Original Article

Effect of music of specific frequency upon the sleep architecture and electroencephalographic pattern of individuals with delayed sleep latency: A daytime nap study

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Abstract

Introduction: Sleep is normal human behaviour. However, the stress in daily life leads to altered sleep behaviour like insomnia, parasomnia, etc. Owing to possible side effects, mind–body interventions like music, yoga and meditation could be a better alternative intervention to pharmacological interventions for the condition. It is known that 432 Hz music to have some effect on the overall sleep quality though some knowledge gap does exist. The present study aims to find the effects of 432 Hz on sleep quality and sleep latency in a daytime nap among subjects with history of delayed sleep latency. **Material and Method:** Fifteen healthy male volunteers aged 18 to 40 years with history of delayed sleep latency were recruited for the study from a cohort of working staff and students at the institute, after due ethical clearance following the inclusion and exclusion criteria. All the subjects were subjected to sleep study with and without music intervention at the gap of 1 week. Sleep parameters recorded include sleep stages, electroencephalogram (EEG), electrocardiogram (ECG), electromyography (EMG), nasal airflow, thoracic movement, nasal saturation etc. **Result:** Outcome of the study shows some decrease in the mean sleep latency ($P > 0.05$) with significant increase in the energy of alpha waves ($P < 0.01$) at the sleep onset. **Conclusion:** It was concluded that 432 Hz music has some significant calming effect as reflected by increased alpha activities without any significant effect upon the sleep latency in the daytime naps.

Keywords: 432 Hz music, Alpha energy, daytime nap, sleep latency

Introduction

Sleep is a normal and essential human behaviour. However, many research studies show abnormal sleep patterns or sleep disorders among older subjects and sleep workers.[1] Sleep disorders may result in fatigue, tiredness, depression and problems in daytime functioning. In patients of cardiovascular disorders (CVDs), respiratory disorders and metabolic disorders, chronic sleep disorders are common.[2,3]

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It has been found from population-based studies that approximately 30% of the adult samples drawn from different countries report one or more of the symptoms of insomnia like difficulty initiating sleep, difficulty maintaining sleep, waking up too early or non-restorative or poor quality of sleep.[4]

Pharmacological treatment to overcome sleep disorders are used widely, but their use is limited by side effects and long-term intervention.[5] As sleep is affected by both physiological and psychological factors, many researchers tried to explore effect of mind–body intervention like music on sleep.[1] Music has been found to decrease sympathetic nervous system activity; reduce anxiety, blood pressure (BP), heart and respiratory rate and has

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positive effects on sleep via muscle relaxation and distraction from thoughts. Music has been a part of meditation since ancient times. Certain records mention use of 432 Hz music as very beneficial tone for inducing sleep. Musicians describe it by words like correct and peaceful tone. However, no previous study in my knowledge has proven effect of 432 Hz music on sleep pattern.

Mind–body interventions use a variety of techniques designed to increase the mind's capacity to affect bodily function and symptoms. These include meditation, prayer, mental healing and therapies that use creative outlets, such as art, music or dance.[6]

Few studies have focused on the effects of music, as a non-pharmacological method of improving the quality of sleep in older adults. A study (Lai *et al.*, 2005) investigated the effects of soft music on sleep quality in older community in Taiwan. It found the use of soothing music as an empirically based intervention for sleep in older people.[7]

Harmat *et al.* (2008) investigated the effects of music on sleep quality in young participants with poor sleep. It states that sleep disorders may result in fatigue, tiredness, depression and problems in daytime functioning.[8] Hernández (2005) explored the effect of a music therapy procedure (music listening paired with progressive muscle relaxation [PMR]) on the reduction of anxiety and improvement of sleep patterns in abused women in shelters. It indicated that music therapy constituted an effective method for reducing anxiety levels and improving sleep quality.[9] A study by Choi (2010) examined the effects of music and PMR on anxiety, fatigue, and improvement of quality of life (QoL) in family caregivers.[10]

Music therapy is a method, which takes the advantage of therapeutic influence of music on psychological and somatic sphere of the human body. It has a modifying influence on vegetative, circulatory, respiratory and endocrine systems. Music show reduced psychopathologic symptoms (anxiety and depression), improves self-rating, influences quality and disorders of sleep, reduces pain and improves patients' openness, readiness and co-operation in treatment process. Music therapy is a conventional treatment and makes up part of an integral whole together with physiotherapy, kinesiotherapy and recuperation.[11]

Aim and Objectives

This study aims to study the effect of 432 Hz music on sleep pattern and sleep latency in the subjects with increased sleep latency. Objectives are to find association between 432 Hz music and different sleep study parameters like Sleep stages, EEG, ECG, EMG, nasal airflow, thoracic movement and oxygen saturation.

Hypothesis

Playing 432 Hz music for 15 to 20 min before sleeping induces sleep and increases deep sleep phase (Stage 3 and 4).

Material and Methods

The study was conducted in sleep lab in department of physiology of All India Institute of Medical Sciences (AIIMS), Patna after taking ethical clearance from the institutional ethics committee. Twenty-five apparently normal healthy male subjects, aged 18 to 40 years were recruited for the study initially after written informed consent but only 15 subjects could complete the study successfully. Subjects were seen to be spending maximum time in non-REM (NREM) sleep. Most of the subjects achieved N2 stage of sleep, both with music and without music. Many did not achieve REM stage and deep sleep. Therefore, the subjects achieving N2 stage in both studies (polysomnography with music and polysomnography without music) were included in the study and others were excluded. Subjects included in the study were male volunteers from AIIMS, Patna campus, aged group 18 to 40 years Male. Patients with history of sleep disorders like hypersomnia, parasomnia, narcolepsy, obstructive sleep apnoea, rapid eye movement (REM) sleep behaviour disorders, circadian rhythm sleep disorders, periodic limb movement disorders, shift work sleep disorders, etc., were excluded from the study. Participants were instructed to abstain from any food or beverage that contained caffeine 24 h prior to the study. A brief demographic and medical history has been taken followed by general physical examination before performance of the nap study.

Nap study, using 58 Ch. polysomnograph SOMNOscreen™ EEG plus (Somnomedics, Germany) was performed during afternoon time for minimum of 1:30 h to study the effect on sleep. All the subjects have been scheduled for nap studies with and without the intervention of music at a 1-week interval.

Participants were instructed to come with clean hair, without oil or conditioner. They were explained all the details of procedure. The scalp was cleaned with alcohol scrub and an EEG 10–20 jelly have been used to adhere electrodes. An impedance of about 1 Kohm have been obtained for each electrode. Polysomnographic data have been recorded with a wireless sensor and analysed using equipment specific software Domino (SOMNOscreen ltd, Germany).

After connecting electrodes, music was played at a volume, which was reported, comfortable and acceptable by the subject. Recording of sleep parameters was started as subject went to bed and lights were switched off. Total of minimum 1:30 hrs recording was taken. Subjects were allowed to awaken spontaneously.

EEG data from O1, O2, P3, P4, F3, F4, A1, A2, EOG1, EOG2, ECG data at two leads, chin movement, plethysmography, periodic leg movements, chest and abdomen movements, ECG, and nasal airflow were used for analysis purpose. The system acquired the data at a sampling frequency of 256 Hz with bandpass filter applied at 0.3 Hz to 48 Hz and notch filter of 50 Hz.

Data preprocessing

High-frequency interferences were filtered out from EEG signals by using a band-pass filter with a range of 0.3 to 48 Hz. Then, artefacts were removed by the blind-source analysis algorithm independent component analysis (ICA). Each subject's signal was decomposed into independent components (ICs). Then, artefacts were selected and removed.

Feature extraction

In this study, EEG signals were segmented into 2-min segments. To ensure that all EEG data had the same length, 2 min segment of second sleep stage was analysed. Features extracted were energy, entropy, and power spectral density.

The energy of a signal depends upon the magnitude of the signal. Wavelet packet node energy is more robust in representing a signal. Total signal energy can be defined in equation (1).

$$E = \sum_{j=1}^{N} |C_{ij}|^2 \quad (1)$$

Where, $i = 1,2\ldots\ldots l$ is the wavelet decomposition level from level 1 to level l. N is the number of the coefficients of detail or approximates at each decomposition level. To analyse specific frequency region, suitable tree structure should be chosen, which represent the wavelet packet energy distribution in that tree.

The data obtained from the subjects were evaluated using the Statistical Package for Social Sciences (SPSS) software for the data processing. Paired *t*-test was applied to see if there was any statistically significant difference between energy of EEG samples from recording with music and without music.

The energy was also compared without averaging, and individual electrodes comparison was done. A more statistically significant difference was obtained in the right frontal and central region between recording with music and recording without music.

Result

The demographic profile of the 15 participants is shown in Table 1. The mean age of participants were 20.4 + 4.1, whereas the mean body mass index (BMI) range was 23.2 ± 2.8. For the convenience of the study, male participants were exclusively taken for the study, as stated earlier.

In Table 2, sleep latency for different stages is compared. Near to significant difference is observed in latency of Stage 1 when comparing recording with music with recording without music. ($P = 0.10$). Other stage latencies and percentage of different stages during sleep do not show any statistically significant differences.

Table 3 compares the energy of alpha range frequency between recording with music and recording without music. Statistically significant differences are obtained with a $P = 1.17 \times 10^{-6}$. The difference is best seen in energy of alpha frequencies in the right frontal and central region, which is highly significant ($P = 1.6 \times 10^{-5}$, $P = 2.6 \times 10^{-5}$).

Similarly, the effect was seen in beta and alpha frequencies in the right frontal and temporal regions.

Figure 1 shows the mean sleep latency among the subjects with and without music induction. They showed a distinct difference, though statistically not significant at 95% confidence interval (CI) ($P > 0.05$). Figure 2 shows the alpha power among subjects of both the groups with statistically significant increase in the subjects of music group in comparison to non-music group.

Discussion

Music has long been known to have some effect on the psychophysical parameters of human beings. The present study attempted to study the effect of a particular frequency of music, i.e., 432 Hz music upon the sleep parameters of individuals having subjective complaint of delayed sleep latency. The parameters mainly studied included sleep latency, sleep latency for individual sleep stages of NREM and REM sleep. Being a daytime nap study, the sleep architecture did not follow the classical pattern, usually observed during night-time, and many subjects could not achieve N3 or N4 stage. Besides sleep latency, total sleep dime (TST), its ratio with various sleep stages and power of alpha waves during N2 stage have been studied in both groups.

It has been observed that sleep latency has shown some observable decrease among the music group individuals in

Table 1: Demographic data of subjects (*n*=15)

Parameters	Mean and SD
Age	20.46±4.20
Height	172.85±5
Weight	69.61±9.90
BMI	23.27±2.84

SD=Standard deviation, BMI=Body mass index

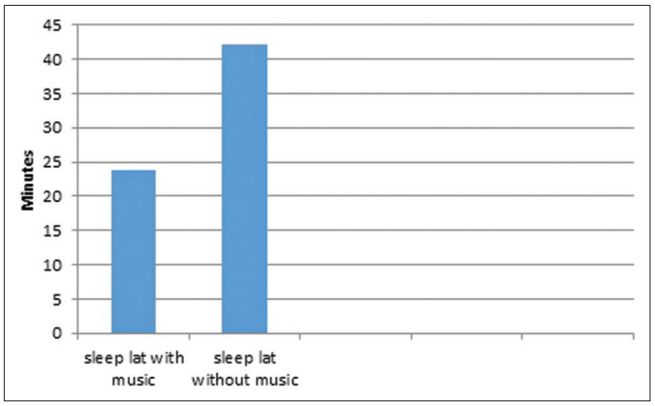

Figure 1: Sleep latency with and without music

Table 2: Sleep profile of subjects with and without music

Sr. No.	Sleep Parameters	Mean value and SD (with music)	Mean value and SD (without music)	*P*
Latency (Min)	9.86±9.26	19.96±23.33	0.19	
Latency N1	10±9.34	26.13±27.11	0.10	
Latency N2	21.01±10.50	11.69±10.83	0.93	
Latency Deep Sleep	25.49±7.32	23.47±9.26	0.44	
Latency REM	25.69±20.88	31±34.63	0.18	
REM TST%	19.49±20.16	33.08±20.05	0.28	
N1 TST%	22.7±16.21	26.64±30.97	0.68	
N2 TST%	40.91±21.86	31.03±12.50	0.16	
N3 TST%	7.51±5.24	7.51±6.95	0.39	
N4 TST%	33.26±24.71	38.65±20.55	0.74	

SD=Standard deviation, REM=Rapid eye movement, TST=Total sleep time

Table 3: The energy for alpha frequency with and without music for different participants

Subject	Energy with music	Energy without music
1	24.73	1.08
2	40.20	14.85
3	15.91	8.48
4	21.82	2.09
5	14.65	7.21
6	26.71	10.83
7	29.11	5.827
8	9.29	3.826
9	8.89	2.23
10	26.35	3.69
11	22.58	5.39
12	9.45	1.56
13	28.88	6.89
14	11.80	1.77
15	15.99	2.65

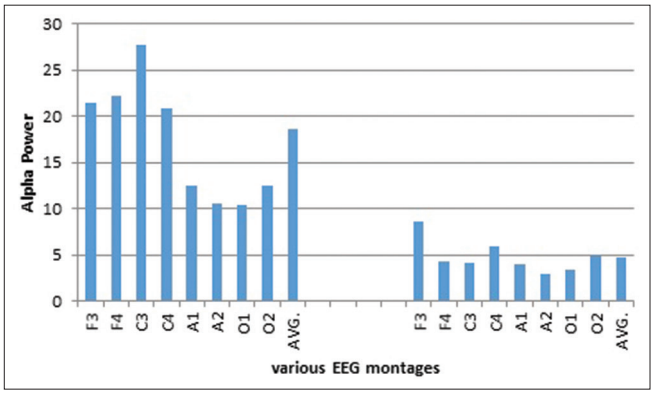

Figure 2: Mean of alpha energy with music and mean of alpha energy without music

comparison to the non-music group participants though statistically non-significant at 95% confidence limit. REM latency also showed a similar trend. Other parameters had mixed results in both groups.

The most significant observation of the study is the increase in the alpha power during sleep seen among the study group participants in comparison to the non-music group observations, which appears to be highly significant statistically ($P < 0.01$).

Music therapy is a method, which takes the advantage of therapeutic influence of music on psychological and somatic sphere of the human body. Its therapeutic properties are increasing being used. Current scientific research has proved its modifying influence on vegetative, circulatory, respiratory and endocrine systems. Works devoted to the effects of music on the patients' psychological sphere have also been confirmed.[11]

Normal sleep is characterised by behavioural and physiologic changes, as well as cycling between two distinct sleep states, REM and NREM. Throughout the sleep time, people cycle between NREM and REM sleep via an ultradian rhythm, with most of sleep spent in NREM.[12] In our study, subjects were seen to be spending maximum time in NREM sleep. Most of the subjects achieved N2 stage of sleep, both with music and without music. Many did not achieve REM stage and deep sleep. Therefore, the subjects achieving N2 stage in both studies (polysomnography with music and polysomnography without music) were included in the study and others were excluded.

Determinants involved in the regulation of sleep are the homeostatic and circadian processes. Despite being highly regulated, sleep is fragile, and its stages and duration may be affected by multiple factors, such as age, drugs, temperature, and medical and psychiatric disease. Our hypothesis is that music is also thought to be a regulator of sleep stages and brain wave activity.[12]

The observations indicate that though latency has some influence of music over it, The most promising effect of music upon the sleep behaviour could possibly be the calming effect as represented by the alpha dominance during Stage 2 of the NREM sleep. Alpha, as is commonly known, represents the relaxed state of mind, and its dominance among the music intervention group is indicative of the possible calming or relaxing effect of 432 Hz music on the sleeping brain. The alpha rhythm is typically seen in at least three different types, which are different in topography and function. First, the posterior alpha rhythm, originating from the parieto-occipital cortex, is dependent on the alertness and attentional factors. Second, there is the mu rhythm, which is dominant in central electrodes and

is related to the somatosensory cortex and movement. Third, the tau rhythm originates from the auditory cortex. It is important to stress that alpha power and brain activity are inversely related. This means that roughly speaking, the bigger the alpha power, the less active the brain. The alpha rhythm is typically predominant in the awake-resting state, either relaxed and comfortable (desynchronised tonic slow alpha) or concentrated (phasic desynchronised alpha), as well as in the case of alpha coma.[13]

Similarly, energy must also be inversely related to activity of brain. Bigger the energy value, less active must be the brain, as shown in this study, where energy is high with music and low without music.

Conclusion

Music, especially the 432 Hz frequency has shown some promising effect over the electroencephalographic activities of brain during a daytime nap. The decrease in latency, although not statistically significant and statistically significant increase in energy of alpha frequency indicates that 432 music Hz frequency music has some significant relaxing effect on the sleeping brain and equivocal effect upon the sleep latency, especially among the individuals with delayed sleep latency.

Limitations

It was a unique study in which an apparently Nobel concept of effect of music on sleep pattern and sleep latency has been studied by a daytime nap study. However, due to resource-limited settings, it had some limitations. Instead of full night gold standard polysomnographic recordings, which would have been a better study technique to test the hypothesis, a daytime nap study has been planned. Subjects were exclusively males, which is another limitation of the study that authors would like to declare. A further study with a bigger database in the light of above findings may be expected to be of high yield for scientific world.

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Conflicts of interest

There are no conflicts of interest.

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