derived from an impressive amount of observations that can be gathered with EMA-based real-time collection (ie, up to 15 alerts × 46 participants × 7 days). Our choice was to report the mean frequency of each AB behaviour over the 7 days at the study population level, as well as to report the proportion of individuals who reported the behaviour at least once a day. With these premises, findings are hard to compare with literature findings, which are collected via retrospective, single-observation self-report.[8] Indeed, while interesting protocols have been recently designed to introduce EMG measurement of daytime clenching with surface electrodes,[21] such experimental designs are limited in time for obvious technical reasons. A recent systematic review on the epidemiology of bruxism in adults retrieved only a couple of papers on AB, reporting a 22.1% prevalence, as defined by the frequency term "often",[22] and a 31% prevalence, independent on the frequency, during the past 6 months.[23] A successive paper reported a 11.2% prevalence based on the generic history-taking item "During the day, do you grind your teeth or clench your jaw?",[24] while an investigation on Brazilian dental students found a 36.5% prevalence, as identified by the question "In the last 30 days have you noticed clenching your teeth while awake and not chewing food?".[25]

As for the specific AB activities, the few literature data suggest that non-functional tooth contacts (ie, teeth contacts during activities not associated with normal functions, such as reading books, watching television, working etc…), recorded at 20-minute intervals for 10 days, were reported by 9.6% of TMD-free subjects recruited as controls in a recent paper assessing the possible role of teeth contacting habits as a risk factor for TMD.[16] A similar investigation found an 8.9% prevalence for wake-time non-functional tooth contacts, as reported on time in response to vibratory wrist alerts.[15] Both studies reported a slightly lower prevalence of teeth contacting habits with respect to our study population (ie, 14.5%).

Factors such as the age of participants, which was lower and with a minimum range in the current investigation, may explain these differences. In addition, the selection of a dental student population with specific training, which might be differently sensitive to report AB behaviours and to use a dedicated application than laypeople and dental patients, could be a limit to the generalisation of findings. This requires a further appraisal of these data in future. However, due to the paucity of available information and the absence of reference values for the frequency of AB, this study findings gathered in a population of healthy subjects could be viewed as a possible starting point to define "normal" AB prevalence in young adults. Nonetheless, it should be also kept in mind that adopting EMA approaches to study the epidemiology of a certain condition leaves the researchers with a huge amount of data to analyse. Guidelines for reporting such data are generally based on good-sense recommendations, suggesting that a detailed description of the strategy of data management procedures is provided to ease a systematic and standardised approach to comparison studies.[26] Thus, it should be kept in mind that the frequency (ie, percentage of positive answers with respect to the total of the received alerts) and prevalence (ie, proportion of individuals who reported the behaviour at least once a day) data reported in the present investigation should be carefully interpreted when compared with future researches.

Based on that, the possible developments of future researches on the topic are quite intuitive and comprise an evaluation of the additive contribution of associated factors and a better understanding of the possible clinical consequences. To do that, a comparison with selected populations with possible associated conditions (eg, myofascial pain) or even to healthy volunteers undergoing stressful periods that may influence their psychological well-being appears as feasible strategies.

In addition, studies on the natural course of AB could be performed. For instance, an interesting finding of this investigation is also the low coefficient of variation over the 1-week observation period, especially as far as the answer "relaxed jaw muscles" is concerned. Such observation suggests that the frequency of the relaxed condition in a population of healthy individuals did not change relevantly from 1 day to another, while variability mostly influenced the reported type of AB behaviour. Based on that, EMA strategies seem potentially reliable to collect consistent data that reduce the influence of a natural fluctuation on estimating the frequency of oral behaviours. Thus, future investigations should also aim to get deeper into the topic of time-related variability in the specific AB activities (eg, teeth contact habits and jaw clenching), which may theoretically even be viewed as part of the same complex spectrum of muscle behaviours that represent an alternative condition with respect to keeping the jaw muscles relaxed.

And finally, as soon as the specific indications for treatment are defined,[27] the potential for the use of smartphone-EMA approaches as a strategy to implement cognitive-behavioural management of AB could be assessed. Indeed, it could be possible that someone who notices to be an AB bruxer could actually try to stop his/her own oral behaviour.

In summary, the current investigation is the first to provide a detailed report on the real-time frequency of several possible AB behaviours (EMA/AB). While the advantages of this approach may be intuitive to researchers involved in the field, it must be pointed out that it may also influence the future construct of bruxism. For years, bruxism has been generically called into cause as a risk factor for several clinical consequences of dental interest, but the literature has always failed to show a clear-cut relationship with the purported effects, such as TMDs, occlusal trauma, implant failures.[3,28,29] Such observations led to a sense of urgency towards the need of redefining bruxism and discriminating between the different bruxism behaviours.[11,12]

Keeping this in mind, possible shortcomings associated with EMA/AB have to be evaluated. In particular, investigations aiming to confirm that EMA approaches to approximate the advocated definite assessment for AB are needed. Indeed, despite the many advantages associated with its adoption, the subjective nature of reports, even if on time, cannot be underestimated. To get deeper into the issue, the reliability and accuracy of such real-time subjective reports should be assessed, possibly by comparing them with real-time assessment of jaw muscles' EMG activity.[30] Such a comparison could be particularly useful if 1 considers that the magnitude of AB activity, rather than its reported presence, could emerge as a critical factor for the study of clinical consequences. On the other hand, it must be also pointed out that most decisions in everyday medical clinical practice actually rely on patients' reports (eg, feeling certain psychological states or not, experiencing pain or not). Thus, thanks to the approach adopted in this investigation, the future design and report of case series on different AB topics could be simplified.

5 | CONCLUSIONS

The present manuscript discussed the possible advantages of introducing EMA approaches in the field of bruxism clinics and research and presented preliminary data on the frequency of AB in a sample of healthy young adults by adopting a dedicated application for smartphones, which provides on-time evaluation. Findings suggest that the average frequency of the different AB behaviours (ie, teeth contact; teeth clenching; teeth grinding; jaw clenching/bracing), as measured based on the percentage of "positive alerts" over a 1-week observation period in the study sample, is 28.3%. Teeth contact habits and jaw clenching (ie, bracing) were the most frequently reported conditions, with an average frequency of 14.5% and 10.0%, respectively. At the individual level, teeth contact was the most prevalent behaviour, with a 39.1%-52.2% proportion of subjects reporting it at least once a day.

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CONFLICT OF INTEREST

Author D.M. took part as a non-paid advisor to the development of the BruxApp software; Author A.B. ideated the BruxApp software and is the copyright owner; Author G.D. developed the BruxApp software; Authors L.F., L.S. and L.G.-N. do not have any conflict of interests concerning this investigation.

ETHICAL APPROVAL

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study protocol was approved by the Treviso Hospital's IRB (code #344-CES-AULSS9).

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

ORCID

D. Manfredini http://orcid.org/0000-0002-4352-3085

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