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Awake bruxism report in a population of dental students with and without ecological momentary assessment monitorization–A randomised trial

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Abstract

Objective: The Ecological Momentary Assessment (EMA) concept was the basis for developing a smartphone application for the real-time report of awake bruxism (AB) activities. The aim of this study was to assess the effects of the EMA with a randomised controlled trial designed to compare the frequency of AB reported in two separate single observation points between a group of students monitored over time with an EMA smartphone application and a non-EMA monitored group.

Methods: Sixty-four ($N = 64$) dental students (22.3 YO [±2.6]; 52F; 12 M) answered the Oral Behaviour Checklist (OBC-1) and were randomised into an EMA-group (EG) and control group (CG). EG were monitored with a smartphone application for AB report during seven consecutive days and completed three EMA monitoring periods (EMA-1, 2 and 3) at one-month intervals. After the third period (EMA–3), both EG and CG answered again the OBC (OBC–2). Descriptive statistics were performed to characterise the sample. Pearson's chi-squared test, Fixer Exact test and post hoc Z test with Bonferroni correction were performed. The study hypothesis was that EMA could influence the AB reported by the participants because it implies an increase in the awareness, self-recognition, and self-control of bruxism behaviours. The level of significance was set at $p < .05$.

Result: The percentage of participants who changed the report of the activity of clenching their teeth while awake between OBC-1 and OBC-2 was significantly higher among participants in EG, when compared to CG ($p = .027$). For all other behaviours reported the within- and between-group differences from OBC-1 to OBC-2 were not significant. Clenching and bracing were the most frequently reported, whilst grinding was the less frequent behaviour.

Conclusion: A smartphone-based EMA approach demonstrated be useful to monitor AB over time, increasing individual's awareness, particularly to bracing and clenching behaviours.

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KEYWORDS
awake bruxism, bruxism assessment, bruxism behaviour, ecological momentary assessment, oral behavioural checklist

1 | INTRODUCTION

Bruxism is defined as a behaviour characterised by repetitive masticatory muscle activity that occurs during sleep and/or wakefulness in otherwise healthy subjects.[1–3] This muscle activity may result in tooth grinding and tooth contact and bracing or thrusting the mandible without tooth contact. Sleep (SB) and awake bruxism (AB) are distinct entities based on the circadian manifestation, with potentially different aetiology.[4–6] The literature suggests SB prevalence of around 8% in adults and 25% in children, whilst AB is generally reported by 20%–30% of adults based on single observation points questionnaires.[6–8] During a 7-day observation period with smartphone-based ecological momentary assessment, the frequency of AB reports (i.e. percentage of positive answers with respect to the total number of received alerts) was around 28%–38%. Teeth contact and mandible bracing were the most frequent AB behaviours.[9–11] In this scenario it is important to underline that the results of the various studies were obtained with different methodological approaches (i.e. single observation points questionnaires vs ecological momentary assessment); consequently, this aspect may explain the differences in the results.

The aetiology of SB and AB is of central origin. Stress sensitivity and anxiety, possibly related with periods of increased emotional pressure, are often associated with a potential increase in muscle activity during sleep and wakefulness.[1–3,12–14] Such activity requires attention and control by clinicians and patients to minimise the potential consequences.

Over the years, many methods have been proposed to assess bruxism, mainly focusing on SB.[1] As for AB, most literature data are drawn from single-observation point questionnaires with a single-item report of bruxism. Oral Behaviour Checklist (OBC), a self-reported scale for identifying and quantifying the frequency of oral behaviours in the past month, is the most used tool, and it is included in the Diagnostic Criteria/Temporomandibular Disorders (DC/TMD). In line with other self-reported instruments, validity of OBC answers is influenced by patients' knowledge and awareness of the bruxism behaviour.[1,2,15,16]

For this reason, strategies to report the AB behaviours in real time, viz., Ecological Momentary Assessment (EMA), have been proposed as an aid to improve patients' awareness of the condition under investigation. EMA refers to a real-time report of a behaviour, a feeling, or whichever condition. In psychological science it is essential to assess the subject's condition in the moment and what he/she is feeling, and it is quite accepted that it helps overcome the limitations of the quantitative methods that are classically used.[9,17,18]

The use of technology based on EMA principles has introduced a new possible way to engage subjects from a therapeutic viewpoint as well (i.e. ecological momentary intervention [EMI]). Such an approach offered interesting perspectives also in the field of AB.[9,11,18–21] Recent works provided preliminary support to its usefulness, also pointing out the need for further studies.[19–22] EMA with mobile devices has been proposed to improve patients' awareness about AB behaviour and potentially contribute to self-control based on the concept of biofeedback and behavioural re-education.[9,20–23] It typically requires participants to complete assessments at predetermined parameters, either in response to specific states or events, or in response to an auditory signal by the researchers. Mobile devices provide an ideal platform for real-time reports at multiple daily recording points over multiple-day spans.[9,23]

Within these premises, this study aimed to assess the potential effects of EMA to change awareness of AB behaviours.[10,19,20,22,24] To achieve this goal, a randomised controlled trial was designed to compare the AB frequency reported at two separate single observation points (using OBC) between a group of healthy young students monitored with EMA and a non-monitored group. The study hypothesis was that report of AB changes more over time in EMA-monitored individuals.

2 | MATERIALS AND METHODS

2.1 | Study sample

All undergraduate students of the last 2 years of the dental degree course of the Faculty of Medicine of the University of Coimbra were invited to take part in the study. Inclusion criteria were a good general and dental health and the availability of a smartphone for app download. Those who met these criteria and agreed voluntarily and without any incentive to participate in the study or any loss for not participating, signed an informed consent form.

This study was conducted following the principles expressed in the Declaration of Helsinki (revised in World Medical Association, 2013). Ethics Committee of the Faculty of Medicine of the University of Coimbra (Portugal) approved the study with ID: 014–CE–2019.

2.2 | Study protocol

Each student answered the Oral Behavioural Checklist questionnaire in the morning of a non-specific business weekday (OBC-T1) and without being together, in the Dentistry Area of Faculty of Medicine of Coimbra, Portugal.[15] OBC includes items on self-report of AB behaviour over the last 30 days, such as grinding the teeth together during waking hours, clenching the teeth together during waking hours or holding the jaw in rigid or tense position, as to brace or protect it.

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Randomization to the EMA-Group or the control group was performed by main investigator by simple randomization technique, without considering age, gender, or year of the course. Except main investigator, all other investigators (main, statistician) not know the result of randomization. All participants were identified by a ID number.

Participants included in the EMA-Group, immediately after filling the OBC, initiated the first of three 7-day periods of real-time AB report using a smartphone application (BruxApp–WMA SRL, Italy). Each EMA period lasted at least 7 days. EMA monitoring periods were separated by a 30-day interval from each other. During the 7 days, between 7 h 30 min to 22 h 00 min, the app sends 20 alerts with fully random schedule and time interval, asking for the real-time report of jaw muscle condition. Users must answer the alert within 5 min by selecting one of the following options on their smartphones: relaxed, bracing (no teeth contact), teeth contact, teeth clenching or grinding. Based on the compliance studied by Colonna et al., participants must answer a minimum of 12 alerts per day to validate daily reports.[10] Days with less than 12 answered alerts were automatically discarded by the application and the period was extended until completing the 7 days. A maximum of three extra days was allowed.

On the last day of the last EMA monitoring period, the participants repeated the OBC questionnaire (OBC-T2). The control group answer the OBC questionnaire at this time too (OBC-T2).

Figure 1 shows a flowchart of the study and Figure 2 the Consort flow diagram.

3 | STATISTICAL ANALYSIS

Data were stored in a database and all statistical procedures were performed using IBM Statistical Package for the Social Sciences software (IBM SPSS Inc., Chicago, IL, USA).

Descriptive statistics were performed to characterise the sample. Pearson's Chi-square test, Fixer Exact test and post hoc *Z*-test with Bonferroni correction were performed.[25] The study hypothesis was that EMA could influence the AB reported by the participants because it implies an increase in the awareness, self-recognition, and self-control of bruxism behaviours. The level of significance was set at $p < .05$.

4 | RESULTS

The CONSORT diagram (Figure 2) shows the general perspective of the study organisation and sample distribution by study groups. Of the 78 students attending the final 2 years of the School of Dentistry, 12 were not eligible for the study, because of a history of TMD pain ($N = 7$), presence of systemic rheumatic disease ($N = 1$) and unwillingness to participate in the study ($N = 4$). Sixty-six answered the initial OBC questionnaire (OBC-1) and were thus randomised in EMA (EG) and control group (CG) ($N = 33$ each). Two dropouts were noticed in EMA-Group because they did not complete the seven-day monitoring for a valid period. Final sample characterisation is presented in Table 1.

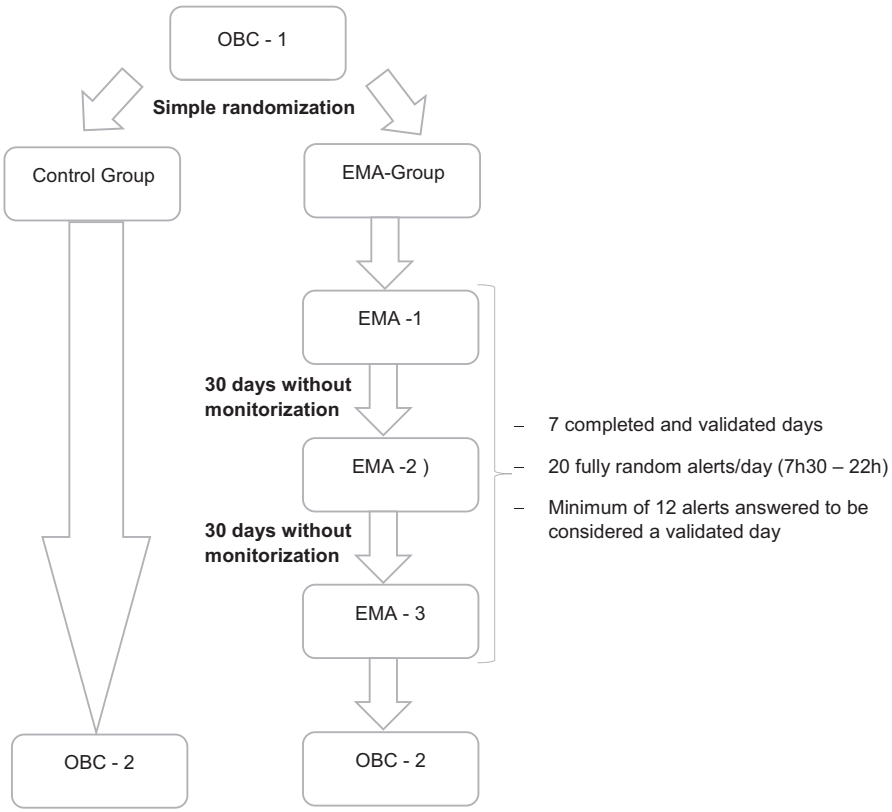

FIGURE 1 Flowchart of the study. EMA, Ecological Momentary Assessment; OBC, Oral Behavioural Checklist.

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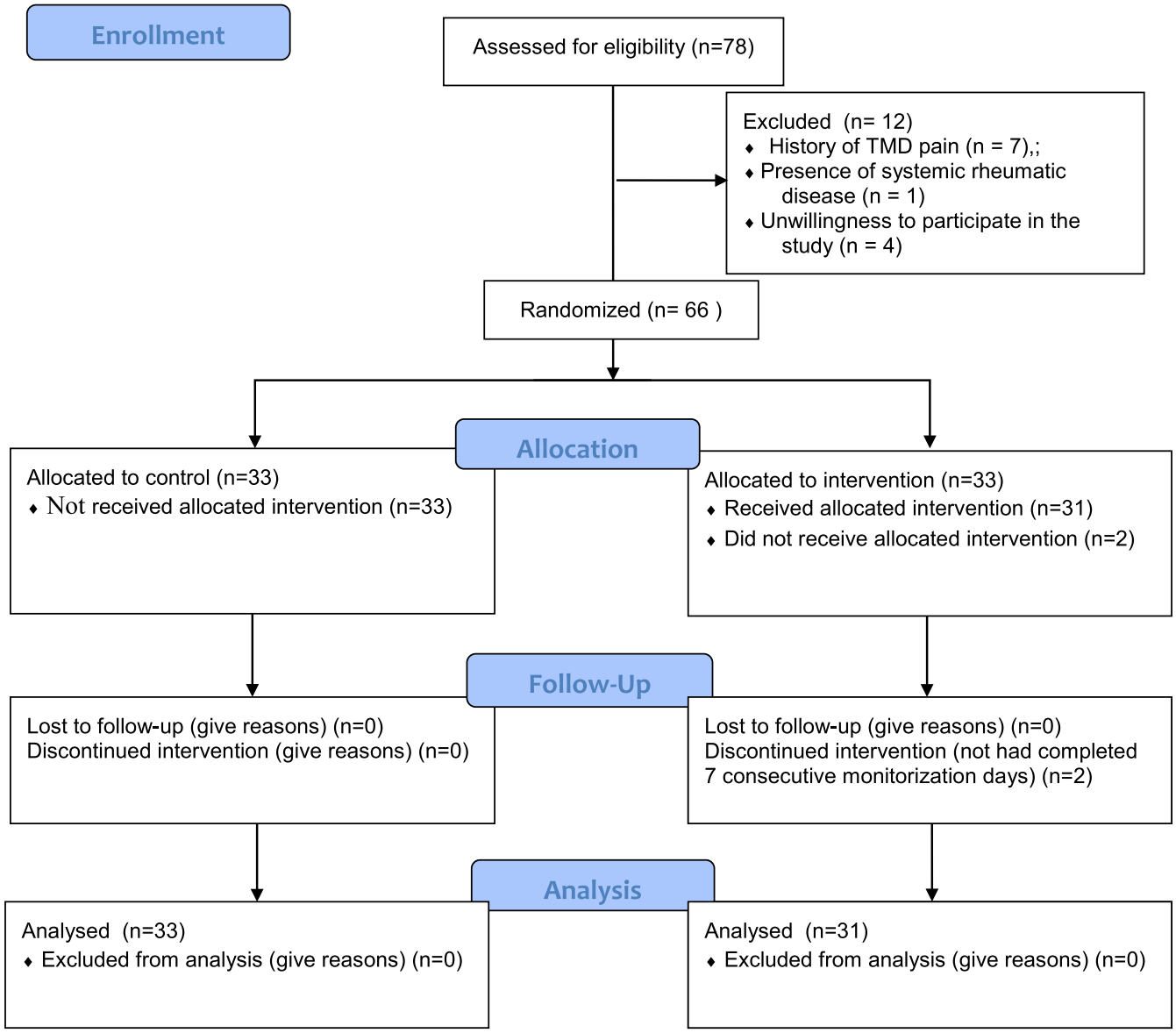

FIGURE 2 CONSORT flow diagram of the study.

The percentage of participants who changed the report of the activity of clenching their teeth whilst awake between OBC-1 and OBC-2 was significantly higher among participants of the EMA-Group, when compared to control group ($p = .027$). For all other behaviours the within- and between-group differences were not significant. Clenching and bracing were the most frequently behaviours reported, whilst grinding was the less frequent behaviour. All the results are presented in Table 2. This table specifies the evolution observed for each AB behaviour assessed using the OBC and the possible responses. If the participant in T2 mentioned more frequency of that specific OBC item, it was considered an 'Activity increase between T1 and T2'. If the participant referred to less, it was considered as 'Activity decrease between T1 and T2'. If the participants answered the same in both as 'Activity remained between T1 and T2'. If in T1 participant answered that he 'did not know' and in T2 reported the existence of the behaviour, it was considered as 'I did not know before, but I knew in T2'. The inverse was considered as 'knew before and did not know at T2'.

5 | DISCUSSION

AB is a behaviour that may be difficult to be aware of and may occur with a certain natural variability and fluctuation. Its identification is classically based on retrospective self-report at a single observation point.[1,7] Recent works in psychology and behavioural therapy suggested the importance of adopting instrumental strategies to foster its awareness. EMA has been referred to as an important strategy for this purpose, comparing with single-time or oriented-by-time assessment strategies.[6,19,20,22] The digital era and the massive interaction with mobile devices created a unique and potentially effective opportunity to put the EMA at the service of AB assessment in

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TABLE 1 Sample characterisation.

	Total sample	EMA-group (%)	Control group (%)	*p*
Sex				
Female	52 (81.3)	27 (51.9)	25 (48.1)	.341[a]
Male	12 (18.8)	04 (33.3)	08 (66.7)	
Age				
Mean [SD]	22.3 [±2.6]	22.4 [±1.1]	22.2 [±3.4]	
Median [Min–Max]	22.0 [20–41]	23.0 [20–24]	22.0 [20–41]	**.006**[b]

Note: Values in parentheses represent the percentage in the row. Values in bold represent a statistically significant association. Different letters represent a statistically significant difference.
Abbreviations: SD, standard deviation; *p*, probability value.
[a]Pearson's chi-squared test.
[b]Mann–Whitney test.

TABLE 2 Comparative analysis between reported awake bruxism (Oral Behavioural Check list items) in the initial and final time among dental participants submitted and not submitted to Ecological Momentary Assessment.

	EMA-group (%)	Control group (%)	*p**
Grinding Teeth during wakefulness (last month)			
Activity remained between T1 and T2	01 (3.2)	03 (9.1)	.715
Activity increase between T1 and T2	03 (9.7)	01 (3)	
Activity reduced between T1 and T2	09 (29)	10 (30.3)	
Didn't know before, but know in T2	02 (6.4)	00 (–)	
No activity in T1 and still without in T2	16 (51.7)	17 (51.5)	
Know before, but didn't know in T2	00 (–)	02 (6.1)	
Clenching Teeth during wakefulness (last month)			
Activity remained between T1 and T2	06 (19.3)	14 (42.3)[a]	**.027**
Activity increase between T1 and T2	12 (38.7)	04 (12.2)[b]	
Activity reduced between T1 and T2	11 (35.5)	09 (27.3)[a,b]	
Didn't know before, but know in T2	00 (–)	00 (–)	
No activity in T1 and still without T2	02 (6.5)	06 (18.2)[a,b]	
Know before, but didn't know in T2	00 (–)	00 (–)	
Bracing/trusting the mandible during wakefulness (last month)			
Activity remained between T1 and T2	03 (9.7)	07 (21.2)	.408
Activity increase between T1 and T2	11 (35.5)	08 (24.2)	
Activity reduced between T1 and T2	01 (3.2)	04 (12.2)	
Didn't know before, but know in T2	03 (9.7)	02 (6.1)	
No activity in T1 and still without T2	13 (41.9)	11 (33.3)	
Know before, but didn't know in T2	00 (–)	01 (3)	

Note: Bold values represent a statistically significant association. Different letters represent a statistically significant difference.
*Fisher Exact test with post hoc *Z* test and Bonferroni correction. Values in parentheses represent the percentage on the column. *p*, probability value.

everyday life.[26] A previous study was a starting point for the current investigation, suggesting some interesting considerations about the correlation between OBC and EMA answers over time.[22] Thus, the comparison of the data obtained by the OBC questionnaire in two distinct single moments, separated or not by an EMA period, is an implementation that can be added with the inclusion of a control group in this investigation.

All participants to the study completed the Oral Behavioural Checklist (OBC-1), a self-report scale for identifying and quantifying the frequency of oral behaviours, developed by Ohrbach and the RDC/TMD Validation Project group and currently considered the best available self-report scale to assess oral behaviours.[15,26,27] After that, to test the study hypothesis, the sample was divided into two groups either undergoing three EMA monitoring periods (EG) or not (CG). The final sample was mostly composed of female students in both groups, without relevant demographic differences, and is representative of the students of the Dentistry Department of Faculty of Medicine of University of Coimbra. Within these premises, it may be anticipated that further studies on possible gender-influences on the study hypothesis are needed

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for future investigations.[22,22,28–30] Regarding age, students in the EMA-Group were on average 1 year older than those in the control group. Since older students attending more advanced years of study are potentially subject to emotional overload due to academic pressure, the age factor is also worthy of further assessment. Additionally, we must recognise the possible influence of the more profound knowledge about AB behaviour in older students.[4,30,31]

To assess the influence of real-time monitoring in AB assessment, and in line with the strategy proposed by Zani et al. and Osiewicz et al., a dedicated smartphone application was used in the EMA-Group in this study.[9,17] A real-time monitoring of a population of dental students was performed in three different reporting weeks at one-month intervals. The rationale behind this approach is that people check their mobile phones up to 150 times a day, demonstrating that mobile devices offer unprecedented access to the monitoring of everyday behaviours. Our results support the hypothesis of Zani et al. (2019), who suggested that the repetition of EMA process in different periods might have the potential to increase awareness and consolidate self-control via behavioural re-education (i.e., Ecological Momentary Intervention–EMI).[9]

Baseline and follow-up OBC answers allowed an evaluation of the changes over time, viz., how the participants changed their OBC reports. In the case of EG, this was a strategy to evaluate the effect of EMA in the self-recognition of AB by the patient. The study hypothesis was that report of OBC/AB items would change differentially in EMA-group comparing to control group. Such findings were hypothesised by previous investigations.[6,9] From a methodological viewpoint it must be noticed that the possible answer 'I don't know' was added to the OBC items to avoid forced negative or positive answers (i.e. 'no' or 'yes'), when, for instance, the student had no idea of the actual answer. Based on that, it is important to point out that the percentage of students who answered 'I don't know' in OBC-1 for grinding or bracing during wakefulness, but recognised the behaviours in OBC-2, was higher in the EMA-Group. These results suggest that information, education, and consciousness for specific behaviours are essential to produce effective awareness, and EMA monitoring demonstrated a potential advantage to this purpose.

The classical conditioning process may be a hypothesis to consider here as well. The patient knows he is being monitored, and a 'stimulus' such as the alert can lead to an 'immediate' development of a particular behaviour that is seen as favourable. It still remains to be seen whether in the absence of stimulus and at medium/long term, the lower frequency of harmful behaviour is mantained.[32,33]

When comparing AB behaviours, grinding was by far the less frequently reported behaviour, in line with the early findings of Bracci et al.[21] The between-groups results for 'grinding teeth during wakefulness' were nearly matched. On the other hand, bracing and clenching were the most frequently reported behaviours, thus allowing to identify important phenotypes of AB. A significant difference was noticed between groups for clenching teeth during wakefulness. The number of participants who maintained or did not identify such behaviour decreased in the EMA-group. This may indicate an increased attention on the detection of a behaviour that was not distinguished/signalled until that moment. Within this framework, smartphone-based EMA can minimise bias since it allows the patient to focus his/her attention more properly on an oral behaviour only at random moments and in the natural environment, thus avoiding any recall biases. On the other hand, natural fluctuation and a paradox interventional effect may also explain the differences in EMA reports over time.[9,10,21,34]

The study sample was not representative of the general population, both in terms of possible knowledge on the topic, emotional academic pressure and the potential impact of COVID-19 study protocols, all of which may lead to overly frequent AB reports.[4,5,19,35–37] Larger and more representative populations might be recruited in future works, also integrating information on the possible aetiology and risk factors and the clinical consequences.

The method itself to obtain the results may also offer a selection bias, since strictly adhering to the study protocol and completing all monitoring periods may be more accurate in a certain type of personality profile. For this reason, a control group was included in the study. A psycho-emotional characterisation of each patient is something to consider in future studies to assess whether if the self-control that is needed to adhere a study protocol may lead to an over-evaluation of self-reported symptoms and behaviours. Indeed, the fact that an individual knows that he/she is being monitored increases his 'condition of alert' and hypervigilance. Knowing that they are being monitored can represent a reactive emotional condition, leading to an increase in the muscular activity and in the reported frequency of the behaviour.[27] Thus, the Axis II characterisation and monitorization with EMA in future studies will be important to take into account this factor.[37–40]

6 | CONCLUSION

As a behaviour, AB needs to be reported properly by an individual, especially in the light of the possible clinical relevance of jaw muscle activities for many dental and medical fields. Within the limits of the present investigation, findings supported that a smartphone-based EMA approach may be useful to monitor AB over time, by increasing individual's awareness particularly to bracing and clenching behaviours, with respect to single-time report.

AUTHOR CONTRIBUTIONS

R.D.: conceptualised the study, defined the methodology, supervised the collection of data, drafted, reviewed and edited the manuscript, primary author and principal investigator; R.V.: investigator, collected data, organised data and co-interpreted the data; I.P.: organised data, statistical analysis and co-interpreted the data; A.C.: reviewed and edited the manuscript; J.M.S.: co-defined the methodology, co-supervised the study; A.B.: co-supervised the study and was resources supporter; D.M.: conceptualised the study and

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supervised all phases of the study, reviewed and edited the manuscript and made final validation.

CONFLICT OF INTEREST STATEMENT

Authors D.M. and A.B. took part as non-paid advisors to the development of the BruxAPP software. Other authors disclosed any commercial or scientific conflict of interest. Data subject to third party restrictions.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/joor.13695.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL APPROVAL

Ethics Committee of the Faculty of Medicine of University of Coimbra—Portugal, approved this study with the reference: 014–CE–2019.

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