Original Article

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Effect of classical music and delta-wave music on sleep bruxism: a pilot study

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Objectives: To determine the effects of classical music and delta-wave music on sleep bruxism, stress, and sleep quality.

Materials and Methods: Eighteen pre-clinical dental student volunteers with self-reported sleep bruxism were recruited from the Faculty of Dentistry Mahidol University. Subjects were randomly and equally divided into 3 groups: control, classical music, and delta-wave music. All participants wore T1 BruxChecker during sleep on the 1st and 2nd night and T2 BruxChecker on the 9th and 10th night. During the 3rd to 10th experimental night, subjects in both music groups listened to the assigned music track for 1 hour before bedtime using headphones, while the control group did not listen to any music. All subjects took the Suanprung stress test (SPST-20) and Pittsburgh sleep quality (PSQI) questionnaires before and after the trial period. The peeled area on BruxChecker and scores from both questionnaires were analyzed using the Wilcoxon and Kruskal-Wallis tests.

Results: All experimental groups showed no statistically significant changes in the peeled area on BruxChecker during the trial. There was no statistically significant difference in the peeled area on BruxChecker among all groups. Only the classical music group showed decreasing stress levels after the trial, although not statistically significant. The delta-wave music group revealed almost statistically significant improved sleep quality (*p=0.058*).

Conclusion: Our pilot study is the first experiment to investigate the effect of classical and delta-wave music on sleep bruxism. Although the results are still inconclusive and neither type of music significantly reduced sleep bruxism activity, listening to classical music revealed a tendency toward relieving stress and reducing sleep bruxism, whereas delta-wave music showed a tendency toward sleep quality improvement.

Keywords: brux checker, classical music, delta-wave music, sleep bruxism, sleep quality, stress

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Introduction

Sleep bruxism is a sleep-related movement disorder with masticatory muscle activity that occurs during sleep and can result in clenching or grinding of teeth. In healthy individuals, bruxism can be considered as a risk factor that could lead to several clinical consequences such as tooth wear, restoration fracture, masticatory muscle pain, and TMJ problems [1]. The etiology of sleep bruxism is unclear and multifactorial. Previous studies suggested that bruxism is not associated with malocclusion, occlusal interferences, or any anatomical factors [2] while psychological factors seem to play a significant role as an etiologic factor of sleep bruxism, especially stress and anxiety. Mirela *et al.* observed that sleep bruxism appeared with the presence of stress or anxiety [3]. Recently, the management of sleep bruxism has been mainly to reduce the harmful effects of bruxism which are tooth wear, masticatory muscle pain,

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and temporal headaches [4, 5]. A nighttime occlusal bite guard is widely used as a therapy for sleep bruxism to guide the occlusion and reduce muscle tone. In addition, occlusal adjustment, psychotherapy, medication, and electrical methods can be considered as the management for bruxism as well [6].

The systematic review, by Chemelo *et al.*, found a significant association of bruxism in patients with stress [7], therefore, reducing stress may also reduce sleep bruxism. Monti *et al.*'s study also showed that the effectiveness of psychological treatments represented a significant improvement in reducing distress [8]. There were several alternative treatments for stress such as cognitive-behavioral stress management, yoga, mindfulness-based interventions, massage, and music therapy [9]. The systemic review of De Witte *et al.* in 2020 showed that music interventions could significantly reduce stress in both physiological and psychological outcomes [10]. Most sleep bruxism episodes occur in the light sleep of non-rapid eye movement (NREM) stage [11]. Since music helps improve sleep quality by inducing rapid eye movement (REM) [12] and prolonging deep sleep duration of NREM [13], hence listening to music may shorten the NREM and reduce the duration of sleep bruxism episodes. Recently, classical music has been proven useful primarily for relieving stress and anxiety. Classical music affects body relaxation through the autonomic nervous system and emotional improvement via dopamine release [14]. Delta-wave music has been applied to treat sleep disorders. Delta-wave music (0.5-4Hz) is binaural beat music with a frequency similar to slow-wave sleep (SWS) brainwaves [12]. Enhancing delta activity in the brain with delta binaural beats can improve sleep quality by reducing anxiety and inducing a calm state [15]. As a role in stress reduction and sleep improvement, music could possibly serve as an alternative way to reduce bruxism. Therefore, our quasi-experimental study aims to determine the effects of music on sleep bruxism (primary outcome), stress, and sleep quality (secondary outcomes). The study was approved by the Human Research Ethics at the Faculty of Dentistry and Faculty of Pharmacy Mahidol University No. MU-DT/PY-IRB 2022/053.1010.

Materials and Methods

Twenty subjects/volunteers were recruited from the Faculty of Dentistry Mahidol University, pre-clinical undergraduate dental students. Inclusion criteria included at least 18 years old with intact permanent dental arches, good occlusal stability, and self-reported sleep bruxism. Exclusion criteria included temporomandibular disorders, pain complaints, systemic problems such as hearing problems, neurological disorders, autoimmune disease, diabetes mellitus, psychiatric disorders, undergoing orthodontic treatment, taking any medication or supplements that affect sleep, pregnancy, regular alcohol consumption, and smoking habits.

Two participants dropped out due to inability to follow the experimental procedure, resulting in 18 subjects: 15 women and 5 men. Participants are prohibited from consuming alcoholic beverages during the trial period and no caffeine beverage at least 6 hours before sleep [16]. Female participants were instructed to commence the experiment 14 days after the first day of the menstrual period to avoid the effects of high estrogen levels [17, 18]. The informed consents were signed. Two custom-made bruxcore plates (BruxChecker®, Scheu-Dental) [19-21] were constructed for each subject to evaluate bruxism activity (Figure 1a).

Participants were randomly assigned into 3 equal groups: The control group, not listening to any music; the Classical music group, listening to classical music; and the Delta-wave music group, listening to delta-wave music, during sleep on experimental nights. The trial period was individually arranged according to their convenience. Before the experiment (T1), all participants completed the Suanprung stress test (SPST-20) [22] and the Thai version of the Pittsburgh Sleep Quality Index (PSQI) [23, 24] questionnaires to evaluate stress and sleep quality. Assigned music MP3 files were given to individuals in both music groups. During the experimental nights, their mobile phones were switched to airplane mode to avoid disturbances from WIFI and cellular signals. The MP3 music playlist was played for 1 hour prior to bedtime, using in-ear headphones at 30-40 decibels, with passive listening or calm activites.

On the pre-experimental, the 1st and 2nd nights, all participants only wore T1 BruxChecker during sleep. During the experimental period, the 3rd to 8th night, all subjects did not wear any BruxChecker but did listen or not listen to the given music playlist, following their assigned group. On post-experimental the 9th and 10th night, all subjects wore T2 BruxChecker and continued with their assigned music condition. After all experimental nights, all participants completed SPST-20 and PSQI questionnaires again at T2. The experimental timeline is shown in Figure 2. The ImageJ program was used to measure the peeled area on BruxCheckers. The photos of each BruxChecker were captured at the same time, using the same camera angle, and in the same environment to control light conditions and decrease errors (Figure 1b). The SPST-20 and PSQI questionnaires were scored and interpreted.

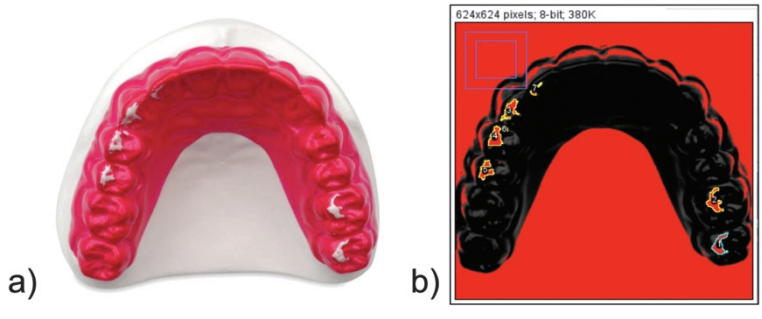


Figure 1 (a) The custom-made BruxChecker was used for sleep bruxism activity evaluation. (b) The ImageJ program measured the peeled area on BruxChecker.

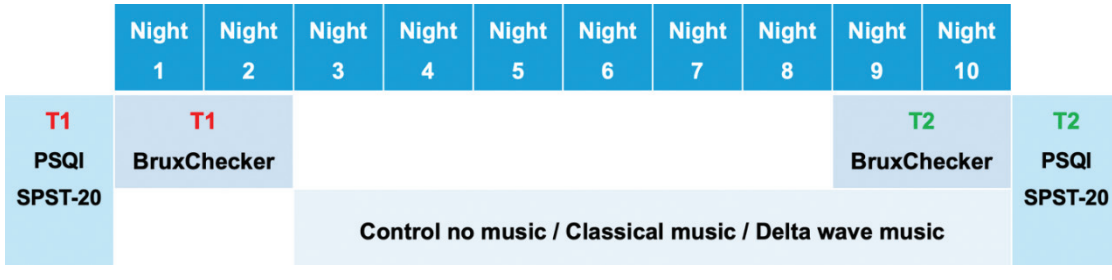


Figure 2 The experimental timeline.

Statistical analysis

The Shapiro-Wilk normality test indicated that the data deviated from a normal distribution due to the small sample size in each group (n=6). The peeled areas on BruxChecker, SPST-20 scores, and PSQI scores were statistically analyzed using SPSS version 18.0 software with a 95% confidence level. Wilcoxon signed-rank test was used to compare the median of T1 and T2 data of each group. Kruskal-Wallis H test was performed to compare the median differences between T1 and T2 data among all experimental groups.

Results

At T1, there is no statically significant difference in the peeled area on Bruxchecker, SPST-20 score, and PSQI score among 3 experimental groups ($p>0.05$). Individual data of T1 and T2 peeled area on BruxChecker, SPST-20 score, and PSQI score are analyzed. 33.3% of subjects in both the control group and the delta-wave music group showed a decrease in the peeled area on BruxChecker, while 66.67% had no reduction in the peeled area. The number of subjects with decreased peeled areas was 50.0% in the classical music group. For the SPST-20, 33.33% of subjects in the control group showed a reduced stress score, and 66.67% did not. The number of subjects with decreased stress scores in the classical music group was 50.0%. In the delta-wave music group, subjects 66.67% exhibited a reduction in the SPST-20 score, while 33.33% showed an increase. For sleep quality, the number of participants in the control and classical music groups who had a decrease and no decrease in PSQI global score were equal (50%). In the delta-wave music group, 83.33% of participants had a reduced PSQI global score, and 16.67% did not.

Due to the small sample size in each experimental group, a median was used to compare between before (T1) and after (T2) experiment data. Tables 1, 2, and 3 demonstrated that there are no statistically significant differences between T1 and T2 data of peeled area on BruxChecker, SPST-20 score, and PSQI score in all 3 groups. However, in the delta-wave music group, the median T2 PSQI score was almost significantly lower than the T1 PSQI score with p-value=0.058.

The comparison of changes (decrease or increase) of data, between before (T1) and after experiment (T2), among control, classical music, and delta-wave music groups are provided in Table 4. There is no statistically significant difference of changes between T1 and T2 data of peeled area on BruxChecker, SPST-20 score, and PSQI sleep quality score among all experimental groups.

Table 1 The median of peeled area on BruxChecker before (T1) and after experiment (T2). (Wilcoxon test, $p<0.05$)

Group	Peeled area on BruxChecker: Median (Q1,Q3)		
	T1 (mm^2)	T2 (mm^2)	*p-value*
Control (n=6)	122.5 (98.8,209.5)	119.5 (104.7, 163.8)	0.686
Classical music (n=6)	139.5 (90.9, 215)	151.5 (73.8, 226.3)	1.000
Delta-wave music (n=6)	188.5 (108.7, 233)	194.5 (111, 262.8)	0.248

Table 2 The median of stress score from Suanprung stress test (SPST-20) before (T1) and after experiment (T2). (Wilcoxon test, $p<0.05$)

Group	SPST-20 score: Median (Q1,Q3)		
	T1	T2	*p-value*
Control (n=6)	30 (28.8, 53)	41.5 (31.8, 46)	0.462
Classical music (n=6)	45.5 (36.8, 57)	43.5 (35.8, 54)	0.753
Delta-wave music (n=6)	35.5 (23.8, 71)	36.5 (28, 56.5)	0.400

Table 3 The median of sleep quality score from Pittsburgh sleep quality index (PSQI) before (T1) and after experiment (T2). (Wilcoxon test, $p<0.05$)

Group	PSQI score: Median (Q1,Q3)		
	T1	T2	*p-value*
Control (n=6)	6 (4.8, 6.3)	5 (4.8,9.8)	0.684
Classical music (n=6)	5.5 (5, 6.3)	6 (4.8,8)	0.595
Delta-wave music (n=6)	7 (4.3,10)	5 (2.8,6.5)	0.058

Table 4 Median differences between before (T1) and after experiment (T2) of peeled area on BruxChecker, SPST-20 score, and PSQI score. (Kruskal-Wallis test, $p<0.05$)

	Group	Median difference T2-T1	*p-value*
Peeled area on BruxChecker	Control (n=6)	-3.00	0.481
	Classical music (n=6)	12.00	
	Delta-wave music (n=6)	6.00	
SPST-20 score	Control (n=6)	11.5	0.716
	Classical music (n=6)	-2.0	
	Delta-wave music (n=6)	1.0	
PSQI score	Control (n=6)	-1	0.135
	Classical music (n=6)	0.5	
	Delta-wave music (n=6)	-2	

Discussion

The present study anticipated that music possibly has positive effects on reducing sleep bruxism and stress; and promoting sleep quality. Sleeping music used in the treatment of sleeping disorders usually has a slower tempo around 60-80 beats per minute (BPM) [25] to sync up with the resting heartbeat (60-100 BPM) [26]. The sound volume under 40 decibels is considered appropriate for sleeping music [27]. As the brain responds to two different frequencies (binaural beats) presented to each ear at once, it results in the perception of the difference in frequency. For instance, listening to 400 hertz tones in the left ear and 404 hertz in the right ear, the binaural beat is 4 hertz. Hence, binaural beats can be heard only when using headphones [28]. Previous studies showed that listening to relaxing music for 15 minutes can reduce blood pressure and heart rate [29], and 30 minutes of music therapy a day resulted in lower anxiety and stress by decreasing human stress responses such as heart rate and cortisol level [30]. Listening to music 45 minutes before bedtime also improves sleep quality [31]. Our study utilized a 1-hour music listening session before bedtime, using in-ear headphones at 30-40 decibels.

The peeled area on BruxChecker

BruxChecker is a bruxcore bruxism monitoring device (BBMD) made from 0.1 mm biocompatible color-coated polyvinyl chloride (PVC) foil that facilitates the recording of bruxism activity. It enables the visualization of static and dynamic occlusal tooth contacts associated with sleep bruxism [19, 20]. The bruxcore plate measurement had low or no correlations with EMG data of bruxism activity [32]. BruxChecker is typically worn in the maxillary jaw for 2 consecutive nights [20], and should definitively indicate a current sleep bruxism habit [33]. A recent Thai study reported that BruxChecker had a sensitivity of 90.9% after two consecutive nights [21]. Our study used a peeled area on the bruxchecker worn for two nights to evaluate the effect of music on sleep bruxism and found no statistically significant changes in bruxism activity, both in classical music and delta-wave music groups. The classical music group showed more tendency toward reduced bruxism activity; 50% of subjects showed decreased peeled area on BruxChecker compared to 33.3% in delta-wave music and control groups. The subjects from the classical music group also gave positive feedback on the music track's musicality and relaxation. The result might be related to individual perceptions of character and emotion of the music and individual stress conditions during the experiment. The delta-wave music group tended to have a more unfavorable effect than the other groups, with 66.7% of its subjects having increased peeled area on BruxChecker. This result might be the effect of unfamiliar soundwaves interrupting the initial sleep phase. Some participants in the delta-wave music group reported discomfort while trying to sleep due to sound disturbance. According to previous studies, delta-wave music significantly promoted deep sleep [12, 34], and relaxation by reducing anxiety and inducing a calm state [15]. Another study reported that delta-wave music therapy with slow 0.8-Hz frequency rhythmic acoustic stimulation leads to a distinct delay in the onset of sleep, but once sleep was established, 0.8-Hz stimulation significantly increased and entrained endogenous slow oscillation activity of the brain [35]. Thus, delta-wave music could be played during the sleeping stage to promote deep sleep by affecting the slow-wave sleep. BruxChecker is not considered the gold-standard diagnostic tool for evaluating

sleep bruxism but rather the sleep study with polysomnographic (PSG) record. Furthermore, the easily peel-off surface of BruxChecker and its technical sensitivity may lead to a false positive in our peeled area data. In our study, PSG is not a practical method due to budget, time limit, and the first night effect. Therefore, BruxChecker was used instead to evaluate sleep bruxism activity, especially in sleep bruxism with teeth clenching and grinding habits. Using BruxChecker in our experiment may not be able to evaluate the rhythmic masticatory muscular activity (RMMA) that occurred without occlusal tooth contact.

Stress evaluation

In this study, all subjects were pre-clinical undergraduate dental students, so it may be assumed that all participants were under the same stress environment. However, the perception of stress varies among individuals and cannot be controlled. Previous studies suggested that high stress among dental students [36] may result in adverse effects such as poor study performance and sleep quality, including sleep bruxism [37]. Our study used the Suanprung Stress Test (SPST-20), a Thai questionnaire purposely constructed by the Department of Mental Health Ministry of Public Health to assess stress levels in Thai people [22]. SPST-20 mainly measures sensitivity or responsiveness to stress, causes of stress, and reactions or symptoms of stress. Most questions were designed to be appropriate for Thai lifestyle and culture. Although our study found no statistically significant difference in stress reduction between the 3 groups, classical and delta-wave music groups tended to have better stress control. The control group had obviously increased stress scores after the experiment, but both music groups showed slightly reduced (classical music) or nearly unchanged scores (delta-wave music). This could imply that both types of music may have positive influences in relieving stress.

Sleep quality evaluation

According to PSQI global score interpretation, the lower the score the better sleep quality [23, 24]. Our statistical analysis of the PSQI questionnaire revealed that in a delta-wave music group, the post-experiment PSQI score was almost statistically significantly lower than the pre-experiment score (p-value=0.058), with 5 subjects out of 6 showed decreased PSQI score after trial. This result may imply that delta-wave music promotes sleep quality, supporting previous studies [12, 15]. Music plays an essential role in increasing deep sleep and decreasing anxiety by reducing sympathetic nervous system activity and helping induce quicker autonomic recovery of the parasympathetic branch of the ANS [38]. Listening to music before bedtime resulted in less sleep onset time, better sleep efficiency, better sleep quality, fewer sleep disturbances, and fewer nocturnal awakenings, measured with a questionnaire [31, 39]. However, we found that some subjects with improved sleep quality also exhibited increased peeled areas on BruChecker. Further study should investigate the relation of sleep bruxism and each PSQI component such as sleep latency, sleep duration, and sleep-related breathing disorders.

Since the etiology of sleep bruxism is believed to be multifactorial, stress and sleep quality are among the factors that affect it. Our obsecured result may caused by confounding variables such as individual perception of character and emotion of music, coping strategies to stress [40], individual personality, and demographic background [41], therefore future crossover study may be more beneficial than a parallel design.

Moreover, the evaluation of stress and sleep quality may have been affected due to the time limitation of this study. In our research, SPST-20 and PSQI were used in 10 days instead of the usual 6-month and 1-month period. Thus, SPST-20 and PSQI scores might not significantly change with the shorter evaluation period. Additionally, each participant did not start the experiment simultaneously, and there were other limitations, such as variations in individual stress levels and sleeping times. Our study also had a small sample size of 18 participants. Future studies should consider recruiting a larger sample size and conducting experiments over a more extended period.

Conclusion

Our pilot study is the first experiment to investigate the effect of classical and delta-wave music on sleep bruxism. Although the results are still inconclusive and neither type of music significantly reduced sleep bruxism activity, listening to classical music revealed a tendency toward relieving stress and decreasing sleep bruxism, whereas listening to delta-wave music showed a tendency toward improving sleep quality.

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