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ORIGINAL RESEARCH

Multi-Sensory Stimuli Improve Relaxation and Sleep Quality in Rotating Shift Workers: A Randomized Controlled Trial

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Purpose: To compare the effects of multi-sensory stimuli on relaxation and sleep quality in 2 periods.

Patients and Methods: This experimental research used a sample group of 60 individuals, divided into three groups, with each group consisting of 20 participants. The test period was divided into two equal periods of 4 days each. The collected data included measurements of relaxation (visually calibrated scale, percentage stress, and heart rate) and sleep quality (percentage sleep, total sleep duration, and duration of deep sleep). Quantitative statistics were employed to analyze the data and compare average differences.

Results: Regarding relaxation, the results from the second period test indicated that Group 2, which received both fragrance and natural sound treatment, outperformed the other groups based on the visually calibrated scale. This group also exhibited lower levels of percentage stress and heart rate as compared to Group 1 and the control group, with a confidence level of $p < 0.05$. In terms of sleep quality, during the second period test, Group 2 achieved more superior results compared to the other groups in terms of percentage sleep, total sleep duration, and duration of deep sleep, with a confidence level of $p < 0.05$.

Conclusion: It can be inferred that multi-sensory stimuli enhanced relaxation and sleep quality.

Keywords: increasing relaxation, the sleep of working people, multisensory stimuli towards relaxation, multisensory stimuli towards sleep quality

Introduction

Sleep quality affects the quality of life especially among the rotating shift workers. Sleep or wake of human beings depends on the cyclic working system of human body or circadian rhythm which is controlled by Suprachiasmatic Nucleus in Hypothalamus and Clock Genes. The environment external to the body including darkness and light influences the circadian rhythm. A nonuniform state of sleep and wake due to unsuitable external environment may affect the quality of sleep.[1,2]

The external environmental factors such as odor, noise, temperature, and relative humidity can enhance relaxation, stress relief, and sleep quality. There have been many studies, both medical and nonmedical, which found that essential content of herbs, pharmacological effects of herbs, patterns of sound, temperature, and relative humidity enhanced sleep quality. From the review of the literature, it was found that various forms of aromatherapy such as fragrant essential oil from lavender, eucalyptus, and orange relieved stress, sleep abnormality, and pain. Aromatherapy may be administered in different forms such as spray on different surfaces or bodily parts and mixing the oil with bath water.[3] The entry of essential oil molecules into the olfactory nerve, accessing the limbic system, initiates a profound impact on emotions. The limbic system, located in the cerebral cortex, plays a pivotal role in controlling and regulating emotions. When stimulated by essential oil molecules, this system triggers a cascade of responses that contribute to emotional well-being.[4] The effect may result in the release of endorphins, bringing about a sense of relief and comfort. Furthermore, the stimulation of enkephalin and serotonin promotes a relaxed mood, fostering a state of tranquility and calmness.[5,6] Research by Yu and Chiou revealed that lavender improved sleep quality.[7]

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The external factor like sound can help improve relaxation and sleep quality. Absolutely, the impact of relaxing sounds on our well-being is profound, and it's closely tied to its ability to stimulate the parasympathetic nervous system. When we listen to soothing melodies, our body responds in various ways that contribute to a sense of balance and relaxation. The parasympathetic nervous system, often referred to as the rest system, is responsible for promoting relaxation and recovery. Relaxing sounds helps bring the autonomic nervous system into balance. The rhythmic patterns and harmonious tones in relaxing sounds have a soothing effect on the body and mind. This promotes a state of relaxation, helping to alleviate tension and stress.[6,8] However, irritating noise has negative impact on daily life routines, especially the sleeping cycle. Loud noise during sleep impacts both physical and mental health of the affected individuals.[8] The problem at hand is twofold: first, the lack of comprehensive knowledge regarding the diverse formats of multi-sensory stimuli, and second, the limited understanding of the nuanced effects of multi-sensory stimuli on relaxation and sleep quality.[6,8] The objective of this research was to compare the effects of multi-sensory stimuli on relaxation and sleep quality in 2 periods. These effects included visual comparative relaxation scale, percentage stress as measured by variation in the heart rate during sleep, heart rate during sleep, and sleep quality as determined by total sleep duration, deep sleep duration, sleep duration with rapid eye movement, sleep efficiency, among the rotating shift workers who were stimulated with fragrance, the workers who were stimulated with fragrance and sound, and the control. The researchers controlled the sleeping environment, viz, fragrance from lavender, natural sound, temperature, and relative humidity in the experimental room. The research hypothesis posited that the group exposed to a combination of fragrance and sound would experience higher levels of relaxation and improved sleep quality compared to the pre-experiment state and the other two groups: one exposed solely to fragrance and a control group. It is known that suitable sleeping environment affect bodily change leading to improved emotion, inducing relaxation and improved sleep quality. The result of this study was expected to lead to improved work efficiency and sustainable quality of life of the rotating shift workers.

Materials and Methods

Sample

This experimental research was conducted using the rotating shift workers in Thailand as the population. The sample group consisted of male and female rotating shift workers aged between 20 and 60 years working regular jobs with shift rotation every month. The nature of work could be classified as light to medium with the working hours of 8–12 hours per day in Thailand.[9] A sample group of 60 individuals was obtained by simple random sampling using a computer program.[10] The sample group was divided into three groups of 20 individuals. Group 1 was stimulated with lavender fragrance with the concentration of 10%v/v. Group 2 was stimulated by lavender fragrance as in Group 1 and the sound of water flow typical of waterfall/fountain at 20–30 decibels, and Group 3 was the control. The selection of the samples was based on the criteria that follows.

1. Inclusion criteria were: ages 20–60 years, working in rotating shift every month, 8–12 working hours per day, voluntary participation in the research by signing a consent form for research in humans, no past history of allergy to herbs, no underlying diseases or medication for relaxation or relief of sleep problems, normal perception of odor and sound, stress free or slight-medium stress (score of less than 41 using stress measurement as per the Department of Mental Health).
2. Exclusion criteria were: inability to participate in every experiment, and being admitted to hospitals or having severe illness which prevents experimental participation.

Instrument

The research tools used in this study consisted of:

Screening Tools

1. A stress measurement form of the Department of Mental Health (SPST-20) containing 20 questions with multiple choices of answers at five levels, viz, stress free, slightly stressed, stressed, highly stressed, highest stressed.
2. An odor sensing and hearing form which contained two parts. Part 1 consisted of 3 questions with 4 choices, viz, fragrance of lavender, fragrance of orange, fragrance of lime, and odorless. (Figure 1). The subject scored zero mark if he did not detect

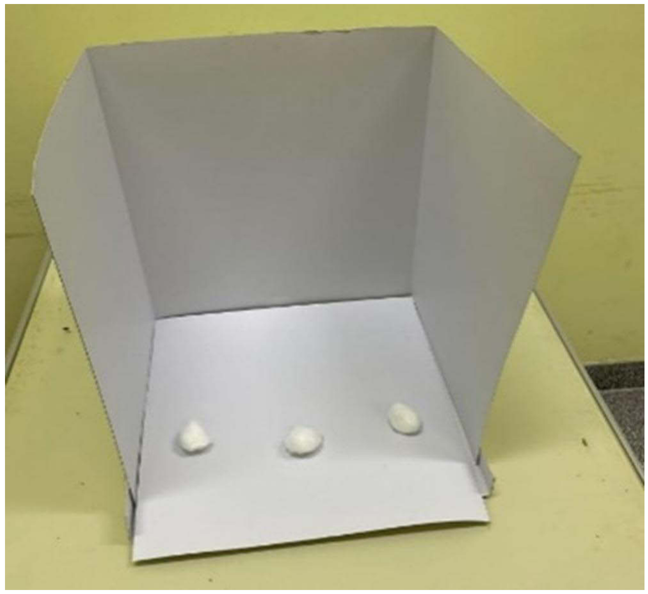

Figure 1 Odor screening tools.

the fragrance or gave a wrong answer whereas one who detected the fragrance and gave the correct answer scored 1 mark. Part 2 measured hearing with 3 questions. The answer for the questions in Part 2 was chosen from 4 multiple choices, namely sound of waterfall, sound of a cat, sound of an electric fan, and soundless. Failure to detect the sound or sound detection with wrong answer scored zero mark whereas sound detection with the correct answer scored 1 mark.

3. An essential oil allergy measurement form with one question was used to measure allergy to essential oil. Every subject was to smell the fragrance via cotton for 20 seconds and 15 minutes. The response to the question was selected from 8 choices including no abnormality, nasal irritation, runny nose, nasal congestion, nasal pain, cough, chest discomfort, and others.

4. Pittsburgh's sleep quality form (Thai version) was used as a sleep quality questionnaire. The questionnaire comprised four open-ended questions, addressing bedtime, sleep duration, wake-up time, and actual sleep time, as well as six questions focusing on sleep problems, self-evaluation of sleep quality, use of sleeping pills, drowsiness, and sleep environment, requiring answers on a rating scale with multiple choices such as none at all, less than once a week, once or twice a week, three times a week, very good, quite good, quite bad, very bad, none, sleep by oneself in a room, sharing a room but separate beds, and sharing a bed. The total score 0 to 21, being less than 5 was interpreted as good sleep quality, otherwise poor sleep quality.[11]

Experimental Tools

1. A fragrance dispenser is an equipment for holding essential oil and dispersing the fragrance of the essential oil to the surrounding air by means of electricity.
2. A loudspeaker was used for sound broadcasting via a flash drive.
3. A digital device was used to measure ambient temperature and relative humidity with digital display.
4. Miscellaneous items such as mattress and air conditioners.

Tools for Measuring Relaxation and Sleep Quality

1. A general questionnaire containing 10 questions about gender, age, marital status, work hours per day, physical exercise, medication, caffeine drink, addictive substance, and underlying disease.
2. The visual Analogue Scale for Relaxation which takes the form of a 10 cm straight line with a scale from 0 to 10. Zero corresponds to no relaxation at all and 10 implies the highest relaxation. All the subjects were requested to circle a mark on the scale to indicate their level of relaxation. The score of 0–2.4 indicated not at all relaxed, 2.5–4.4 slightly relaxed, 4.5–6.4 relaxed, 6.5–8.4 highly relaxed, and 8.5–10 highest relaxed.[12]

3. A wrist actigraphy is a non-invasive device used to assess cycles of bodily activities. In this case, it indicated total sleep duration, and variation of heart rates. It sensed the heart rate using an optical technique, analyzed it using a time-domain method, and interpreted the result by an algorithm. The measured level of stress was given in percentage and recorded on the wrist actigraphy.

Quality Examination of the Research Tools

1. Examination of content validity of the tools such as odor sensing and hearing form and the visual analogue scale were examined by five experts on herbs, environmental health, multi-sensory stimuli, relaxation, and sleep quality. The result of the examination revealed that the IOC was 1.0.
2. Examination of tool reliability was conducted by having a group of 20 individuals similar to the subjects of this study use the tools before actual use with the subjects.
2.1 The odor sensing and hearing form was tested with the results being analyzed by the Kuder-Richardson 20 (KR20) statistics to give the reliability value of 0.89.
2.2 The results from the trial use of the visual Analogue Scale for Relaxation were statistically analyzed to yield the Cronbach's Alpha Coefficient of 0.73.
2.3 The questionnaire for sleep quality assessment (Thai version Pittsburgh form) was analyzed by the test-retest reliability to yield the reliability value of 0.89.
3. Multi-sensory stimuli test was performed on 5 individuals similar to the subjects of this study. Each individual was subjected to multi-sensory stimuli continuously for 2 days, and no adverse effects were observed.
4. The wrist actigraphy used in this study passed the manufacturer's test with the sensitivity of 95.8% and the specificity of 73.4%. The devices were calibrated with polysomnography to yield the value of 83%. The devices were reset every time before use.
Questionnaires and various forms were used for data collection in this study with earnest regard for research ethics. Rights protection of the subjects of this study was conducted in the following

This Study Complies with the Declaration of Helsinki

1. Articulation of the research proposal which was approved by Committee of Research Ethics Burapha University as per the document IRB3-066/2564 dated June 12, 2021 to the subjects of this study.
2. The researchers explained the objectives of the research and its methodology to the sample group and that participation in this research was on only a voluntary basis. All the gathered data were strictly confidential and only the overall results of the study might be disclosed without reference to any individuals without any harm in any way to the individuals and their affiliated organizations. Informed consent was obtained from each participant, and their confidentiality is strictly maintained by assigning unique identifiers. All data are securely stored, accessible only to researchers. The researchers will publish only aggregate results, and the data will be retained for one year after the research's publication before being destroyed.

Design

Step 1: An investigation into multi-sensory stimuli from the literature concerning concepts and related theories.
Sep 2: An investigation into the effects of multi-sensory stimuli on relaxation and sleep quality by comparing the group being subjected to odor stimulus and the group being subjected to odor and sound stimuli. (Figure 2).
1. Experimental procedure for Group 1 (stimulated with odor only)

- During Day 1 and Day 2, the subjects were assigned to sleep in a normal room without being subjected to odor or sound. Relaxation and sleep quality were monitored by wrist actigraphy.
- During Day 3 and Day 4, the subjects were assigned to sleep in the room where the fragrance of lavender was dispersed to the ambient via an essential oil dispenser. Relaxation and sleep quality were monitored by wrist actigraphy. Relaxation was also assessed by the visual Analogue Scale for Relaxation.
- During Day 5 to Day 11 (rest period), the subjects stayed at their own homes with guidance on how to conduct themselves during the period.

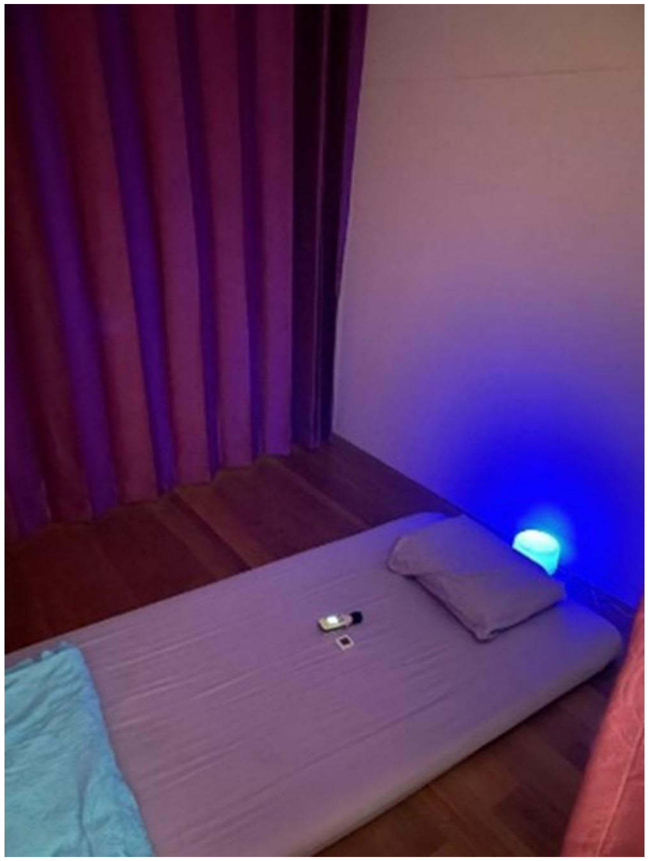

Figure 2 Arrangement of multi-sensory stimuli.

- During Day 12 to Day 13, the subjects slept in normal rooms as during Day 1 to Day 2.
- During Day 14 to Day 15, the subjects were assigned to sleep while being subjected to the fragrance of lavender via the essential oil dispenser and the sound of water flow, waterfall, and fountain at the sound level of 20–30 decibels. Relaxation and sleep quality were monitored by the wrist actigraphy. Relaxation was also assessed by the visual Analogue Scale for Relaxation.

2. Experimental procedure for Group 2 (stimulated by odor and sound)

- During Day 1 to Day 2, the subjects were assigned to sleep in normal rooms without being subjected to odor or sound. Relaxation and sleep quality were monitored by wrist actigraphy.
- During Day 3 and Day 4, the subjects were assigned to sleep while being subjected to the fragrance of lavender was dispersed to the ambient via an essential oil dispenser and the sound of water flow, waterfall, and fountain at the sound level of 20–30 decibels. Relaxation and sleep quality were monitored by wrist actigraphy. Relaxation was also assessed by the visual Analogue Scale for Relaxation.
- During Day 5 to Day 11 (rest period), the subjects stayed at their own homes with guidance on how to conduct themselves during the period.
- During Day 12 to Day 13, the subjects slept in normal rooms as during Day 1 to Day 2.
- During Day 14 to Day 15, the subjects were assigned to sleep in the room where the fragrance of lavender was dispersed to the ambient via an essential oil dispenser. Relaxation and sleep quality were monitored by wrist actigraphy. Relaxation was also assessed by the visual Analogue Scale for Relaxation (Figure 3).

3. Experimental procedure for Group 3 (control)

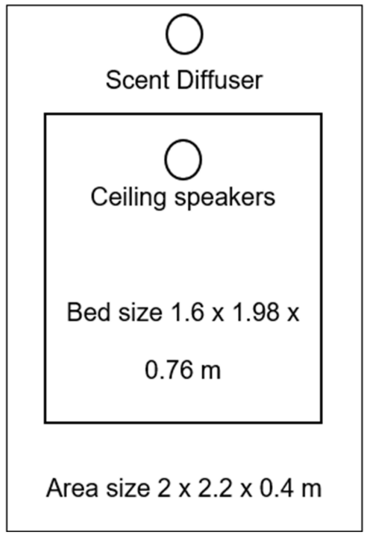

Figure 3 Multi-sensory stimuli diagram.

During Day 1 to Day 4, the subjects were assigned to sleep in normal rooms without being subjected to odor or sound. Relaxation and sleep quality were monitored by wrist actigraphy. Relaxation was also assessed by the visual Analogue Scale for Relaxation.

Statistical Analysis

A literature survey of 37 articles on concepts and related theories on multi-sensory stimuli revealed that lavender fragrance at the concentration of 10%v/v and natural sounds at the sound level of 20–30 decibels were mostly used in research. Statistical analysis was carried out to determine percentage, average, standard deviation of the data. Comparison of the general data among the samples was conducted using the Chi-square test. One-way ANOVA was employed to analyze the discrepancies among the sample groups.[13] Multiple comparison by the method of Scheffe and dimensionless Kruskal–Wallis Test were used if the data distribution was not normal. Scheffe's method is commonly employed when comparing multiple groups in analysis of variance (ANOVA). Multiple comparisons were also carried out by the method of Dunnett's T3. Dunnett's T3 is often employed when there is a violation of the assumption of equal variances and when group sizes are unequal.

Results

Examination of the sample groups found that The Chi-square Test was applied for categorical variables, such as gender, marital status, exercise, consuming caffeine, tobacco and alcohol, and congenital disease. Meanwhile, the Kruskal–Wallis Test was used for continuous variables including age, daily working time, and monthly income. All subjects had no problems with scent smelling and hearing. The sample group had a mean SPST-20 score of 26.28 ± 2.62, indicating a level of moderate stress. 50.00% of the sample reported that the overall quality of sleep is quite poor. It was found that these parameters of the three groups did not significantly differ ($p > 0.05$) (Figure 4).

Comparison among the groups during the experiment revealed that the group being stimulated by the fragrance had their average score on the visual Analogue Scale for Relaxation enhanced by 1.95 with a standard deviation of 0.94 whereas the group stimulated by fragrance and sound had their average score increased by 3.45 with a standard deviation of 0.94. On the contrary, the average score of the control group improved by 0.25 with a standard deviation of 0.55. During the experiment, the scores of the three groups on the visual Analogue Scale for Relaxation differed statistically significant ($p < 0.001$). Comparison between groups by the method of Scheffe discovered that the group stimulated by fragrance and sound significantly had a greater improvement of the score on the visual Analogue Scale for Relaxation than the group stimulated by fragrance only and the control group ($p < 0.001$). Furthermore, the group stimulated by

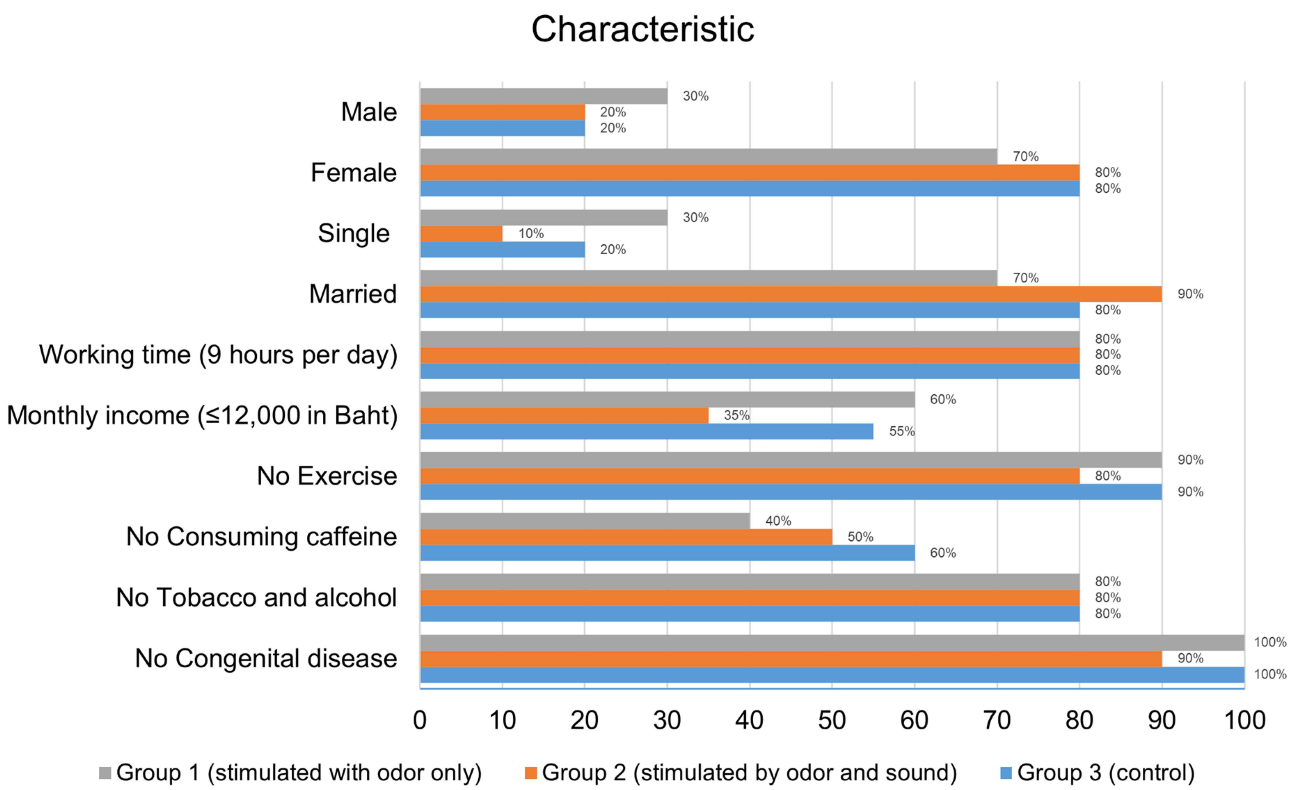

Figure 4 The Characteristics of the sample groups.

fragrance only significantly had a greater improvement on the visual Analogue Scale for Relaxation than the control group ($p < 0.001$) (Table 1).

Comparison among the groups during the experiment disclosed that the group with fragrance stimulation had a percentage stress as measured by the change in heart rate during sleep reduced on the average by 4.73% with a standard deviation of 1.17%. The group with fragrance and sound stimulation had the percentage stress reduced by 8.63% with a standard deviation of 1.48. The control group had the percentage stress reduced by 0.77% with a standard deviation of 2.18%. During the experiment, the three groups had significantly different percentage stresses as determined by the change of the heart rate ($p < 0.001$). Comparison of the percentage stress as measured by the change of the heart rate by the method of Cheffe revealed that the group with fragrance and sound stimulation had a greater change in the percentage stress as measured by the heart rate change than the other groups ($p<0.001$). In addition, the group with fragrance stimulation significantly experienced a greater change in the percentage stress than the control group ($p<0.001$) (Table 1).

Table 1 Comparison of Relaxation Among Group 1, Group 2, and Group 3 (Control)

Relaxation	Change During the Experiment			*p*
	Mean Change (SD)			
	Group 1 (n=20)	Group 2 (n=20)	Group 3 (n=20)	
1. score (the visual Analogue Scale for Relaxation)	+1.95 (0.94) **	+3.45 (0.94) **	+0.25 (0.55) **	<0.001
2. percentage stress as determined by the change in the heart rate during sleep	−4.73 (1.17) **	−8.63 (1.48) **	−0.77 (2.18) **	<0.001
3. heart rate change during sleep	−5.38 (2.28) **	−10.85 (2.48) **	−0.25 (2.25) **	<0.001

Notes: ** $p < 0.001$ Multiple comparisons by Scheffe's method.

Comparison of changes among the group disclosed that the group with fragrance stimulation had a reduction in the heart during sleep of 5.38 pulses per minute with a standard deviation of 2.28 pulses per minute whereas the group with fragrance and sound stimulation had the heart rate during sleep reduced by 10.85 pulses per minute with a standard deviation of 2.48. The control group had the heart rate during sleep reduced by 0.25 pulses per minute with a standard deviation of 2.25. The differences in the reduction of the heart rate during sleep among the three groups were statistically significant (p < 0.001). Comparison of the changes of the heart rate during sleep among the groups by the method of Scheffe showed that the change in the group with fragrance and sound stimulation was significantly greater than the other groups (p < 0.001). The change in the heart rate of the group with fragrance stimulation was also found to be significantly greater than that of the control group (p < 0.001) (Table 1).

In the comparison of change during the experiment, it was found that stimulation by fragrance improved the total sleep duration by 38.65 minutes with a standard deviation of 23.90 minutes whereas stimulation by fragrance and sound increased the total sleep duration by 54.30 minutes with a standard deviation of 45.86 minutes. The total sleep duration of the control group improved by 2.90 minutes with a standard deviation of 12.86 minutes. The average total sleep duration of the three groups was found to be significantly different (p < 0.001). Comparison of the change in the total sleep duration among the groups by Dunnett's method showed that the group stimulated by fragrance and sound experienced a greater change in the total sleep duration than the control group (p < 0.001). On the contrary, the change in the total sleep duration between Group 1 and Group 2 was not statistically significant (p = 0.454). The group with fragrance stimulation significantly experienced a greater change in the total sleep duration than the control group (p < 0.001) (Table 2).

On the effect of deep sleep, it was found that the Group 1 experienced an increase of deep sleep duration of 24.65 minutes with a standard deviation of 43.82 minutes while Group 2 experienced an increase of deep sleep duration of 46.10 minutes with a standard deviation of 49.52 minutes. Group 3 experienced an increase of deep sleep duration of 0.25 minutes with a standard deviation of 10.78 minutes. The deep sleep durations of the three groups were found to be significantly different (p < 0.002). By employing Dunnett's T3 test, it was found that Group 1 significantly experienced a greater change of deep sleep duration than Group 3 (p < 0.002). Furthermore, Group 1 experienced a less change in deep sleep duration than Group 2 but did a greater change in deep sleep duration than Group 3, albeit insignificantly (p > 0.05) (Table 2).

On comparing the change during the experiment, it was found that Group 1 experienced an increase in average sleep duration with rapid eye movement of 7.60 minutes with a standard deviation of 19.31 minutes while Group 2 experienced an average increase of 7.00 minutes with a standard deviation of 28.22 minutes, and a Group 3 experienced an average increase of 2.45 minutes with a standard deviation of 5.47 minutes. The difference in sleep duration with rapid eye movement among the three groups was insignificant (p=0.674) (Table 2).

On the effect of the change of sleep efficiency, it was disclosed that Group 1 experienced an increase in sleep efficiency of 1.16% with a standard deviation of 1.45% while Group 2 experienced an increase in sleep efficiency of 1.19% with a standard deviation of 1.11%, and Group 3 experienced an increase in sleep efficiency of 0.26% with a standard deviation of 0.85%. The difference in sleep efficiency among the three groups was found to be significant (p = 0.02). Comparison of the change in sleep efficiency by the method of Cheffe revealed that the change in sleep efficiency of Group 2 was

Table 2 Comparison of Relaxation Among Group 1, Group 2, and Group 3 (Control)

Sleep Quality	Change During the Experiment			*p*
	Mean Change (SD)			
	Group 1 (n=20)	Group 2 (n=20)	Group 3 (n=20)	
1. Total sleep duration	+38.65 (23.90) **	+54.30 (45.86) **	+2.90 (12.86)	<0.001
2. Deep sleep duration	+24.65 (43.82)	+46.10 (49.52) *	+0.25 (10.78)	0.002
3. Sleep duration with rapid eye movement	+7.60 (19.31)	+7.00 (28.22)	+2.45 (5.47)	0.674
4. Sleep efficiency	+1.16 (1.45) *	+1.19 (1.11)	+0.26 (0.85)	0.020

Notes: * p < 0.05 Multiple comparisons (Scheffe, Dunnett's T3), ** p < 0.001 Multiple comparisons (Dunnett's T3).

significantly greater than Group 3 ($p = 0.046$) and that Group 1 experienced less increase in sleep efficiency than Group 2 but greater increase in sleep efficiency than Group 3, albeit insignificantly ($p > 0.05$).

Discussion

This study attempted to investigate the effects of multi-sensory stimuli on relaxation and sleep quality of rotating shift workers by subjecting the subjects of study to the fragrance of the essential oil of lavender at the concentration of 10% v/v and natural sounds such as water flow, waterfall, and fountain at the sound level of 20–30 decibels in the room with controlled temperature of 24.5–25.5 degrees Celsius and 50–60% relative humidity. The controlled environment in the room was established at least half an hour prior to the commencement of the experiment and kept until completion of the sleeping test. The sources of the stimuli and associated equipment were placed on an area of 220 × 120 cm. The bed size (width × length × height) was 1.6 × 1.98 × 0.76 m. The bed was placed on a wooden structure with the size of 2 × 2.2 × 0.4 m surrounded by curtain on three sided and the ceiling. The essential oil dispenser was placed on the bedhead, and the loudspeaker on the ceiling. Temperature and relative humidity control was also installed in the room. The sleep experimental room was conducive to sleeping and the participating subjects perceived the relaxing ambience which influence the improvement in the physiological change, resulting in relaxation and improved sleep quality of the subjects. Essential oil of lavender gives out a nice fragrance causing the subjects to feel fresh and relaxed. The chemical property of the essential oil of lavender stimulates the nervous system and the brain to increase producing neurotransmitters such as Serotonin, Enkephalin, and Endorphin with the effect of feeling peaceful and relaxed. Neurotransmitters are also involved in the sleep-wake cycle and are converted to melatonin, a hormone that regulates sleep, ultimately resulting in improved sleep quality.[14,15] In addition, the sounds of water flow waterfall, and fountain were musical sounds with low frequency and slow and steady rhythm which stimulate the parasympathetic nervous system to cause additional peace leading to the generation of alpha waves which are the waves in the range of 8–13 Hz. Alpha waves are generated when the subjects are feeling peaceful and relaxed. The time taken to fall asleep is thus reduced, and the first phase of sleep, Non-rapid eye movement Sleep, is also reduced.[16,17]

After applying multi-sensory stimuli to the subjects in the three groups, it was observed that they experienced greater relaxation than before stimulation, aligning with the hypothesis. The effects of the stimuli resulted in the stimulation of the scent sensor which sent the signal to the brain causing the activity of the Limbic system leading to feeling peace and enhanced relaxation. Related research found that essential oils had pharmacological effects on the gastrointestinal system, respiratory system, and the central nervous system. The sounds of nature such as water flow, waterfall, and fountain stimulated the hearing sensory system which transmitted the signal to the brain influencing the activity of the Limbic system, resulting in the feeling of peace and improved score on the visual Analogue Scale for Relaxation. Percentage stress as determined from the change of the heart rate during sleep, and average heart rate all improved leading to improved relaxation.[18,19]

After the three groups were stimulated by the stimuli in the first and the second periods, Group 2 experienced greater relaxation than Group 1 and Group 3. The multi-sensory stimuli by scent and sound stimulated the senses of scent and hearing which were transmitted to the brain resulting in the activity of the Limbic system which further stimulated the parasympathetic nervous system leading to higher relaxation and peace.[20,21] The multi-sensory stimuli produced more improved results than a single stimulus, aligning with the hypothesis. Related research found that stimulation through relaxing music, electrical heat stimuli, and aroma foot bathing for 20 minutes twice per week could reduce stress, heart rate, and blood pressure, resulting in improved mental health.[22]

After exposure to the multi-sensory stimuli, rotating shift workers experienced better sleep quality than before, aligning with the hypothesis. The effect of the sound and the fragrance stimuli in the environment at 24.5–25.5 deg Celsius and 50–60% relative humidity was transmitted to the Limbic system of the brain which resulted in enhanced stimulation of the parasympathetic nervous system, leading to the feeling of higher peace, and thus enhanced sleep quality. In addition, it also affects the biological clock which is controlled by suprachiasmatic nucleus (SCN) in the hypothalamus, which is in turn controlled by clock genes, causing the release of melatonin to enhance sleep in terms of the total sleep duration, shallow sleep duration, deep sleep duration, sleep duration with rapid eye movement, blood oxygen quantity during sleep, and sleep efficiency.[23] Related research indicated that therapy by inhaling fragrance of a mixture of chamomile, or clary sage, or lavender with jojoba (1:9) twice a day, morning and before bed, improved sleep quality.[24]

After being exposed to the multi-sensory stimuli, rotating shift workers who experienced fragrance and sound stimulation reported better sleep quality than those without stimulation, aligning with the hypothesis. The stimulation by more than one stimulus resulted in various bodily responses which stimulated the activity of the Limbic system of the brain, increased stimulation of the parasympathetic nervous system, and increased release of melatonin leading to higher peace and better sleep in terms of the total sleep duration, shallow sleep duration, deep sleep duration, sleep duration with rapid eye movement, blood oxygen quantity during sleep, and sleep efficiency, blood oxygen quantity during sleep, and sleep efficiency. The influence of such stimulation resulted in positive changes as compared with stimulation by a single stimulus. Related research found that a relaxation promotion program by Dhamma music and fragrance therapy influenced sleep quality. Exposure to Dhamma music and fragrance from essential oils of ylang ylang (Cananga odorata) and Lavender for 45 minutes resulted in improved score of sleep quality.[25,26]

However, it is important to acknowledge some limitations in our research. The study employed a sample group consisting of 20 participants divided into three groups. The sample size was determined using the G*Power package, configuring the F-test with an effect size (Effect Size) of 0.80, a significance level (α) of 0.05 for the first type of test error, and a test power (1-β) of 0.95.[9] The resulting sample size calculated was 17 participants per group. However, the researcher opted to set the sample size at 20 individuals per group, which represents the smallest number on the normal curve distribution. Factors such as perception, sensitivity, participant demographics, and environmental variables may have an impact on relaxation and sleep quality. Moreover, the study focused on a single type of odor and a single type of sound as multi-sensory stimuli.

Future studies should include individuals working both day and night shifts to compare the effects of multi-sensory stimuli. These studies should explore various types of multi-sensory stimuli, such as different medicinal plant smells and a range of sounds, to enhance the diversity of stimuli. Additionally, researchers should investigate the effects of multi-sensory stimuli on different populations, including the elderlies, medical personnel, learners, online distance teachers, patient care assistants, and patients with chronic diseases, sleep problems or those who are bedridden.

Conclusion

Rotating shift workers may use multi-sensory stimuli to improve their sleep by using the essential oil of lavender at the concentration of 10% v/v and the natural sound (water flow, waterfall, or fountain) at 20–30 decibels in a room with the temperature of 24.5–25.5 deg Celsius and 50–60% relative humidity. Such an environment must be initiated 30 minutes prior to bedtime and maintained throughout the entire sleep period. Medical and public health organizations as well as concerned personnel may use the research results to improve relaxation and sleep quality. Furthermore, they can be used in the formulation of policy for promoting health of rotating shift workers groups. The study introduces a novel perspective by investigating the impact of multi-sensory stimuli on relaxation and sleep quality. The demonstrated significant improvements contribute to the existing body of knowledge, shedding light on effective interventions for enhancing well-being, especially in the areas of sleep and mental health. This research serves as a valuable addition to the field, providing concrete evidence of the positive effects of multi-sensory stimuli and paving the way for further advancements in the understanding and application of sensory interventions for improved mental and physiological states.

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Disclosure

The authors report no conflicts of interest in this work.

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