https://ijpp.com

Indian Journal of Physiology and Pharmacology

Original Article

The influence of desynchronised circadian rhythm on emotional contagion and reactivity: A comparative study

Nirmala Subhash Anand[1], Medha Shubhangi[1], Cristóbal Johan Martínez Aarli[2], Antonio García Ríos[3], Veronica Raniello[4], Sakshi Rao[1]

[1]Department of Physiology, Jawaharlal Nehru Medical College, Belagavi, Karnataka, India, [2]Department of Physiology, Medicine University of Seville, Seville, [3]Department of Physiology, Faculty of Medicine in Malaga, University of Malaga, Malaga, Spain, [4]Department of Physiology, University of Genoa, Italy School of Medical and Pharmaceutical Sciences Student in Medicine and Surgery, Genova, Italy.

***Corresponding author:**
Medha Shubhangi,
Department of Physiology,
Jawaharlal Nehru Medical College, Belagavi, Karnataka, India.

medhashubhangi29@gmail.com

Received: 10 August 2023
Accepted: 12 April 2024
EPub Ahead of Print: 29 November 2024
Published: 27 December 2024

DOI
10.25259/IJPP_435_2023

Quick Response Code:

ABSTRACT

Objectives: The objective of this study was to assess the impact of acute sleep deprivation (12 h) on emotional and autonomic reactivity and processing in nursing shift workers at KLE's Prabhakar Kore Hospital and MRC. The impact of acute sleep deprivation on emotional behaviour in health-care personnel, especially nurses, is a topic of significant interest in the scientific community. Despite this, the existing body of literature on this topic remains relatively scarce. This is particularly important in the field of nursing, where socioemotional behaviour, irritability and volatilities are compulsory evil and an occupational hazard. This study aims to delve into the effects of acute sleep deprivation on emotional behaviour among shift-working nurses. It explores the correlation between desynchronised circadian rhythms, emotional processing, and reactivity, with a specific focus on their interaction with declarative memory. The impact of sleep deprivation on associative memory is also touched on.

Materials and Methods: Seventy-two nursing students (III year) who were posted for night duties (8 p.m.–8 a.m.) and age- and gender-matched day-time working nurses were recruited. Following their respective shifts, they were made to fill Pittsburgh Sleep Quality Index (PSQI), Stanford Sleepiness Score and Hospital Anxiety and Depression Scale (HADS) questionnaires. To assess emotional contagion, the nurses underwent a facial affective recognition task, and to assess autonomic reactivity, heart rate variability (HRV) in the form of the root mean square of the successive difference (RMSSD) was recorded using an HRV phone tracker.

Results: The results of our study prove that sleep deprived group (SD) nurses had poor PSQI global score (females [12 ± 7.6] and males [12.34 ± 5.4]) as compared to daytime controls (female [7 ± 4.8] and male [7.2 ± 6]). Sleep-deprived female nurses showed a tendency toward sleepiness (3.66 ± 0.24) as compared to SD male nurses, who showed greater anxiety (8 ± 1.1) on the HADS questionnaire as compared to daytime controls. During the affective facial recognition task (AFRT) for emotional contagion, the SD female nurses showed hyperarousal to negative valence emotions such as anger (4 ± 11.12) and fear (4.2 ± 9.0) as compared to controls. There was blunting toward positive valence emotions (happy) in SD (1.5 ± 11) as compared to daytime controls (2.5 ± 10.2), but no statistical change among the male SD and controls. HRV in relation to negative valence emotion to assess reactivity (anger) was associated with sympathetic activity characterised by reduced RMSSD (39 ± 7.0) in SD female nurses as compared to controls (51 ± 12.46); no statistically significant change was observed in male counterparts. There was no notable change in emotions such as surprise and disgust among SD and controls in both genders.

Conclusion: Results obtained from our study suggest fragmented sleep quality as well as a higher incidence of morning sleepiness in night-shift workers. The AFRT showed heightened hyperarousal following a negative valence (anger and fear) Stimuli but a blunted response toward happy and sad pictures. The vagal dominance in the form of RMSSD showed a blunted response during negative valence emotions, suggesting increased sympathetic preponderance during viewing those during sleep-deprived states.

Keywords: Amygdala, Emotional processing, Sleep deprivation, Shift workers, Nurse

INTRODUCTION

The impact of sleep deprivation on cognitive processes has sparked considerable interest owing to its comorbidity with various neurological, mood and psychiatric disorders.[1] However, despite the growing prevalence of behavioural disturbances associated with sleep disruption, this area has received limited scientific attention.

Examining the effects of altered sleep patterns on neurological functions holds particular relevance for health-care professionals, as their ability to concentrate, maintain attention and regulate emotions is critical for optimal patient care.

Among the health-care workforce, nurses represent the largest contingent, accounting for approximately 50% of hospital personnel.[2] It is worth noting that nurses who work night shifts endure sleep deprivation due to the extended duration of their work hours. Furthermore, the demanding nature of their professional responsibilities exposes them to physical and mental chronic stress.

These aforementioned factors render nurses particularly susceptible to sleep disruption, leading to adverse effects on their physical and emotional well-being. Involvement in shift work disrupts their circadian rhythms, further exacerbating the risk of physiological and psychological disturbances.[3] Commensurately, these individuals are more prone to developing sleep disorders, experiencing daytime drowsiness and exhibiting reduced performance in their work. Moreover, the psychological stress generated within the occupational environment significantly impairs their overall quality of life.[4]

There is evidence that sleep deprivation can affect memory, with emotional memory being more susceptible to disruption than neutral memory.[5,6] This disparity likely stems from the crucial role of sleep in facilitating the long-term consolidation of emotional memory.[7] Studies have demonstrated that sleep deprivation can engender heightened activity within the amygdala, specifically in response to negative stimuli, indicating a potential augmentation of the amygdala's reactivity to negative emotions during sleep deprivation.[8,9] However, other studies have shown that sleep deprivation can also lead to faster response times to positive stimuli, suggesting that the effects of sleep deprivation on emotional reactivity may be more complex.[10]

Emotional contagion refers to the phenomenon where one person's emotions and related behaviours can influence and spread to others within a social or interpersonal context.[11] Partial sleep deprivation led to reduced activity in the fusiform gyrus when processing angry faces and lower ratings of happiness for all stimuli.[12]

Working 12-h shifts has been associated with reduced empathy and heightened burnout, with females exhibiting higher rates of exhaustion-related burnout symptoms.[13]

A study by Medic *et al*. explains that short-term disruption of sleep is associated with increased stress responsivity, somatic problems, reduced quality of life, emotional distress, mood disorders and other mental health problems, cognition, memory, and performance deficits, and behaviour problems in otherwise healthy individuals.[14]

There is an apparent contradiction within the existing research. While it is widely accepted that sleep deprivation impairs physiological bodily processes, there is a dearth of definitive evidence in the literature regarding the specific impact of acute sleep deprivation on emotional reactivity. The conflicting nature of the data mandated the conduct of this study.

Objective

The objective of this study was to assess the impact of acute sleep deprivation (12 h) on emotional and autonomic reactivity and processing in nursing shift workers at KLE's Prabhakar Kore Hospital and MRC.

MATERIALS AND METHODS

1. Study design: A comparative study
2. Sampling technique: Purposive
3. Sample size estimation = 72
4. Sample size estimation - Expected reduction-(mean) = d = 13.4
    - SD = 48 = σ
    - Power = 80%
    - α error= 0.05;
    - One-sided $Z\alpha = 1.65$ and β error = 0.2;
    - $n = ([Z\alpha + Z\beta]\ \sigma/d^2) = 71.64 =$ **72**
5. Source of data: The study population included 72 (4th year) nursing students aged 21–23 who worked night shifts (8 p.m.–8 a.m.) at KLE Hospital.
6. Inclusion and Exclusion Criteria for Experiment Group [Table 1].
7. Exclusion Criteria for the control group [Table 2].
8. Study Flow-chart [Figure 1].

The control population consisted of 72 age- and gender-matched day-shift working students.

Table 1: Inclusion and exclusion criteria for experiment group

(4th year) Nursing students doing night shifts (8 pm–8 am)	H/O prior sleep disorders
Aged 21–23 years	Having H/O diabetes or other major illness
Both genders were recruited	H/O alcohol consumption or tobacco chewing
At least 12 h of sleep deprivation.	H/O any psychiatric illness or any medication affecting sleep (e.g.- Cetirizine)

H/O: History of

Table 2: Exclusion criteria for the control group
H/O daytime napping
H/O social media addiction
H/O habitual night-time phone use
H/O gadget addiction
H/O prior, sleep disorders and insomnia
Having H/O diabetes or other major illness
H/O alcohol consumption or tobacco chewing
H/O any psychiatric illness or any medication affecting sleep (e.g.- Cetirizine)
H/O: History of

Tools

The sleep log and Pittsburgh Sleep Quality Index (PSQI) Questionnaire[15] were used to confirm compliance with the sleep schedule.

The Stanford Sleepiness Scale (SSS) was used to assess sleepiness.[16]

A hospital anxiety and depression scale (HADS)[17] questionnaire was given to assess anxiety and depressive symptoms among populations. It is a 14-item self-report questionnaire that measures anxiety and depression symptoms. The scale has two subscales: HADS-A (anxiety) and HADS-D (depression). Each item is scored on a 0–3 Likert scale, with higher scores indicating more severe symptoms. The global score for each subscale ranges from 0 to 21, with a cut-off point of ≥8 used to define possible cases of anxiety and depression. Scores of 0–7 suggest normal, 8–10 borderline abnormal and 11–21 abnormal.

Emotional contagion was assessed by the Facial Affective Recognition Task using free pictures from the Paul Eckmann and Friesen series.[18]

To assess autonomic reactivity, we used the heart rate variability (HRV) root mean square of the successive difference (RMSSD) (surrogate maker of HF, parasympathetic activity) and the root mean square of successive RR differences (time domain) using a BIPR Samsung Galaxy wearable watch.

Study protocol

Ethical clearance was obtained from JNMC's Ethics Committee for conducting the study. (Ref: MDC/DOME/77).

The experimental group underwent 15 days of night duty and was evaluated on the 3rd day of their posting. Participants refrained from consuming caffeine and alcohol and engaging in screen time for 24 hours prior to and during the study. They maintained a normal sleep-wake schedule, obtaining an average sleep duration of 7–9 h per night and waking between 6:00 and 9:00 in the morning. Written informed consent was obtained from all participants. The experimental protocol commenced daily at 9:30 a.m. once the shift workers returned to their rooms. The participants completed the PSQI, SSS and HADS questionnaires. A 5-min baseline measurement of HRV using the Samsung Galaxy BIPR tracker determined the parasympathetic vagal index (RMSSD). The effective facial recognition task (AFRT) developed by Paul Eckman and Friesen was then administered. Internet-sourced Paul Eckman facial affective images, representing six basic emotions (happy, sad, fear, angry, disgust and neutral) in a 70:30 ratio, were utilised. Each emotion had five corresponding images, resulting in a total of 30 images. These images were converted into a computer-administered task where participants classified each facial expression photograph into one of the six emotion labels (happiness, surprise, fear, sadness, disgust and anger). Each image was displayed on a laptop screen for 5 s before disappearing, while the six emotion labels remained visible for participants to select using a mouse. Subsequently, valence and arousal were assessed using two 5-point Likert scales (1 indicating negative valence and low arousal, 5 indicating positive valence and high arousal). A 5-min interval separated each image presentation. After responding to each emotional picture, HRV (RMSSD) was measured using the BIPR phone tracker.

Statistical analysis

Statistical analysis was done using the Statistical Package for the Social Sciences, version 25. Descriptive data involving quantitative variables were summarised through the mean and standard deviation (mean ± SD). '*t*-value' was calculated and '$P = 0.05$' was considered statistically significant.

RESULTS

The findings of our study demonstrate that female nurses with sleep deprivation (SD) have a lower overall sleep quality score (PSQI Global score: 12 ± 7.6) compared to daytime controls (7 ± 4.8). SD female nurses exhibit signs of sleepiness (3.66 ± 0.24), while SD male nurses show higher levels of anxiety (8 ± 1.1) on the HADS questionnaire compared to daytime controls. During the emotional contagion task for affective facial recognition, SD female nurses display heightened responses to negative emotions such as anger (4 ± 11.12) and fear (4.2 ± 9.0) compared to controls. They also show reduced responsiveness to positive emotions (happy) in SD (1.5 ± 11) compared to daytime controls (2.5 ± 10.2), whereas no significant changes are observed among male SD nurses and controls. When examining HRV in relation to negative emotions, specifically anger, SD female nurses exhibit lower parasympathetic activity (characterised by reduced RMSSD: 39 ± 7.0) compared to controls (51 ± 12.46), while no statistically significant differences are observed among male counterparts. Notably, there are no significant differences in emotions such as surprise and disgust between SD individuals and controls in both genders.

1. Sociodemographic details [Table 3]
2. Comparison of sleep indices using the PSQI questionnaire among shift workers and controls – [Table 4]
3. Comparison of sleepiness using SSS in sleep-deprived females and males – [Graph 1]
4. Comparison of anxiety and depression among sleep-deprived and control groups – [Graph 2]
5. Comparison of autonomic reactivity among sleep-deprived and controls – [Graph 3]
6. Comparison of emotional reactivity (arousal) and vagal outflow (RMSSD) using facial affective tasks among sleep-deprived and controls (Females) – [Table 5]
7. Comparison of emotional reactivity (arousal) and vagal outflow (RMSSD) using facial affective tasks among sleep-deprived and controls (Males) – [Table 6].

DISCUSSION

In our study, the mean age of the participants was 22 years, and the shift work duration was 12 h.

Table 3: Sociodemographic details.

Age	• 21–23 years
Gender	• Females (SD=44; Controls=44) and • Males (SD=28; Controls=28)
Qualifications	• Nursing students doing shift work at KLE's Hospital and Research Centre
Hours of actual sleep (SLEEP LOG)	• Average 4–5 h of daytime sleep in shift workers (nurses) as compared to 8 hours of night-time sleep in the control population working in day hours.
Substance abuse such as smoking and alcohol	• Neither population
History of endocrine disorders.	• Nil

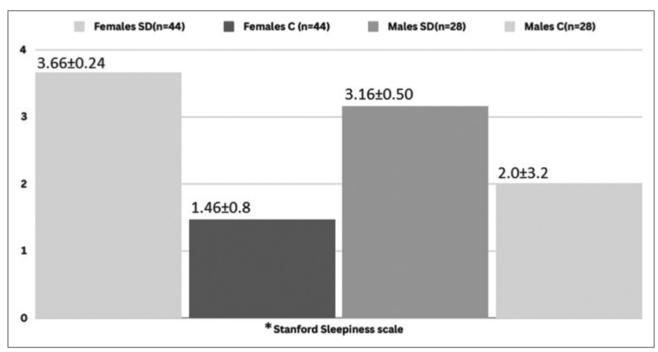
SD: Sleep deprived, KLE: Karnataka Lingayat Education Society

The results of the PSQI showed that 67% of the nurses had poor sleep quality (global score 12, subcomponent scores around 2). A study by Gómez-García *et al.* in Spain reported a deteriorated PSQI score in nurses with night shifts compared to nurses with day shifts, indicating deteriorated sleep quality among night shift workers.[19] As part of the health-care system, where shift work is a necessary hazard, nursing staff experience sleepiness and discomfort in their work environment. This reduces the quality of healthcare delivery to patients and increases the risk of occupational errors.

The results of our SSS showed that female nurses had a slightly lower score (3.16 ± 0.24) than male nurses (3.66 ± 0.50). Although this difference was not statistically significant, this could be due to the greater sensitivity of female psychological status to stress.[20]

The results of the HADS questionnaire showed that female shift workers had significantly higher anxiety levels (8 ± 1.1) than controls (6.73 ± 0.16). However, no gender differences were found for depression. Our nursing staff was relatively young, and they may have been more anxious because they had not yet developed coping strategies. The unpredictability of the work schedule and the seriousness of the patients' conditions may also have been contributing factors.

Our findings also revealed blunted vagal outflow as indicated by the RMSSD values. Sleep deprivation leads to a decrease



Graph 1: Comparison of sleepiness using Stanford sleepiness scale in SD females and males. *Statistically significant, $P < 0.05$ (SD: Sleep deprived, C: Control).

Table 4: Comparison of sleep indices using PSQI questionnaire among shift workers and controls.

PSQI	SD females (*n*=44)	SD males (*n*=28)	Control females (*n*=44)	Control males (*n*=28)	*P*-value
Subjective sleep quality	1.8±8	1.5±6	2±7.9	1±0.8	0.01*
Sleep latency	2.8±12	2.4±2.5	1.2±10	1.3±2	0.7
Sleep duration	2±6.7	1.6±7.2	1.8±5.5	0.9±1.1	0.78
Sleep efficiency	2.8±6.5	1.99±3	1.5±4.3	1.33±5	0.5
Sleep disturbances	2.2±7.9	2±4.3	0.8±7.7	0.63±4.4	0.2
Daytime disturbances	2±2.3	1.85±2.11	1.1±3.11	1±2.33	0.1
Global score	12±7.6	12.34±5.4	7±4.8	7.24±6	0.04*

*Statistically significant, $P<0.05$, SD: Sleep deprived, PSQI: Pittsburgh Sleep Quality Index

Table 5: Comparison of emotional reactivity (arousal) and vagal outflow (RMSSD) using facial affective task among SD and C's (females).

Emotional reactivity	Females SD	Females C	*P*-value
1) Happy	1.5±11	2.5±10.2	0.002*
RMSSD	56±4.32	50±4.32	0.01*
2) Sad	2±7.4	3.2±6.7	0.04*
RMSSD	48±8.89	49±1.76	0.12
3) Fear	4.2±9.0	3.1±7.7	0.05*
RMSSD	41±7.18	51±1.21	0.01*
4) Disgust	3±13	3.2±12.8	0.2
RMSSD	48±4.45	49±3.12	0.9
5) Surprise	3±12.9	2.8±9.7	0.1
RMSSD	47±5.61	50±4.32	0.7
6) Anger	4±11.12	3±11.9	0.001*
RMSSD	39±7.0	51±12.46	0.05*

*Statistically significant, *P*<0.05, RMSSD: Root mean square of the successive differences, SD: Sleep deprived, C: Controls

Table 6: Comparison of emotional reactivity (arousal) and vagal outflow (RMSSD) using facial affective tasks among sleep deprived and controls (males).

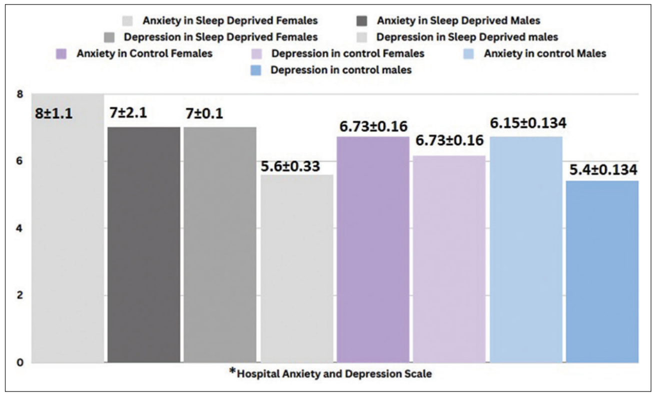
Emotional reactivity	Males SD	Males C	*P*-value
1) Happy	2.8±8.1	3±6.7	1.112
RMSSD	54±18.23	60±17.9	0.875
2) Sad	2±11.3	2.8±14.9	0.7
RMSSD	56±11.15	58±12	0.12
3) Fear	3.2±5.5	2.3±5.7	0.9
RMSSD	56±13.41	57±11.3	0.5
4) Disgust	2.5±9.8	2.8±3.6	0.2
RMSSD	58±13.11	59±12.7	0.4
5) Surprise	2.4±22	2.8±25	0.1
RMSSD	53±15.17	59±16.71	0.1
6) Anger	2.4±4.8	2.7±5.9	0.11
RMSSD	53±14.8	54±15.32	0.9

RMSSD: Root mean square of the successive differences, SD: Sleep deprived, C: Controls, Statistically significant P = <0.05.

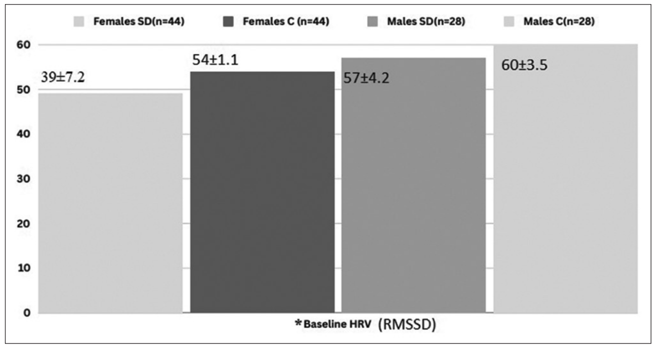
in vagal innervation activity and an increase in sympathetic activity. Goff *et al*. have provided an explanation for this phenomenon, stating that the body's regulatory mechanisms are designed to prevent sudden surges in sympathetic activity during the waking state. However, sleep deprivation disrupts this regulatory balance and results in greater fluctuations in autonomic activity.[21]

The AFRT results showed that nurses engaged in night shifts exhibited heightened arousal for negative valence emotions, such as anger (4 ± 13.1) and fear (4.2 ± 9.0). These results are consistent with studies that have shown that sleep deprivation, with <5 h of sleep per night, increases emotional disturbance.[22]

In line with our results, a study conducted by Bauducco *et al*. discovered that adolescents who obtained inadequate



Graph 2: Comparison of anxiety and depression among SD and controls. *Statistically significant, *P* < 0.05. The data are in mean with standard deviation. (HADS: Hospital anxiety and depression scale, SD: Sleep deprived, C: Control).



Graph 3: Comparison of autonomic reactivity among sleep deprived and controls. The test used to determine *P*-value is student *t*-test. *Statistically significant, *P* < 0.05 (HRV: Heart rate variability, RMSSD: Root mean square of the successive differences, SD: Sleep deprived, C: Controls).

amounts of sleep were more prone to engaging in norm-breaking behaviour, as well as displaying increased hostility and anger.[23] This further supports the notion that compromised sleep duration has detrimental effects on emotional regulation and behavioural functioning.

Studies have shown that sleep deprivation can lead to increased amygdala activity in response to both negative and positive stimuli.[24] This is because sleep deprivation weakens the connectivity between the amygdala and prefrontal areas of the brain, including the medial prefrontal cortex. This disruption can lead to hyperactivity toward emotional stimuli and a decrease in the ability to regulate emotional responses.[25]

Even a single episode of total sleep deprivation has been linked with greater subjective reports of anxiety, anger and stress in response to mildly stressful situations. This is likely because the amygdala is involved in both emotions and sleep architecture. When the amygdala is hyperactive, it can lead

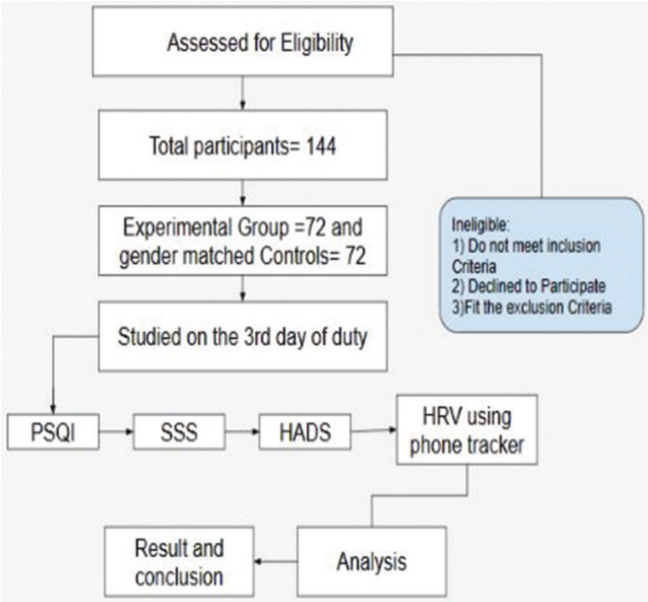


Figure 1: Study flowchart. PSQI: Pittsburgh sleep quality index, SSS: Stanford sleepiness scale, HADS: Hospital anxiety and depression scale, HRV: Heart rate variability.

to heightened responses to negative stimuli, even when those stimuli are not particularly threatening.

By weakening the connectivity between the amygdala and prefrontal cortex, sleep deprivation can lead to increased reactivity to emotional stimuli and a decrease in the ability to regulate emotional responses, resulting in negative consequences, including increased anxiety, anger and stress.

Implication

This study provides important insights into the intricate dependence of emotional processing, autonomic reactivity and sleep deprivation. The findings of our study show that irregularities in the circadian rhythm as a result of shift work lead to defective sleep quality, errors in socio-behavioural patterns and analytical reasoning and create difficulties in areas where quick decisions for patients' management, such as handling instruments, giving medication to patients and following orders, which are of utmost importance, become questionable. In view of the World Health Organization's high estimates on the occurrence of anxiety and depression in the upcoming decades as a part of occupational hazards, this study recommends a remedial measure to relieve the adverse effect of night shifts and poor sleep quality, sleep hygiene education should be provided early and regularly for all clinical nurses, and managerial and policy-based support should be increased.

Limitations

1. The main limitation of our study was the use of Caucasian static images rather than Indian facial images because of the lack of free availability of the latter.
2. Full-body posturing in dynamic images gives a better representation.
3. The recording of sleep debt and recovery sleep, along with different sleep phases, would have provided meaningful insights.
4. The data collection occurred in the morning. However, it is important to note that for participants in the sleep deprivation group, their circadian rhythm likely dictates a pattern of sleeping during the day and being awake during the night. As a result, while they may not be conventionally sleep-deprived, they would likely experience a physiological urge to sleep in the morning due to their altered sleep-wake cycle.
5. The total duration of the AFRT surpasses 150 min, it is probable that participants encountered fatigue, thus potentially affecting the test's accuracy.

CONCLUSION

Our study found that even a solitary episode of acute sleep deprivation manifested as deteriorated sleep patterns in sleep workers. Female shift workers were more likely to experience anxiety than their male counterparts.

The subjects showed heightened emotional reactivity to negative valence emotions, such as anger and fear. Besides, they exhibited blunted emotional reactivity to positive valence emotions, such as happiness and sadness. There was no significant change in response to neutral valence emotions, such as surprise or disgust.

The HRV measurements suggested that even sleep deprivation can lead to sympathetic overactivity. This is consistent with previous research that has shown that sleep deprivation can lead to sympathetic overactivity.

Acknowledgements

We would wish to thank all our participating nurses and MSAI foreign exchange STS students for being a part of the study.

Ethical approval

The research/study approved by the Institutional Review Board at Jawaharlal Nehru Medical College, Belagavi, number MDC/DOME/77, dated 29th March 2019.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Walker MP. The role of sleep in cognition and emotion. Ann N Y Acad Sci 2009;1156:168-97.
2. Babamohamadi H, Davari H, Safari AA, Alaei S, Pordanjani SR. The association between workload and quality of work life of nurses taking care of patients with COVID-19. BMC Nurs 2023;22:234.
3. Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. Semin Neurol 2005;25:117-29.
4. Triolo PK. Occupational health hazards of hospital staff nurses. Part I: Overview and psychosocial stressors. AAOHN J 1989;37:232-7.
5. Frankland PW, Bontempi B. The organization of recent and remote memories. Nat Rev Neurosci 2005;6:119-30.
6. LaBar KS, Cabeza R. Cognitive neuroscience of emotional memory. Nat Rev Neurosci 2006;7:54-64.
7. Holland P, Lewis PA. Emotional memory: Selective enhancement by sleep. Curr Biol 2007;17:R179-81.
8. Yoo SS, Gujar N, Hu P, Jolesz FA, Walker MP. The human emotional brain without sleep--a prefrontal amygdala disconnect. Curr Biol 2007;17:R877-8.
9. Motomura Y, Kitamura S, Oba K, Terasawa Y, Enomoto M, Katayose Y, *et al*. Sleep debt elicits negative emotional reaction through diminished amygdala-anterior cingulate functional connectivity. PLoS One 2013;8:e56578.
10. Gerhardsson A, Åkerstedt T, Axelsson J, Fischer H, Lekander M, Schwarz J. Effect of sleep deprivation on emotional working memory. J Sleep Res 2019;28:e12744.
11. Herrando C, Constantinides E. Emotional contagion: A brief overview and future directions. Front Psychol 2021;12:712606.
12. Tamm S, Schwarz J, Thuné H, Kecklund G, Petrovic P, Åkerstedt T, *et al*. A combined fMRI and EMG study of emotional contagion following partial sleep deprivation in young and older humans. Sci Rep 2020;10:17944.
13. Fowler LA, Ellis S. The effect of 12 hour shifts, time of day, and sleepiness on emotional empathy and burnout in medical students. Clocks Sleep 2019;1:501-9.
14. Medic G, Wille M, Hemels ME. Short-and long-term health consequences of sleep disruption. Nat Sci Sleep 2017;9:151-61.
15. Available from: https://www.goodmedicine.org.uk/files/assessment,%20pittsburgh%20psqi.pdf [Last accessed on 2023 Aug 03].
16. Available from: https://www.med.upenn.edu/cbti/assets/usercontent/documents/stanford%20sleepiness%20scale.pdf [Last accessed on 2023 Aug 03].
17. Available from: https://www.svri.org/sites/default/files/attachments/2016-0113/HADS.pdf [Last accessed on 2023 Aug 03].
18. Available from: https://www.paulekman.com/product-category/uncategorized/research-products [Last accessed on 2023 Aug 03].
19. Gómez-García T, Ruzafa-Martínez M, Fuentelsaz-Gallego C, Madrid JA, Rol MA, Martínez-Madrid MJ, *et al*. Nurses' sleep quality, work environment and quality of care in the Spanish National Health System: Observational study among different shifts. BMJ Open 2016;6:e012073.
20. Oginska H, Pokorski J. Fatigue and mood correlates of sleep length in three age-social groups: School children, students, and employees. Chronobiol Int 2006;23:1317-28.
21. Goff EA, Nicholas CL, Simonds AK, Trinder J, Morrell MJ. Differential effects of waking from non-rapid eye movement versus rapid eye movement sleep on cardiovascular activity. J Sleep Res 2010;19(1 Pt 2):201-6.
22. Anderson C, Platten CR. Sleep deprivation lowers inhibition and enhances impulsivity to negative stimuli. Behav Brain Res 2011;217:463-6.
23. Bauducco SV, Flink IK, Jansson-Fröjmark M, Linton SJ. Sleep duration and patterns in adolescents: Correlates and the role of daily stressors. Sleep Health 2016;2:211-8.
24. Available from: https://www.diva-portal.org/smash/get/diva2:1499173/FULLTEXT01.pdf [Last accessed on 2023 Aug 03].
25. Minkel JD, Banks S, Htaik O, Moreta MC, Jones CW, McGlinchey EL, *et al*. Sleep deprivation and stressors: Evidence for elevated negative affect in response to mild stressors when sleep deprived. Emotion 2012;12:1015-20.

How to cite this article: Anand NS, Shubhangi M, Martínez Aarli CJ, García Ríos A, Raniello V, Rao S. The influence of desynchronised circadian rhythm on emotional contagion and reactivity: A comparative study. Indian J Physiol Pharmacol. 2024;68:298-304. doi: 10.25259/IJPP_435_2023