DOI: 10.7860/JCDR/2023/58384.17729

Original Article

Physiology Section

Comparing the Timbre of Different Musical Sounds used in Music Therapy and its Effect on the Quality of Sleep in Medical Students with Insomnia- A Prospective Interventional Study

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ABSTRACT

Introduction: Stress and the pressure to perform in a competitive world has led to a rise in insomnia cases, especially in medical students. Music serves as a great alternative or additional therapy and hence, specifying the details of the type of music and creating a standard set of musical parameters, e.g., a specific value for tempo that sleep music should have. This will make it a more viable and clear option. One of these important but minimally explored aspects is timbre of music.

Aim: To assess and compare the effect of timbre of different musical sounds on an individual's quality of sleep, duration and day time sleepiness.

Materials and Methods: This prospective interventional (community trial) study was done in the Department of Physiology, Velammal Medical College Hospital and Research Institute, Madurai, Tamil Nadu, India for three weeks. Hundred medical students having insomnia were chosen and split into five groups: Group A-Sitar, B-violin, C-vocal, D-flute and E-control. Groups A-D had to listen to tracks with an assigned timbre for 20 minutes before going to sleep daily for three weeks. Pittsburg Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS) were used to assess sleep quality, duration and day time sleepiness. Kruskal-Wallis test was used to analyse the results.

Results: Sleep quality improved with sitar being the one that improved the quality the most, followed by violin, then flute and finally, vocal (p-value=0.001). Sleep duration improved with sitar being the one that showed the most improvement, followed by flute, then violin and finally, vocal (p-value=0.001). Daytime sleepiness decreased with sitar being the one that decreased it the most, followed by violin, then flute and lastly, vocal (p-value=0.021).

Conclusion: The most effective timbre in improving sleep quality, duration and reducing day time sleepiness was Sitar and the least effective was vocal.

Keywords: Instruments, Sleep disturbances, Vocal

INTRODUCTION

Sleep is a natural state of rest that allows the body to rejuvenate itself both physically and mentally. Insomnia disorder is characterised by chronic dissatisfaction with sleep quantity or quality that is associated with difficulty falling asleep, frequent night-time awakenings with difficulty returning to sleep, and/or awakening earlier in the morning than desired. Inspite of contradictory evidence, results have largely been interpreted within the context of the hyperarousal hypothesis. For example, hyperarousal model of insomnia has reported to be in harmony with the increased and decreased Gamma-aminobutyric acid (GABA) in insomnia patients [1].

People with acute insomnia present symptoms such as fatigue, dizziness, nausea and decreased neurological function [2]. A clear link is seen between stress and insomnia. Stress-related insomnia leads to a vicious circle by activating the Hypothalamic Pituitary Adrenal (HPA) system and an awareness of the close interaction between sleep and a stress system is emerging [3]. Student's quality of sleep may be influenced by high stress and pressure of maintaining average grade points [4]. There are various studies showing that pharmacological measures have been taken for treatment of insomnia but have shown a list of negative side effects including nausea, dizziness, dependency, withdrawal, amnesia and seizures and in some cases mortality [5,6].

Music therapy is an alternative form of treatment that has proven to reduce stress and improve sleep quality in individuals [7,8]. Types of music therapy include Analytical music therapy, Benenzon music therapy, Cognitive Behavioural Music Therapy (CBMT), Community music therapy, Nordoff-Robbins music therapy, Guided Imagery and Music (GIM) and Vocal psychotherapy [9]. A previous study had shown that people who listen to music have new auditory projections established between the medial geniculate body of the auditory pathway and parts of limbic system including cingulate gyrus, amygdala and orbito-frontal cortex [10]. But, there is also research that shows no significant improvement in quality of sleep on listening to music that contradicts the above stated study [11].

Timbre is the attribute that distinguishes sounds of equal pitch, loudness, and duration. It contributes to our perception and discrimination of different vowels and consonants in speech, instruments in music and environmental sounds. Despite its importance, timbre remains one of the least studied and perhaps most challenging features of sound to understand [12]. A particular timbre of a musical instrument invokes a particular emotion in people and can either increase feelings like fear, sadness, joy or calm [13]. Hence, it can be said that timbre has an influence on mental state.

From the above stated study, the effect of timbre on mental state was understood. The aim of the present study was to assess and compare the effect of timbre of different musical sounds on an individual's quality of sleep, duration and day time sleepiness. Null hypothesis of the present study was that timbre of different musical sounds has no effect on the individual's quality of sleep, duration and day time sleepiness.

MATERIALS AND METHODS

This prospective interventional (community trial) study was carried out in the Department of Physiology of Velammal Medical College

Hospital and Research Institute in Madurai, Tamil Nadu, India, from the months of August 2019 to October 2019. Institutional Ethical Committee Clearance (IEC No: VMCIEC/23/2019) was obtained. The study subjects were taken only with explicit informed consent and were given the option to back out with no penalty.

Inclusion criteria: Hundred volunteer medical students with complaints of lack of sleep, aged 18-25 years, of both genders. PSQI score ≥5 and ESS score ≥ 11 were considered as having sleep disturbance [14,15].

Exclusion criteria: Individuals with the history of hearing impairment, neurological, psychological illness and on any medication were excluded.

Sample size calculation: PSQI score of music group and control group were 3.27±1.80 and 5.17±2.21, respectively. Based on the findings of the present research, estimated Cohen's D effect size was 0.654 [16]. When we considered 95% confidence level and 80% power of the study, a minimum of 18 subjects in each groups were required.

Study Procedure

Four different instruments were chosen, each with its own distinctive timbre- Sitar (lute timbre), Violin (String Timbre), Flute (Woodwind Timbre) and vocal. The music was controlled for all other aspects such as rhythm, melody, volume, performance quality, and tempo. In order to make sure, there were no variations, the job of creating the tracks was given to an experienced music director. The style of music chosen was Indian classical. The Raag chosen was Bihaag, as it is stated to be a sleep-inducing Raag [17].

A form containing PSQI questionnaire (18 questions- about sleep quality and duration), ESS questionnaire (eight questions- all about daytime sleepiness) and a case sheet containing 17 questions covering information about personal details, vitals, important medical history and sleep habits was distributed [14,15].

First, a detailed message was sent via WhatsApp to five medical colleges in Tamil Nadu, including ones in Madurai, Theni, Tirunelvelli and Trichy, explaining the study and requesting for people interested in participating to contact the Department of Physiology of Velammal Medical College Hospital and Research Institute. The selection criteria for these places were based on their geographical placement in South Tamil Nadu. The form was distributed to interested students only. The members of the department and students conducting the research evaluated and assessed these forms and calculated the final scores manually. After analysing 363 filled questionnaires, 100 volunteers who fit the inclusion criteria were found to have insomnia (PSQI score ≥5 and ESS score ≥11) and they were recruited for the study after obtaining voluntary, informed consent.

The 100 volunteers were split non randomly into five groups, A, B, C, D, and E each consisting of 20 members. Group A were given the track with the sitar, Group B was given the track with the violin, Group C was given the track with the vocal and Group D was given the track with the flute. Group E were taken as the control group and not given any track and were instructed to not listen to any music before or during sleep.

The participants were told to download an application called 'Last.fm' in order to track their listening history and make sure that the treatment was being followed. They had to create an account and the application kept a log of the dates that they listened to the track and whether or not they listened to it in its entirety. The track was prepared at 60 beats per minute. The tracks were sent through Google drive and participants were asked to listen to the track through headphones or earphones.

Participants were asked to listen to the track for 20 minutes before going to sleep daily. A weekly assessment of sleep, using the same questionnaire sent out at the beginning of the study, was taken. They were asked to keep the volume at 50% in order to assure uniformity. After the completion of the experiment, a final assessment was done. Parameters that were studied include- quality, duration and day time sleepiness.

The questionnaires were filled prior to the experiment, then after week 1, then week 2 and then finally, after week 3. A sum of 5 or greater on the PSQI represents a "poor sleeper". A score of 11 or more on ESS indicates excessive daytime sleepiness.

STATISTICAL ANALYSIS

The data was analysed using Statistical Package for the Social Sciences (SPSS), version 16.0. Shapiro-wilk test was used to assess the normality conditions of the continuous data. The empirical data did not follow normal distribution. Therefore, parametric statistical test could not be used to compare the scores between groups. Hence, Kruskal-Wallis test was used to compare the more than two groups with respect to the mean rank. Dunn test was used to do the multiple comparison of the combinations of two groups. The p-value<0.05 was considered statistically significant.

RESULTS

The mean age was 22.6±3.2 years. The number of males were 55 and females were 45. All participants of the study had similar levels of sleep quality, daytime sleepiness and sleep duration with respect to the PSQI score (measuring sleep quality and sleep duration) and ESS score (measuring daytime sleepiness) at the baseline [Table/Fig-1]. Therefore, all the groups were comparable.

Variables	Group	Mean score	Mean rank	p-value (Kruskal-Wallis test)
PSQI Score	Vocal	7.90±2.59	59.50	0.351
	Sitar	7.38±3.54	46.19	
	Violin	7.45±2.33	55.08	
	Flute	7.30±2.13	53.55	
	Control	6.55±1.88	43.05	
ESS Score	Vocal	13.05±2.46	58.31	0.445
	Sitar	12.76±2.28	55.31	
	Violin	12.65±2.66	51.28	
	Flute	12.10±2.12	44.13	
	Control	11.80±1.15	47.95	
Sleep Duration (hours)	Vocal	5.59±0.94	46.90	0.112
	Sitar	5.90±1.15	56.86	
	Violin	5.40±0.87	40.70	
	Flute	5.65±1.12	49.75	
	Control	6.10±0.95	63.25	

[Table/Fig-1]: Baseline characteristics.

There was a significant difference in the PSQI score and ESS score across the intervention and control groups during first week follow-up (p<0.05), but not in the sleep duration. The most effective in terms of PSQI score (improvement in sleep quality) was sitar, followed by violin, then flute, and lastly vocal group although they showed improvement compared to the control. The most effective in terms of ESS score (reducing daytime sleepiness) was vocal, followed by sitar, followed by flute and lastly violin, although, they also showed better results than the control group. Sleep duration was not significantly affected in the first week [Table/Fig-2-4].

There was a significant difference in the PSQI score, ESS score and sleep duration across the intervention and control groups during second week follow-up (p<0.05). There was a significant difference in the PSQI score, ESS score and sleep duration across the intervention and control groups during third week follow-up (p<0.05). The most effective in terms of PSQI score (improvement in sleep quality) was

PSQI Score							
After intervention	Group	N	Mean score	Mean Rank	p-value	Dunn test (p-value)	
First Week	Vocal	20	5.14±1.93	50.12	0.008	Control vs Vocal=0.030 Control vs Sitar=0.024 Control vs Violin=0.034 Control vs Flute=0.012 Flute vs Violin=0.625	Flute vs Sitar=0.486 Flute vs Vocal=0.423 Violin vs Sitar=0.329 Violin vs Vocal=0.357 Sitar vs Vocal=0.891
	Sitar	20	5.19±3.57	44.12			
	Violin	20	4.95±2.11	45.40			
	Flute	20	4.75±1.37	45.58			
	Control	20	6.90±2.27	72.73			
Second Week	Vocal	20	4.38±1.66	52.33	0.001	Control vs Vocal=0.012 Control vs Sitar=0.003 Control vs Violin=0.001 Control vs Flute=0.001 Flute vs Violin=0.856	Flute vs Sitar=0.624 Flute vs Vocal=0.426 Violin vs Sitar=0.529 Violin vs Vocal=0.473 Sitar vs Vocal=0.836
	Sitar	20	4.14±2.95	40.90			
	Violin	20	3.95±2.14	41.78			
	Flute	20	3.70±1.45	40.90			
	Control	20	7.00±2.22	82.08			
Third Week	Vocal	20	4.00±1.26	54.29	0.001	Control vs Vocal=0.001 Control vs Sitar=0.001 Control vs Violin=0.001 Control vs Flute=0.001 Flute vs Violin=0.725	Flute vs Sitar=0.883 Flute vs Vocal=0.042 Violin vs Sitar=0.632 Violin vs Vocal=0.043 Sitar vs Vocal=0.045
	Sitar	20	3.00±1.55	37.50			
	Violin	20	3.20±2.02	37.83			
	Flute	20	3.15±1.56	40.18			
	Control	20	7.58±2.36	87.55			

[Table/Fig-2]: PSQI levels after intervention.
Kruskalwallis test p-value **p<0.05 was considered statistically significant. (PSQI=Pittsburgh Sleep Quality Index, ESS=Epworth Sleepiness Scale)

ESS Score							
After intervention	Group	N	Mean score	Mean Rank	p-value	Dunn test (p-value)	
First Week	Vocal	20	9.29±4.09	43.57	0.002	Control vs Vocal=0.021 Control vs Sitar=0.028 Control vs Violin=0.036 Control vs Flute=0.039 Flute vs Violin=0.528	Flute vs Sitar=0.463 Flute vs Vocal=0.385 Violin vs Sitar=0.396 Violin vs Vocal=0.428 Sitar vs Vocal=0.782
	Sitar	20	9.52±2.14	43.67			
	Violin	20	10.00±2.29	49.03			
	Flute	20	10.05±3.89	46.60			
	Control	20	12.30±1.75	75.43			
Second Week	Vocal	20	9.00±4.01	46.60	0.001	Control vs Vocal=0.029 Control vs Sitar=0.021 Control vs Violin=0.013 Control vs Flute=0.028 Flute vs Violin=0.462	Flute vs Sitar=0.245 Flute vs Vocal=0.743 Violin vs Sitar=0.672 Violin vs Vocal=0.459 Sitar vs Vocal=0.046
	Sitar	20	8.05±3.19	39.48			
	Violin	20	8.70±2.72	44.83			
	Flute	20	9.05±3.75	45.35			
	Control	20	12.60±1.57	82.10			
Third Week	Vocal	20	8.24±4.25	50.74	0.001	Control vs Vocal=0.001 Control vs Sitar=0.001 Control vs Violin=0.001 Control vs Flute=0.001 Flute vs Violin=0.873	Flute vs Sitar=0.649 Flute vs Vocal=0.548 Violin vs Sitar=0.723 Violin vs Vocal=0.684 Sitar vs Vocal=0.039
	Sitar	20	6.38±3.32	38.21			
	Violin	20	7.15±3.70	43.78			
	Flute	20	7.85±5.05	46.53			
	Control	20	12.05±2.89	78.95			

[Table/Fig-3]: ESS Score after intervention.
Kruskal-Wallis test p-value **p<0.05 was considered statistically significant. (PSQI=Pittsburgh Sleep Quality Index, ESS=Epworth Sleepiness Scale)

Sleep Duration							
After Intervention	Group	N	Mean score	Mean Rank	p-value	Dunn test (p-value)	
First Week	Vocal	20	6.21±0.79	56.52	0.331	NA	
	Sitar	20	6.29±0.90	58.02			
	Violin	20	5.97±0.77	48.70			
	Flute	20	6.07±0.96	51.55			
	Control	20	5.70±0.86	42.13			
Second Week	Vocal	20	6.31±0.94	53.60	0.064	NA	
	Sitar	20	6.31±0.95	53.00			
	Violin	20	6.175±0.75	49.55			
	Flute	20	6.60±0.80	63.58			
	Control	20	5.72±0.88	37.60			
Third Week	Vocal	20	6.28±0.77	51.86	0.021	Control vs Vocal=0.036 Control vs Sitar=0.031 Control vs Violin=0.034 Control vs Flute=0.033 Flute vs Violin=0.127	Flute vs Sitar=0.152 Flute vs Vocal=0.194 Violin vs Sitar=0.146 Violin vs Vocal=0.198 Sitar vs Vocal=0.141
	Sitar	20	6.55±0.86	59.31			
	Violin	20	6.35±0.67	54.53			
	Flute	20	6.32±0.85	55.15			
	Control	20	5.52±1.02	32.79			

[Table/Fig-4]: Sleep duration after intervention.
Kruskal-Wallis test p-value **p<0.05 was considered statistically significant. (PSQI=Pittsburgh Sleep Quality Index, ESS=Epworth Sleepiness Scale)

sitar, followed by violin, then flute and lastly vocal group although they showed improvement from control.

After comparing the baseline and third week results, the present study showed that after three weeks of the said intervention, sitar was the most effective in improving all three aspects (quality of sleep, daytime sleepiness and sleep duration) and vocal was the least effective though the results were better than the control group. In the author's opinion the points that give a potential explanation of the results have been given in the discussion.

DISCUSSION

Sleep quality of individuals can be intensified by using a non pharmacological treatment i.e., music therapy [18]. A study done by testing the effect of Indian classical music microtones on sleep quality showed improvement in the sleep quality of the participants of that study [19]. Complexity of music is notably difficult to define and characterise. It can refer to both aspects of the structure as well as the subjective interpretation of audience based on their experience. Complex music takes longer to become familiar and the liking for it increases overtime, whereas, less complex sounds are easier to familiarise with but listeners tend to dislike it over time [20]. According to a study done by Brown S et al., unfamiliar but pleasant music activates ventral anterior cingulate cortex, the hippocampus, anterior insula, and also the nucleus accumbens resulting in a positive effect on the limbic system [21].

Multiple studies support the superiority of effectiveness of instrumental music over vocal music in decreasing stress levels, anxiety and sleep disturbances. A study done on testing the effect of vocal music over instrumental music on anxiety showed that listening to instrumental music had a far greater effect in reducing the anxiety levels [22]. Whitehead JC and Armony JL also demonstrated that instrumental music specifically activated anterior planumtemporale in superior temporal gyrus whereas vocal music activated a broader area in the right superior temporal gyrus [23]. Planumtemporale is most sensitive to pitch stimuli. So, the localisation of the effect of the sound, may potentially contribute to the increased effectiveness of instrumental music compared to vocals. The present study, that aimed to assess and compare different instruments to each other and vocal music, supported the findings of the above studies that instrumental was more effective in helping with sleep disturbances.

However, music warranted the subjects to exercise at a notably lower heart rate and oxygen consumption. It helped in reducing the metabolic cost and had a relaxant effect due to activation of parasympathetic nervous system [24]. This probably explains why the vocal track in the current study, despite not being as effective as instrumental, still showed improvement when compared to control. The first week results showed that although sitar was most effective in improving sleep quality, it required more time for the full effect to be appreciated because, in general, it takes atleast three weeks for the full effect of therapy to show [7]. The second week results showed sitar as the most effective in improving sleep quality and decreasing daytime sleepiness and flute as the most effective in increasing sleep duration and sleep quality. So, these results emphasise the superiority of instrumental music over vocal in effectively curing the sleep disturbances [22].

The reason the participants were asked to listen for 20 minutes was because maximum attention span is 20 minutes after which, the brain becomes fatigued, which is counterproductive to the study [25]. The track was prepared at 60 beats per minute as that has been suggested to be the ideal beat as it matches heart rate and produces relaxing effect [26]. Raag Bihaag was chosen for the present study as it has been shown to induce peaceful sleep [17]. It consists of mainly "shuddha" notes which are stated to induce a calming emotion and "madhyama" notes, the tonality of which was found to be associated with feelings of hope and peacefulness [27]. This may decrease negative emotions and hence improve sleep.

The present study results showed that after three weeks of the said intervention, sitar was the most effective in improving all three aspects (quality of sleep, daytime sleepiness and sleep duration) and vocal was the least effective though the results were better than the control group. In the author's opinion, the above points give a potential explanation of the results.

The need for non pharmacological intervention for insomnia is eminent. Sleep deprivation and insomnia have become increasingly common in students and young adults these days and show serious consequences, the number one cause for this being stress. Music therapy is being viewed as a viable option as it has many good qualities with little consequence and very little negative side effects. Although music comes down to preference, creating a standard, more specific point of reference through research can help make this treatment more effective, increasing its legitimacy and giving it an edge over pharmacological methods and other non pharmacological methods. Details such as an ideal rhythm and timbre can help save time in treatment and increase its effectiveness.

Limitation(s)

The assessment was subjective and can be affected by placebo effect/participant bias. Also, sleep was not supervised in a sleep lab. Furthermore, individuals who were obese were not excluded, which could have affected the results, as obesity is a cause of sleep apnoea.

CONCLUSION(S)

The present study had demonstrated that the Indian musical instrument, sitar, appears to improve quality of sleep, duration of sleep and decreasing daytime sleepiness compared to the other instruments, flute and violin. The instrumental music appeared more effective in the above discussed parameters compared to vocal track. Finally, music in all forms (instrumental and vocal) appeared more effective than none at all.

More research would be required in the area of music, as a therapeutic tool for sleep disorders. Present study could potentially be expanded to different age groups, such as elderly people and children. Further studies to assess the differences in the responses to the current music scores based on ethnicity and population demographics would add value to the current knowledge in this area. More scientific studies can be done by using sleep laboratories, polysomnographs and Electroencephalogram (EEG) machines to track, whether sitar affects the brain differently.

Funding: The present study was done as a part of ICMR STS 2019. The funding gap for the study was met by generous contribution from Chennai Speciality Clinic Health Foundation (registered charity–TP 36038562/2018).

Acknowledgement

The authors would like to express gratitude towards Mr. Sundar C Babu for composing and recording the music tracks for the study.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jun 17, 2022
- Manual Googling: Nov 02, 2022
- iThenticate Software: Nov 17, 2022 (13%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: As given above
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jun 11, 2022**
Date of Peer Review: **Aug 25, 2022**
Date of Acceptance: **Dec 27, 2022**
Date of Publishing: **Apr 01, 2023**