Original Research

The Effectiveness of Alpha Binaural Beats in Reducing Stress and Rumination and Promoting Sleep Quality in University Students with Poor Sleep Quality

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Abstract

Background and Objective: Binaural beats are a novel type of non-invasive interventions. The present research aimed at assessing the effectiveness of alpha binaural beats in reducing stress, and rumination and promoting sleep quality in students with poor sleep quality.

Materials and Methods: This study was a randomized controlled trial in which the statistical population included all university students with poor sleep quality in Mashhad, Iran, in 2020. According to inclusion criteria and ethical considerations, 24 students (12 women and 12 men) took part in this study. To reach the study objectives, the experimental group (12 students) received alpha binaural beats (10 Hz) for 30 minutes for 30 nights, and the control group (12 students) was on the waiting list. The research instruments consisted of the Pittsburgh Sleep Quality Index (PSQI), Ruminative Response Scale (RRS), and Perceived Stress Scale (PSS).

Results: Based on demographic variables, there was no significant difference for age and gender between control and experimental groups ($P > 0.05$). Binary logistic regression analysis was performed and showed that alpha binaural beat intervention could have a protective effect on the variables of sleep quality [odds ratio (OR) = 0.77, $P < 0.0001$], rumination (OR = 0.85, $P < 0.0001$), and stress (OR = 0.69, $P < 0.0001$).

Conclusion: Alpha binaural beats play an effective role in reducing perceived stress and rumination and improving sleep quality in students. The present study proposed a novel non-invasive intervention for psychological disorders.

Keywords: Atrial premature complexes; Dichotic listening tests; Rumination syndrome; Sleep; Students

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Introduction

University students are exposed to many stressors in their daily lives that lead to a variety of psychological disorders (1). These problems strengthen each other in an imperfect cycle, thereby failing in school, prone to substance abuse, and interpersonal relationships (2). One of the problems is poor sleep quality, which is one of the most common mental health problems of college students (3). Becker et al. studied the prevalence of sleep disorders among students from several colleges and concluded that 62% of students suffered from poor sleep quality (4). In Iran, a meta-analysis found that about 56% of college students had poor sleep quality (5). Many studies have also reported shorter sleep times for college students, difficulty falling asleep, nightmares, and reduced daily productivity (6). Thorsteinsson et al. in a nonclinical sample investigated the association between the severity of stress symptoms, ruminating anxiety and depression, and sleep quality. According to their proposed model, rumination enhances the relationship between stress and poor sleep quality with mental illness (7). Rumination is defined as a type of maladapted and passive emotional regulation that focuses a person on the causes and consequences of a destructive experi-

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ence (7). Previous studies have also emphasized the link between rumination and other mental disorders (8). Rumination before bedtime adversely affects sleep quality, and poor sleep quality results in more frequent ruminations (9). Symptoms emphasize the need for psychological intervention to reduce mental illness and increase student potential.

A large number of interventions, including rumination-focused cognitive-behavioral therapy (10), mindful intervention (11), and compassion-focused therapy (12) have been proposed to reduce experienced stress, decrease rumination, and promote sleep quality among university students, and consequently, a variety of findings have been achieved. The interventions have been associated with a variety of outcomes, some of which have had only a short-term effect (13). One of the most recent interventions is to affect individuals' brain wave patterns (14), one of which is binaural beats (15).

Binaural beats are the illusion of changing brain waves according to the frequency of beats in a specific range (16). Binaural beats are created when the two tones reach each ear at slightly different frequencies (for example, the 250 Hz right ear and the 270 Hz left ear) the frequency between two ears is equal (10Hz). Thus, the electroencephalography (EEG) pattern is maintained by a specific frequency difference between the two audible tones (binaural beats). The effect of binaural beats depends on the frequency and range of the delta, theta, alpha, and beta waves. Previous studies have documented that alpha binaural beats can be used for quiet attention and relaxation (17). According to Gupta et al., alpha binaural beats can be used for meditation (18). Jurvanen also found in his study that the combination of alpha and theta domains might contribute to relaxation and meditation in non-clinical populations (19). Abeln et al. investigating the effect of binaural beats on the subjective sleep quality of athletes and their mental and physical condition (binaural beats of about 2-8 Hz in 8 weeks) that found a significant increase in motivation for improved group (20).

A review of the research literature indicates that binaural beats were effective in clinical and nonclinical populations. However, no studies have investigated the effects of binaural alpha beats on the psychological characteristics of college students, especially the rumination of students suffering from poor sleep quality. Accordingly, the current research aimed at assessing the effectiveness of alpha binaural beats on decreasing stress and rumination, and improving sleep quality in students with poor sleep quality.

Materials and Methods

Participants: This study was a randomized controlled trial (with experimental and control groups). The study's statistical population included all students with poor sleep quality, who were enrolled at Ferdowsi University in Mashhad, Iran. Through an academic announcement, students with symptoms of poor sleep quality were invited to participate in the study. According to the inclusion and exclusion criteria, 24 students with poor sleep quality (12 women and 12 men) studying at Ferdowsi University of Mashhad were included in the study. Inclusion criteria were informed consent, poor sleep quality [Pittsburgh Sleep Quality Index (PSQI) ≥ 6], not suffering from severe psychiatric and neurological disorders, no alcohol and substance abuse according to the clinical interview by the first researcher (an MA student of psychology), normal hearing status based on the participant's comments, no cardiovascular problems, and no pregnancy. Exclusion criteria were unwillingness to pursue the research due to personal reasons, feeling discomfort from hearing binaural beats, taking drugs or substances after the intervention, and not implementing the intervention protocol for more than two days a month (total length of the intervention). The participants were randomly assigned into control (n = 12) and experimental (n = 12) groups (Figure 1) by picking up the red (i.e., the control group) and blue (i.e., the experimental group) balls from a bag.

Intervention protocol: There was a pre-test after the participants were divided into groups. Students in the experimental group after going to bed and placing in a right position, including a calm and suitable atmosphere for sleeping, moderate room temperature (24˚ Celsius), and closing eyes during the binaural beats play, listened to alpha binaural beats for 30 minutes at 22:00 pm for 30 nights to sleep in their room. Each night, around 21:30, the participants were reminded of bedtime by text messages. The alpha binaural beat in this study was developed by Audacity Software (http://www.audacityteam.org) and provided via standard headphones (21). The frequencies sent to the left and right ears were 250 and 260 Hz, respectively, and the binaural effect of the 10-Hz beat (alpha domain) was investigated.

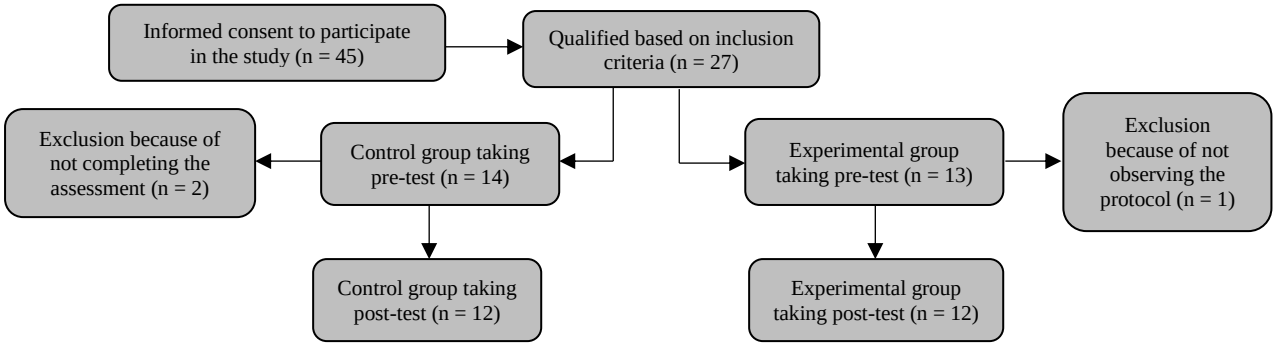

Figure 1. Participants in pre-test and post-test phases

No binaural beat intervention was received by the control group (waiting list). The two groups experienced the same conditions in other cases.

Research instruments

PSQI: This index was applied for evaluating sleep quality and patterns over the last month. It discriminates between "good" and "poor" sleepers by using 19 questions and seven components. Each item is scored between 0 and 3, with the maximum score of 3 for each component. The sum of the scores of the seven components presents the total score ranging between 0 to 21, with a score of ≥ 6 indicating poor sleep quality (22). Using Cronbach's alpha, the validity of the PSQI was estimated to be 0.8; moreover, its test-retest reliability was reported to range from 0.93 to 0.98 (23). The values have been used in several studies, indicating the high reliability and validity of the instrument (24).

Ruminative Response Scale (RRS): Nolen-Hoeksema and Morrow in 1991 (25) developed this 22-item scale, scoring from 1 (almost never) to 4 (almost always). It is a self-report scale on one's reactions to depression, symptoms, possible causes, and consequences (26). Using internal consistency method (Cronbach's alpha), Treynor et al. reported the validity of this scale and its subscales (this scale has three name (Note. R = Reflection; B = Brooding; D = Depression-Related) to be 0.85, 0.80, and 0.76, respectively (27). They also confirmed the acceptable internal validity and high predictive validity of this scale (27). The Persian version of the questionnaire also revealed acceptable internal consistency and test-retest reliability (28).

Perceived Stress Scale (PSS): Cohen et al. developed this scale. It encompasses 14 items scored on the basis of a five-point Likert scale in the range between 0 to 4, which assess one's global stress over the last month. This questionnaire assesses thoughts and feelings about stressful life events, control, domination, and coping with psychological pressure and experienced stress (29). The internal consistency of this scale was about 0.74 (29). In Iran, the reliability of this questionnaire was about 0.76, indicating the acceptable validity of the instrument (30).

Statistical analysis: SPSS software (version 24, IBM Corporation, Armonk, NY, USA) was applied for data analysis. Kolmogorov-Smirnov test was used to test the normality assumption. Binary logistic regression analysis was performed using the "Enter" method to identify the effect of the intervention on the variables of sleep quality, rumination, and perceived stress.

Ethical considerations: Participants were informed of the study process and details and completed informed consent forms. They were also assured of the security of their personal information. After completing the study, the control group received the same intervention (alpha binaural beats). If needed and required, participants in the trial group continued to receive individual interventions after the study ended. The Ethics Committee of Islamic Azad University, Neyshabur Branch, Neyshabur, Iran, approved this study (IR.IAU.NEYSHABUR.REC.1399.028).

Results

The mean and standard deviation (SD) of the age and sleep quality of all participants in the research were 24.14 ± 3.01 and 7.02 ± 1.61, respectively. Table 1 compares the demographic characteristics and severity of sleep quality (used for primary screening of students for diagnostic interview) of the university students in the control and experimental groups. As given in this table, no significant difference was observed between the groups concerning gender, age, and sleep quality ($P > 0.05$).

Table 1. Comparison of demographic characteristics and sleep quality of students

Parameters	Experimental group	Control group	P-value
Age (year)			
Men	25.07 ± 3.15	24.97 ± 3.24	0.09
Women	23.26 ± 3.16	23.19 ± 3.32	0.11
Total	24.15 ± 3.11	24.07 ± 3.22	0.11
Gender			> 0.99
Men	6 (50)	6 (50)	
Women	6 (50)	6 (50)	
Sleep quality	7.12 ± 1.44	6.98 ± 1.69	0.22

Data are presented as mean ± standard deviation (SD) or number and percent

The mean and SD of the concerned variables in the experimental and control groups are presented in table 2, according to which the mean of sleep quality (pretest = 7.12 ± 1.44, post-test = 5.39 ± 1.31, P < 0.001), rumination (pretest = 46.83 ± 15.67, posttest = 33.91 ± 12.58, P < 0.001), and perceived stress (pretest = 31.16 ± 11.02, post-test = 21.01 ± 9.82, P < 0.001) decreased in the experimental group (comparing pretest and posttest scores based on paired t-test); however, only the mean of sleep quality decreased in the control group that was not significant either (P > 0.05).

As shown in table 3, binary logistic regression analysis performed in table 3 showed that alpha binaural beat intervention could have a protective effect on the variables of sleep quality [odds ratio (OR) = 0.77, P < 0.0001], rumination (OR = 0.85, P < 0.0001), and stress (OR = 0.69, P < 0.0001).

Discussion

This research evaluated the effectiveness of alpha binaural beats on reducing stress and rumination and promoting sleep quality in students with poor sleep quality. The study findings revealed that alpha binaural beats could be significantly effective in reducing stress and rumination and improving the quality of sleep among university students.

The findings of some studies in the literature are consistent with those of the present study. Gupta et al. carried out a study to examine the significant changes in the alpha brain waves caused by meditation. To this end, they played 10-Hz binaural music for 10 individuals while recording their brain waves (EEG). They found out that alpha binaural beats led to brain relaxation by inducing a specific frequency in the range of 8-10 Hz (reducing the frequency of the waves); hence, it can be used as an effective intervention to control the brain by making the brain oscillate at certain frequencies (18). In Italy, Casciaro et al. regarded alpha binaural beats to be effective in changing individuals' heart beats (31). In a qualitative study, Jurvanen found the use of alpha and theta binaural beats to be effective for relaxation and meditation and recommended future researchers to delve into the effectiveness of these frequencies on stress and psychological disturbances (19). Since these factors influence the perceived daily stress (32), the use of alpha binaural beats seems to control this uncompleted cycle.

Abeln et al. examined the effect of combined binaural beats (2-8 Hz) on German athletes and concluded that two months of intervention could improve the mental quality of sleep (20). The effect of other binaural beat frequencies on sleep patterns has also been documented in some studies (33, 34). No study on binaural beats and rumination was found; however, the relationship between perceived stress and rumination has been repeatedly addressed in many studies. The previous studies have also associated reduced rumination with a decrease in perceived stress (35). A study was conducted by Cook et al. to assess the effectiveness of rumination-focused cognitive-behavioral therapy on stress and depression in university students. They concluded that the intervention could decrease perceived stress and depressive symptoms among students by reducing rumination (10).

Table 2. Mean and standard deviation (SD) of pre-test and post-test scores for sleep quality, rumination, and perceived stress in both groups of experimental and control

Variables	Experimental group			Control group		
	Pretest	Posttest	P-value	Pretest	Posttest	P-value
Sleep quality	7.12 ± 1.44	5.39 ± 1.31	< 0.001	6.98 ± 1.69	6.71 ± 1.71	0.080
Rumination	46.83 ± 15.67	33.91 ± 12.58	< 0.001	41.08 ± 17.99	42.08 ± 17.80	0.150
Stress	31.16 ± 11.02	21.01 ± 9.82	< 0.001	33.50 ± 13.31	35.83 ± 12.44	0.200

Table 3. Binary logistic regression analysis

Variable	B	SE	Wald	df	P-value	OR (95% CI)
Sleep quality	-0.23	0.13	30.74	1	< 0.001	0.77 (0.71-0.81)
Rumination	-0.18	0.22	33.16	1	< 0.001	0.85 (0.78-0.95)
Stress	-0.31	0.19	90.07	1	< 0.001	0.69 (0.64-0.77)

OR: Odds ratio; CI: Confidence interval; df: Degree of freedom; SE: Standard error

Putnam and McSweeney attributed the changes in the alpha activity of the peripheral region to depressive symptoms, stress intensity, and rumination (36). Few studies have challenged the efficiency and impact of binaural beats, e.g., Lopez-Caballero and Escera (37) and Bang et al. (38) studies. In these studies, different variables such as the intervention protocol, statistical population, psychiatric symptoms of research participants, and target variables might explain the research findings.

Brainwave activity set to an alpha rhythm is associated with relaxation and calm (39). By selecting binaural rhythms with alpha wave patterns, the researchers sought to induce a relaxed and calm psychological state and observe the severity of tinnitus, anxiety, depression, and arousal was affected or not. Some researchers have attempted to link alpha activity to physiological arousal. Alpha rhythms are most evident when the subject is awake, eyes closed, and relatively relaxed. Alpha rhythms tends to disappear or diminish when the subject is mentally focused or physically active or when becomes tense, apprehensive, or anxious (39). It is, therefore, described as occupying an intermediate position in the neural activation process continuum from deep sleep to a state of intense emotional arousal as described by wakefulness theory (40). The mechanism of action for alpha binaural beats is such that they make the brain change the frequency of its waves in the frequency range of the presented beat (41). Given that, depending on the type of activity and the existing stress intensity, each individual's brain has a certain frequency range during a day (42); entertainment can affect brain function. As it was mentioned, an increase in the density of alpha waves is associated with calm, attention and relaxation, thereby reducing perceived stress. The findings of the present study can be justified, since stress reduction is considered to be associated with improving rumination and sleep quality (10).

Limitations: The limitations of this study are not using objective data collection methods such as polysomnography, functional magnetic resonance imaging (fMRI), EEG, and so on, relying exclusively on clinical interviews by a psychologist, and including small sample size. Future researchers are recommended.

Conclusion

Given the limitations of the study, alpha binaural beats seem to be effective in reducing perceived stress and rumination and improving university students' quality of sleep. This finding exhibits the effect of a novel and effective intervention on university students' poor sleep quality cycle.

Conflict of Interests

Authors have no conflict of interests.

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