Original Research
Temporomandibular Joint Dysfunction

Influence of awake bruxism behaviors on fatigue of the masticatory muscles in healthy young adults

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Abstract: The present cross-sectional study aimed to analyze the relationship between awake bruxism and fatigue of masticatory muscles in healthy young adults. For this purpose, 121 graduate students participated in this study. Frequency of awake bruxism was collected for 7 consecutive days by ecological momentary assessment (EMA) using an online survey (mentimeter). Muscle fatigue was tested one day after EMA assessment, which consisted of voluntarily and continuously clenching at 30% (kgf/cm^2) of maximum bite force (MBF) until exhaustion. The percentage of change in MBF after the clenching task, as compared to the MBF before the clenching task was measured. The average frequency of awake bruxism was 45.5% during 7 days. Sustained clenching resulted in a significant reduction in MBF values in the total sample ($p < 0.05$). Nevertheless, no significant correlation was found between frequency of awake bruxism behaviors and percent of change in MBF and endurance time during the fatigue test. Therefore, it can be concluded that young healthy adults present a relatively high frequency of awake bruxism behaviors that do not seem to impact the degree of masticatory muscle fatigue.

Keywords: Bruxism; Ecological Momentary Assessment.

Introduction

Awake bruxism is defined as masticatory muscle activity during wakefulness characterized by repetitive or sustained tooth contact and/or bracing or thrusting of the mandible and is not a movement disorder in otherwise healthy individuals[1]. Awake bruxism etiology is multifactorial,[2] with biological, psychosocial,[3] and genetic[4] factors interacting[5] with each other and with concomitant conditions, such as environment and lifestyle that may contribute to the extent of awake bruxism manifestation.[6,7] Epidemiological studies of awake bruxism have shown prevalence rates of 22% to 30% in adults[8] and 33% in dental students based on self-report data, while other studies show frequencies of 23% to 38% in young adults assessed with the ecological momentary assessment (EMA) method; which quantify AB frequency in real-time during the day, in the natural environment of individuals.[3,9] Although an association between awake bruxism and increased incidence of painful temporomandibular disorders has been pointed out, studies have failed to support a direct relationship between the two.[10] However, reports have demonstrated that an experimental task involving sustained jaw clenching may induce perceived acute muscle tenderness[11], pain, and muscle fatigue,[12] suggesting a possible relationship between awake bruxism and these variables.[13]

On the other hand, there is limited information about the association between awake bruxism and muscle fatigue. Peripheral muscle fatigue involves a series of biochemical and physiological changes[14] characterized by a decrease in maximal force or power production in response to contractile activity,[15] resulting in the inability of the muscles to maintain high levels of force for a long time.[16] Studies of masticatory muscle fatigue have shown that sustained tooth clenching produces an increase in electromyographic activity in the masticatory muscles[17] and a reduction in maximum bite force (MBF) after the task.[17] Since experimental studies suggest that muscle hyperactivity from low-level dental clenching induces muscle fatigue[17] and pain in healthy individuals,[18] one might assume that awake bruxism behaviors might be related to fatigue of masticatory muscles in these individuals. Indeed, muscle fatigue is one of the most commonly reported non-painful symptoms after sustained clenching.[19] Thus, comprehensive data on the relationship between awake bruxism and fatigue of masticatory muscles in healthy individuals should be collected to understand the clinical implications.

Based on the above, the main objective of this study was to assess the frequency of awake bruxism behaviors over a one-week period in a sample of healthy young adults and evaluate the relationship between awake bruxism behaviors and masticatory muscle fatigue induced by a sustained clenching task. We hypothesized that the frequency of awake bruxism in healthy young adults would have a significant impact on the magnitude of fatigue, as determined by the endurance time to exhaustion and the reduction in MBF.

Methodology

Participants

The sample was comprised by 150 healthy young adults among graduate students at the Bauru School of Dentistry, University of São Paulo, São Paulo, Brazil. Sample size calculation was done using G*Power 3.1.9.2 software (Düsseldorf, Germany). It was expected that a effect size of 0.25 for the association between awake bruxism behaviors and changes in MBF and endurance time to fatigue would be worth detecting considering a power of 80%, a significance level of 5% and an anticipated drop-out rate of 20%. Therefore, the sample size estimation was 150 participants. Participants were recruited by emails, social media postings and in the classroom between April 2019 and January 2020. To participate of the study the following selection criteria were considered: complete natural dentition except for third molars, no signs or symptoms of temporomandibular disorders according to the temporomandibular disorders pain screener,[20] and good general health. They were also required to have access to a smartphone. Exclusion criteria included ongoing orthodontic treatment and present psychiatric, neurological, or systemic diseases. All participants were informed about the research purposes and signed a free informed consent form before the study. This study was approved by the Research Ethics Committee of the Bauru School of Dentistry under CAAE number 99729118.6.0000.5417.

Outcome variables

The main variables measured were: a) frequency of awake bruxism activities for a 7-day period and b) masticatory muscle fatigue considering endurance time (seconds) until fatigue and percentage of change in maximal bite force after sustained submaximal clenching.

Assessment of awake bruxism

An interactive web-based survey program called Mentimemer® was used as EMA[21] strategy to obtain the frequency of awake bruxism. This method allows for real-time collection of reports from volunteers at multiple time points throughout at the moment of the experience being assessed in their natural environment.[22] Participants received a notification with a link via WhatsApp from the survey program asking them to indicate their dental status according to the following question: “Which of the following option best describes the contact of your teeth?". Participant had to choose one of the following options: a) My teeth are not touching; b) My teeth are not touching, but I feel my muscles are tense; c) My teeth are lightly touching; d) I am clenching my teeth; or e) I am grinding my teeth.

One day before the start of the study, participants received a training session for information about the study and the assessment tool. Participants were instructed to ignore notifications while eating or talking and to pay attention to awake bruxism behaviors to obtain reliable answers. Participants were also asked to answer the questions within 5 minutes of receiving the alert (valid answer), after which time no responses were recorded by the digital platform. A total of 10 alerts were sent daily at random intervals from 8:00 to 12:00 and from 14:00 to 20:00 , avoiding lunch time. Data were recorded over a one-week period and a minimum of 60% of valid answers were required.[23] No additional recording day was specified to avoid adaptation or fatigue to the EMA. Each participant received an individual code that was used to identify responses retrospectively. After the observation period, the platform provided a pre-formatted Excel file containing all participant responses. Only the researchers had access to these data.

The frequency of awake bruxism was expressed as a percentage in relation to the total number of answered alerts.

Sustained submaximal clenching fatigue test

To perform the sustained submaximal clenching fatigue test, participants sat comfortably on a chair in an upright position directly facing the screen of the bite force transducer equipment. The experiment was divided into three parts: a) pre-fatigue maximal bite force (MBF) test, b) fatigue test, and c) post-fatigue MBF test.[17]

For the assessment of the MBF, a bite force transducer was placed on the first molar of the dominant side of each participant with a customized silicone impression template (Zetalabor, Zhermack®, Italy), shaped to minimize discomfort at the moment of biting and allow the transducer to be placed in the same location in posterior assessments. Bite force was measured in kgf/cm^2 and displayed on a screen so that participants and the clinician would know the bite force values. The transducer was calibrated, disinfected with alcohol, and covered with cellophane film before being used on each participant. Before the measurements, the participants were trained and familiarized with the method:[17]

a. The pre-fatigue test consisted of clenching at MBF for 4 seconds. This test was repeated three times with an interval of 5 minutes between each test. The pre-fatigue MBF (pre-MBF) was defined as the highest value of the three measures. Then, a 10-minute rest were given to all participants before the next step.
b. The fatigue test was based on a sustained submaximal clenching, *i.e.*, 30% of the bite force calculated from the pre-MBF and participants were asked to practice in order to reach this force target. So, participants performed the fatigue test at 30% pre-MBF,[17] controlled by the visual feedback of the bite force value. This phase ended when participants could no longer maintain the target bite force, as indicated by a decrease of > 10% from the target bite force for more than 3 consecutive seconds observed by a clinician. Endurance time (time period) was recorded from the beginning to the end of the fatigue test.[17]
c. The post-fatigue MBF test was carried out immediately after the end of the fatigue test. Participants were asked to perform the post-fatigue MBF (post-MBF), which consisted of clenching at MBF once for 4 seconds. All participants were verbally encouraged during each stage of the task.[17]

According to fatigue test, two variables were considered and calculated for statistical analysis:

a. Endurance time: time (seconds) from the beginning to the end of the sustained submaximal clenching fatigue test;[17]
b. Maximal bite force change: The percentage of change in MBF before and after sustained submaximal clenching fatigue test. This percentage was based on the following equation: $[=\{(\text{pre-MBF}) - (\text{post-MBF})\} / (\text{pre-MBF}) \times 100]$.[17]

Study design

The general schematic representation of the study design is presented in Figure. This includes three stages: a) First day: subject introduction about Ecological Momentary Assessment (EMA) use, b) 7-day period of exposing participants to the EMA to evaluate awake bruxism activities, c) Day after EMA evaluation: determination of masticatory muscle fatigue based on endurance time and percentage of change in maximal bite force as previously described.

Statistical analysis

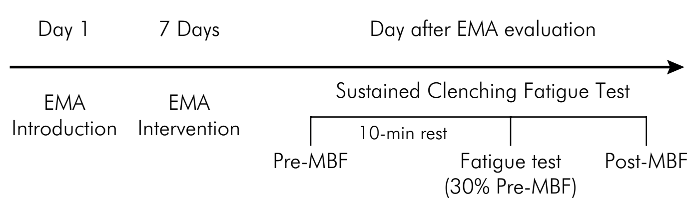
Means and standard deviations (SD) were calculated for age and MBF, and median and interquartile range for endurance time and changes in the MBF. Frequencies of awake bruxism behaviors were calculated as percentages. The Kolmogorov-Smirnov test was used to assess data normality. The independent samples T-test was used for comparison of awake bruxism frequency between sexes (complete and light touching of teeth). The Mann-Whitney test was used to compare differences between sexes for frequency of awake bruxism behaviors, changes in MBF, and endurance time. Data of MBF before and after the muscle fatigue test were compared using the paired T-test for each sex and the total sample. The Spearman correlation coefficient was calculated to determine the strength of the association between the frequency of awake bruxism behaviors (overall and each behavior) and changes in MBF and endurance time to fatigue. All tests were performed at a 5% significance level ($p < 0.05$), and the SPSS version 2.6 software was used for all analyses.

Results

One hundred and fifty graduate students were initially recruited to participated of the study, but 121 (80 females and 41 males; mean age 27.5 ± 3.16 years) completed the 7-day EMA protocol with at least 60% of valid answers.

On average, the frequency of the total AB behaviours over the seven days was 45.5%. Individually, the different activities related to awake bruxism were calculated as follow: "teeth not touching" relaxed jaw muscle, 54.5% (± 26.15), "teeth slightly touching" 29.4% (± 18.30%), "clenching" 9.8% (± 14.10), "teeth not touching, but muscles feel tense" 5.7% (± 11.01), and "grinding" 0.60% (± 2.86) of the total recordings. No significant differences were found between sexes in the frequency of awake bruxism behaviors (p>0.05).

The descriptive data related to measurement of masticatory muscle fatigue, *i.e.*, maximal bite force change and endurance time, were showed in Table 1.



Pre-MBF: pre-fatigue maximum bite force; Post-MBF: post- fatigue maximum bite force.

Figure. Schematic representation of the study design.

Table 1. Data of endurance time and maximum bite force before and after sustained clenching fatigue test.

Variable	Endurance time (s)	Pre-MBF (Kgf/cm²)	Post-MBF (Kgf/cm²)	Change in the MBF (%)
	Median (interquartile range)	Mean SD	Mean SD	Median (interquartile range)
Men (n = 41)	117 (74.5)	46.76 ± 13.76	36.97 ± 12.19*	20.8 (23.5)
Women (n = 80)	105.5 (71)	37.46 ± 10.72	29.65 ± 9.92*	20 (28)
All (n = 121)	109 (72.5)	40.61 ± 12.58	32.13 ± 11.24 *	20 (27.3)

Pre-MBF: Pre-fatigue Maximum bite force; Post-MBF: post- fatigue Maximum bite force; Change in MBF (%) = (pre-MBF) - (post-MBF) divided by (pre-MBF) x 100. Mann-Whitney-test - No significant differences ($p > 0.05$) between sexes for changes in MBF after fatigue test and endurance time. *Paired t-test: Significant difference ($p < 0.05$) between Pre-MBF and Post-MBF in men and women and in total sample.

Table 2. Correlation of AB behaviors (each behavior individually and overall b+c+d+e) and the percentage of change in MBF and endurance time.

AB Behavoiurs	Change in MBF (%)		Endurance time (s)	
	Correlation coefficient (r)	p-value	Correlation coefficient (r)	p-value
b	-0.01	0.91	-0.14	0.10
c	-0.14	0.13	0.13	0.15
d	0.10	0.26	-0.08	0.39
e	-0.0007	0.99	-0.07	0.42
b+c+d+e	-0.15	0.09	-0.008	0.92

AB behaviours: b: I am not touching my teeth, but I feel my muscles are contracted; c: I am slightly touching my teeth; d: I am clenching my teeth; e: I am grinding my teeth. Change in MBF (%) = (pre-MBF) - (post-MBF) divided by (pre-MBF) x 100. *Spearman correlation coefficient ($p < 0.05$).

A significant reduction in maximal bite force (MBF) after the sustained submaximal clenching fatigue test was found for males, females and in the total sample ($p < 0.05$). Men presented higher pre-MBF and post-MBF values compared to women, but no significant differences were found between sexes for percent MBF change and for endurance time from the beginning to the end of the sustained submaximal clenching fatigue test (Table 1).

Correlation coefficients between the frequency of awake bruxism behaviors and masticatory muscle fatigue variables are shown in Table 2. The total frequency or each isolated behavior of awake bruxism did not significantly correlate either with the percentage of maximum bite force change (before and after fatigue test) or with the endurance time ($p > 0.05$).

Discussion

To the best of our knowledge, this is the first study to assess the correlation between the frequency of awake bruxism and masticatory muscle fatigue (endurance time and percentage of MBF change) in healthy young individuals. The main findings showed that the average frequency of awake bruxism during the seven-day follow-up period was 45.5%, with no differences between sexes. Also, MBF decreased significantly after sustained clenching task. Notwithstanding, no significant correlation was found between awake bruxism behaviors and muscle fatigue.

According to current literature, EMA allows real-time data collection at the time of awake bruxism behaviors.[3,21] In the present study, a 7-day protocol was used to avoid participant fatigue and a decrease in frequency of awake bruxism over time due to natural fluctuation and the self-awareness effect caused by EMA[9]. Previous studies reported that high anxiety[24], stress[25] and tasks requiring mental and practical skills[26] increase masseter muscle activity. In general, students have higher stress levels compared to the general population, possibly due to the commitment and challenges of their activities (mental and physical).[27] Other studies have also found a positive and significant correlation between awake bruxism behaviors and psychological factors such as anxiety, depression, and stress in students from a college preparatory.[3] Since our study population was students, it was expected that they had a higher mean frequency of awake bruxism behaviors compared to the general population[28], however comparisons could be difficult since both studies used different methods to assess awake bruxism behaviors. Compared to other studies with students, in which the prevalence of awake bruxism behaviors ranged from 26% to 38.4%,[3,9,21] our results also showed a higher frequency of awake bruxism behaviors, which could be due to the fact that students experience more stress and anxiety after graduation and consequently exhibit more awake bruxism behaviors. Considering the frequency of each oral behavior, the most common in this study was “teeth slightly touching” (29%), followed by "clenching" (9.8%) and "teeth not touching, but muscles feel tense" (5.7%), while "teeth grinding" had the lowest prevalence (0.6%). These results are consistent with other studies and indicate that awake bruxism is not associated with potentially harmful behaviors.[3,9,21]

A significant decrease in MBF was found after the sustained submaximal clenching fatigue test (20% decrease), in accordance with other similar studies.[12-17] The cause of fatigue is complex and not completely clear[29]. However, it has been suggested that the cause of muscle fatigue could be energy depletion and impaired vascular flow, oxygen debt, and accumulation of waste products in the muscle[30]. Moreover, no significant differences were found between sexes in the percent of MBF decrease and endurance time, which may be due to the fact that all volunteers were healthy, and the responses were probably similar. On the other hand, it has been reported that men have a higher perception of fatigue than women after a 30-min fatigue task at 10% MBF[31]; however, since no objective assessment of the data was performed in the aforementioned study, a comparison of these data with our results is not feasible.

To assess the possible influence of awake bruxism on muscle fatigue, we tested the association between the frequency of awake bruxism behaviors and the endurance time and percent MBF change after the fatigue test. Although no association was found, some participants reported awake bruxism in more than 90% of the time. It is known that hemodynamic characteristics and muscle symptoms depend on the magnitude and duration of muscle contractions[32]. Awake bruxism behaviors are characterized by muscle contractions of low intensity [33] and short duration[34], making it difficult to understand how this activity may contribute to potential muscle damage. In addition, "teeth touching slightly" was the most frequent awake bruxism behavior in our study, which may explain in part the lack of association between variables. Also, regular muscle activities are characterized by rest periods between contractions, which allow muscle recovery and prevent muscle fatigue[35]. Additionally, masticatory muscles are originally resistant to fatigue[36] and the occurrence of muscle fatigue depends on the type, duration, and intensity of the exercise[29]. Eccentric muscle movements, which are infrequent in awake bruxism, were more associated with delayed onset of muscle soreness and participants showed increased fatigue levels 24 and 48 hours after experimental eccentric contractions.[37] Therefore, it could be assumed that in our study awake bruxism itself was not capable of fatiguing masticatory muscles, mainly because of its reduced intensity and duration in healthy individuals. This result allows us to classify the awake bruxism found in our studied population as a "normo-bruxism" according to the proposal of Svensson & Lavigne, 2020, since no signs or symptoms (related pain) or any pathological impact on oral and general health was found.[38]

Finally, we suggest that in young healthy adults, masticatory muscles should not be considered more or less susceptible to fatigue based on the frequency of awake bruxism, because the force-producing capacity is not associated with the frequency of awake bruxism, which means that normal muscle activities such as eating, speaking, and swallowing should not be compromised. Likewise, it is important to understand that different factors interact on an individual basis to produce muscle fatigue and that the effects depend on the type and level of muscle activity and the host response[2] which could influence in treatment approach. The present study considered fatigue as a decrease in MBF and endurance time after a sustained clenching task, unlike previous studies that focused mainly on the evaluation of fatigue as a symptom subjectively scored by the participant[31] and found an association between the feeling of fatigue and bracing and thrusting of the mandible.[39] Differences in the methodology, the target of MBF, the population studied, and the criteria of the fatigue test[17] made it difficult to compare our results with other studies. It is important to note that our results cannot be directly extrapolated to individuals with temporomandibular disorders, since they are more sensitive to pain and fatigue,[26] and present awake bruxism behaviors more frequently, for longer periods of time, and with higher intensities.[40]

Some limitations in the present study must be considered. Awake bruxism frequency using EMA is a subjective, self-reported strategy that depends on participant responses; thus, we recommend objective assessments such as electromyography together with a clinical examination, to have a more reliable diagnosis in future studies. Our study included a convenience sample of graduated students, and therefore, the results should not be extrapolated to other populations. The duration and intensity of each awake bruxism behavior were not evaluated in the present study, but these variables could be relevant for different associations of awake bruxism and muscle symptoms. In addition, assessment of other non-painful muscle symptoms should be considered in future studies.

Conclusion

Despite the relatively high frequency of awake bruxism behaviors in healthy graduate students, they do not seem to have an impact on the level of fatigue of masticatory muscles.

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