

The influence of altered circadian rhythm on sleep quality and cognition among shift workers of KLE Hospital: A comparative study

Sakshi Rao and Nirmala S. Anand^{1*}

Department of Physiology, Jawaharlal Nehru Medical College, KAHER, Nehru Nagar, Belagavi-590010, Karnataka, India

Received: 10th March 2020; Accepted: 25th June 2020; Published: 01st July 2020

Abstract: *Objectives:* In shift workers, the internal biological clock is disrupted, leading to a substantial deterioration in sleep quality and cognitive abilities. Also, critical thinking, analytical reasoning and making quick decisions for patient management which are of utmost importance become questionable. *Aim:* To assess the effect of nighttime sleep deprivation on sleep quality and assessment of cognition in nurses doing night shift by doing a comparative study with age and gender-matched day time working controls. *Materials and Methods:* Ethical clearance was obtained from the institution. The study population of trainee nurses doing night shifts at KLE hospital and age and gender-matched controls doing day duty were selected and enrolled for data collection by inclusion - exclusion criteria and sample size calculation. Pittsburgh Sleep Quality Index questionnaire was used to assess sleep quality over the past 1-month. Montreal cognitive assessment test was conducted to detect the presence of any cognitive impairment among populations assessing 7 components of cognition. *Statistical analysis:* Mean \pm SD was used and 'p value=0.005' was considered statistically significant. *Results:* Mean global PSQI score was 6.68 for shift workers while 5.56 for controls. Mean score for Montreal test was 23.64 for nurses and 27.76 for controls. *Conclusion:* In shift workers, sleep quality was poor and a significant reduction in cognitive functions like execution and memory recall as compared to day time working control population. These findings are related to the irregularities in the circadian rhythm and the natural cycle of sleep and waking, which in turn deteriorates cognitive abilities.

Keywords: Cognition, Shift work, Sleep quality.

Introduction

Young adults (18-25 years) on an average require 7 to 9 hours of sleep, a sleep of shorter duration than that causes sleep deprivation [1]. A person's quality of life can be disrupted due to an important yet underestimated cause which is sleep loss (National Sleep Foundation 2007). A circadian rhythm is a biological process that shows an endogenous, oscillation of about 24 hours and is driven by a circadian clock and persists in the absence of environmental time cues. The suprachiasmatic nucleus (SCN), located in the hypothalamus is the site of a master circadian clock, made of a network of neurons and displays a self-sustained circadian (near 24 hour) rhythm in neuronal firing [2].

The SCN has an important role in coordinating circadian rhythmicity. It does so by

communicating timing information to oscillators in the brain, and almost all the peripheral tissues and organs [3]. The SCN receives information about light through the eyes. The retina of the eye contains "classical" photoreceptors ("rods" and "cones"), which are used for conventional vision and specialized photosensitive ganglion cells, and project directly to the SCN, where they help in synchronization of this master circadian clock [4].

Disruption of the endogenous circadian control mechanism would result in circadian rhythm disorders. At the molecular level (transcription-translation feedback loops) drives circadian rhythms in both SCN and peripheral cells. The endogenous circadian rhythm is synchronized with external environments daily by agents like light,

physical activity, and melatonin. In dark, the inhibitory effect is removed and the release of melatonin inhibits the firing rate of SCN neurons permitting the sleep drive [5]. Retina gives information to SCN which interprets it and passes it to the pineal gland. In response, the pineal secretes the hormone melatonin. The secretion of melatonin peaks at night and decreases during the day and its presence provides information about night-length [6].

Shift work is work that takes place on a schedule outside the traditional 9 to 5 job. It can involve evening or night shifts, early morning shifts, and rotating shifts [NATIONAL SLEEP FOUNDATION]. Our increasingly 24x7, globalized work world demands that some people work at night, have extended work hours. Studies have shown that Shift workers have an altered circadian rhythm and dyshomeostasis [7].

Shift work increases chances of workplace accidents, with studies showing an increase in the rate of accidents linked to the use of sharp instruments and items by medical personnel, as well as medication and diagnostic errors and increased patient death [6], as lack of sleep in shift workers makes them less alert. Studies have linked sleepiness and fatigue to having an effect on memory, psychomotor coordination, information processing, and decision making, all of which are needed to safely and effectively perform a variety of work tasks [8]. Multiple studies have proven beyond doubts that adequate sleep or even power naps alleviate the detrimental side effects of sleep deprivation [9]. Some studies have also shown that higher executive functions remain rather stable during night time [10].

Some say that night shift workers will eventually adjust to their odd hours, being awake at night on their days off. But there is little support for this contention. The conflicting nature of the entity provides a platform that we should intrigue the topic and study in- depth about it.

Aim: To assess the effect of nighttime sleep deprivation on sleep quality and assessment of cognition in nurses doing night shift duties for 3 times a week and regular day duty for rest 3 days by doing a comparative study with age and gender- matched day time working controls.

Material and Methods

Source of data: The study population selected were Nursing staff working at KLE hospital doing night shift duties and age and gender-matched day time working controls. They were enrolled for data collection according to predetermined inclusion and exclusion criteria and sample size calculation.

Sample size estimation:

Expected reduction-(mean) = $d = 13.4$

$SD=40=\sigma$

Power = 80%

α error= 0.05; indicates the probability that differences revealed by statistical analysis really do exist.

One sided $Z\alpha = 1.65$ and β error = 0.2; statistical procedures result in a judgment of no significant differences when the differences do exist.

$Z\beta = 0.84$

$n = [(Z\alpha+Z\beta) \sigma/d^2] = 54.8=55=60$

Inclusion criteria: Nursing staff who are doing hospital duties in shifts, aged between 19-23yrs, without any hearing difficulty as tested by tuning fork, without any visual difficulty as tested by Snellen's and Jaegger's chart, without any muscular disease.

Exclusion criteria: having H/o diabetes or any other major illness, H/o alcohol consumption or tobacco chewing in any form. H/o any psychiatric illness or any medication affecting sleep.

Methodology: Ethical clearance was obtained from the institution before the start of the study. Based on the inclusion - exclusion criteria sample population was chosen. All the participants were explained the nature of the study and a voluntary informed written consent for participation was taken from them before the start of the study. Following tests were conducted: Pittsburg Sleep Quality Index and Montreal Cognitive Assessment Test.

Scoring of PSQI: PSQI had 19 items, was used to measure several different aspects of sleep, seven component scores and one composite score were calculated. The component scoring considered subjective sleep quality, sleep

latency, sleep duration, habitual sleep efficiency, sleep disturbances using sleeping pills and daytime dysfunction. Scoring for each component was done from 0–3. Seven component scores were added to obtain a global PSQI score, ranging from 0 to 21, where lower scores denote a healthier sleep quality.

Scoring of Montreal cognitive assessment test-30-point test done in approximately 10 minutes. The short-term memory recall task (5 points) involves two learning trials of five nouns and delayed recall after approximately three minutes. Visuospatial abilities, multiple aspects of executive functions, attention, concentration, and working memory, language, fluency, orientation to time and place were evaluated. A score of ≥ 26 was considered normal.

Statistical analysis: Statistical analysis involved quantitative variables summarized through mean and standard methods of deviation (Mean \pm SD). ‘p value=0.005’ was considered statistically significant.

Results

Socio-demographic information: 30 nursing staff doing night shift a KLE Hospital and 30 age and gender-matched daytime working controls were selected for the above study and demographic data was plotted.

Demographic Information	
Age	19-23yrs
Gender	Females
Qualifications	Nursing staff doing night shift at KLEH and daytime working controls.
Hours of actual sleep	Average 4-5 hours of daytime sleep in shift workers (nurses) as compared to 6-8 hours of night time sleep in the controls working in day hours.
Substance abuse like smoking, alcohol, etc.	Neither population
History of endocrine disorders.	Nil

Pittsburgh Sleep Quality Index to assess sleep quality over the past 1 month.

Graph-1:Pittsburgh Sleep Quality Index (PSQI)

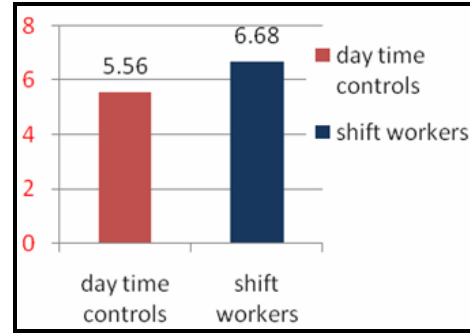


Table-1: Pittsburgh Sleep Quality Index

PSQI	Shift workers	Day time Controls	P value
Mean Score \pm SD	6.68 \pm 3.65	5.56 \pm 4.25	0.004

Montreal Cognitive Assessment test: To detect the presence of any cognitive impairment.

Graph-2: Montreal Cognitive Assessment

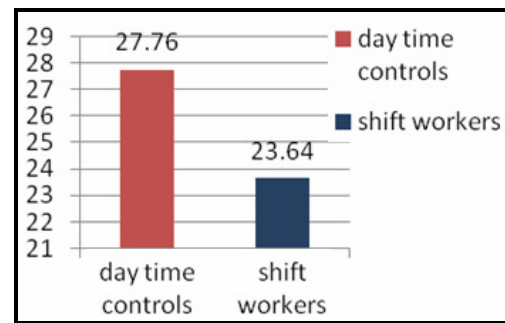
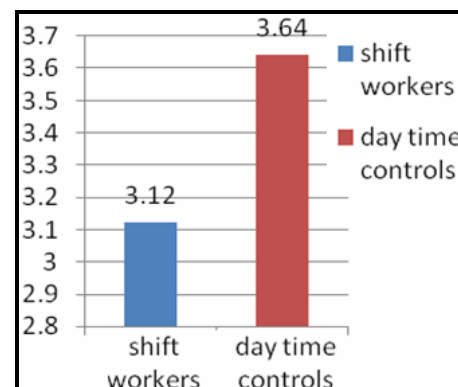


Table-2: Montreal Cognitive Assessment test

MOCA	Day time Controls	Shift workers	p value
Mean Score \pm SD	27.76 \pm 3.11	23.64 \pm 2.45	0.001*

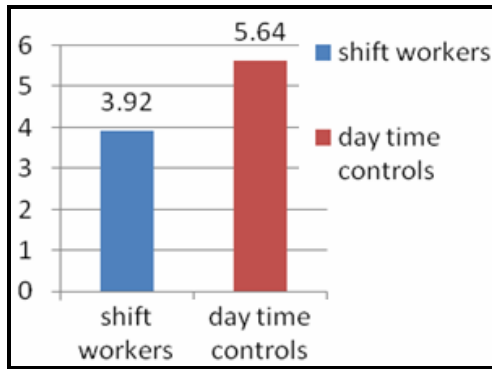
Graph-3: Short term memory recall:



Short term memory recall	Day time Controls	Shift workers	p value
Mean score ± SD	3.64 ± 1.76	3.12 ± 1.54	0.003

Executive functions	Day time controls	Shift workers	p value
Mean score ± SD	4.00 ± 2.32	3.4 ± 1.94	0.005

Graph-4: Attention, Concentration and Working memory

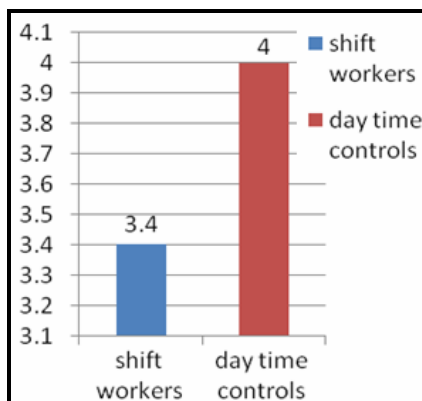


Attention, concentration working memory	Day time Controls	Shift workers	p value
Mean score ± SD	5.64 ± 3.17	3.92 ± 2.65	0.005

Visuo-Spatial Abilities: Mean score of shift workers is 2.92 ± 1.89 and 3.56 ± 1.17 by controls. p value is 0.46 considered non-significant.

Language- Confrontation, Repetition, and Fluency: Mean score obtained by shift workers is 4.76 ± 2.67 and by controls was found to be 6.00 ± 3.97 . p value of 0.35 is considered to be non-significant.

Graph-5: Executive functions



Orientation to time and place: Mean score obtained by shift workers is 6.00 ± 3.74 and 5.92 ± 4.41 by controls. p value = 0.95 is considered to be insignificant.

Discussion

The present study was conducted on *Shift Workers* (Nursing Staff Working at KLE Hospital) to assess the effects of altered circadian rhythm on sleep quality and cognition among them compared with age and gender matched day time working controls. Results obtained showed GLOBAL PSQI score to be on a higher side for shift workers (nurses) as compared to the control population, showing poor sleep quality among shift workers over the past 1 month. Also, sleep duration was reduced among shift workers. Some previous studies done on shift emergency physicians have shown a significant percentage of the participants suffering from poor sleep quality [11].

The mean score of Montreal cognitive assessment test was lower among shift workers, below the normal score of 26 or over. While the control population fits into the normal category, showing that shift workers have cognitive impairments due to their altered circadian rhythm (disturbed sleep-wake cycle). In short term memory recall mean score for nurses was comparatively lower than day time controls. Second component assessed was visuospatial abilities; mean score for nurses was lower than controls.

Executive functions assessment was done in which nurses obtained a mean score significantly lower than controls getting a perfect score. The mean score obtained by nurses in attention, concentration and working memory was much lower to a score obtained by controls. Language component of cognition assessed showed nurses to have a mean score comparatively lower than controls

receiving a perfect score. The last component assessed was orientation to time and place in which both groups obtained a nearly perfect score, showing no association with the altered circadian rhythm. Hence, most components of cognition assessed were found to be significantly impaired.

Studies have shown that Shift workers have an altered circadian rhythm and dyshomeostasis [12], make workers more prone to workplace accidents, with studies showing a boosted rate of accidents linked to the use of sharp instruments and items by medical personnel, as well as medication and diagnostic errors and increased patient death [13]. Several studies have mentioned fatigue to be the main disadvantage of shifts impairing cognitive performance, decrease in alertness [14]. The reason may be the relation observed between cognitive performance and frontal lobe that is vulnerable to sleep deprivation, generally night sleep. Studies have also linked sleepiness and fatigue to decreases in vigilance, reaction time, memory, information processing, and decision making, all of which are needed to safely and effectively perform a variety of work tasks [15].

Decrease in sleep time creates some involuntary episodes called Micro Sleep lasting for around 10-15 seconds, during which there is impairment in memory and alertness, resulting in errors while working [16]. Studies have also shown that sleep deprivation due to shift work can hasten neuroinflammation by selected markers and can subsequently lead to neuro-degeneration, as it is believed that there is alteration in neuro-protective markers and dominance of neuro-inflammatory processes [17]. In addition, sleep deprivation can be responsible for loss of communication skills. Some also say that sleep deprivation reduces the ability to make sound decisions [18].

In the current study also, I found that shift workers have disturbed circadian rhythm, poor sleep quality and majority of cognitive functions were impaired. However; contrary to most studies, some studies did not find any association between shift work and cognition in humans [19], hence studies at a larger scale are required to be conducted to establish relation between shift work and cognition.

Conclusion

The current study pointed out that in shift workers (the resultant fatigue), there was a significant reduction in cognitive functions, poor short-term memory recall, less visuospatial abilities, poor execution, lowered concentration as compared to day time working controls. These findings are related to the irregularities in the circadian rhythm and the natural cycle of sleep and waking, which in turn lead to reduced work performance and deteriorate cognitive abilities like, attention, executive functions, planning and concentration.

Also; critical thinking, analytical reasoning and making quick decisions for patients' management like handling instruments, giving medication to patients, following orders etc. which are of utmost importance becomes questionable. Moreover, the sleep quality among nurses was poor, which was dependent on long working time and short resting time. However, there was no change observed in orientation to time and place. The work assigned to the studied sample of nurses requires them to possess qualities like adequate alertness and consistent performance. If the workers will not possess these qualities, the safety of work would be at risk.

Implications

Nursing skills are required for proper care and handling of the patients. There is need to set limits for working hours, preventive measures like improving lighting in the working environment, and letting staff members take a nap during the shift) should be taken based on scientific evidence to improve both patient's safety and optimize nursing staff learning. So, there should be a proper protocol for work duties that should include an adequate rest period provided to them after a certain assigned period of work hours.

Similarly, it also applies to senior and junior residents, attendants and other night- shift workers involved in critical care of the patients to provide proper care without significantly affecting themselves.

Limitations of research: The responses of all the participants may not be free from biases. Reducing working hours can impose loss to the organization and, therefore, may not be easily accepted in practice.

Financial Support and sponsorship: Nil

Conflicts of interest: There are no conflicts of interest.

Acknowledgment

This is an STS project taken under KAHER; I would like to sincerely thank all the participants who volunteered to be a part of this study as well as the technical support staff.

References

- Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, Carlos LO et. al. National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health*. 2015; 1(4):233-243.
- Swaab DF, Fliers E, Partiman TS Brain. The suprachiasmatic nucleus of the human brain in relation to sex, age and senile dementia. <https://www.ncbi.nlm.nih.gov/pubmed/4041816> (retrieved on-9/03/2020).
- Fukuhara C, Tosini G. Peripheral circadian oscillators and their rhythmic regulation. *Frontiers in Bioscience*, 2003; 642-651.
- Herzog ED, Takahashi JS and Block GD. Clock controls circadian period in isolated suprachiasmatic nucleus neurons. *Nature Neuroscience*, 1998; 1:708-713.
- Yagita K, Tamanini F, van Der Horst GT, Okamura H. Molecular mechanisms of the biological clock in cultured fibroblasts. *Science*. 2001;292(5515):278-281.
- Preitner N, Damiola F, Lopez-Molina L, Zakany J, Duboule D, Albrecht U et al. The orphan nuclear receptor REV-ERB alpha controls circadian transcription within the positive limb of the mammalian circadian oscillator. *Cell Journal*, 2002; 110(2):251-260.
- Eide EJ, Virshup DM. Casein kinase I: another cog in the circadian clock works. *Chronobiology International*. 2001; 18(3):389-398.
- Moore RY, Speh JC, Card JPJ Comp Neurol. The retinohypothalamic tract originates from a distinct subset of retinal ganglion cells. *Journal of Comparative Neurology*. 1995; 352(3):351-366.
- Reppert SM, Perlow MJ, Ungerleider LG, Mishkin M, Tamarkin L et al. Effects of damage to the suprachiasmatic area of the anterior hypothalamus on the daily melatonin and cortisol rhythms in the rhesus monkey. *The Journal of Neuroscience*. 1981; 1(12): 1414-1425.
- Jin X, von Gall C, Pieschl RL, Gribkoff VK, Stehle JH, Reppert SM, Weaver DR. Targeted disruption of the mouse Mel (1b) melatonin receptor. *Mol Cell Biol*. 2003; 23(3):1054-1060.
- Machi MS, Staum M, Callaway CW, Moore C, Jeong K, Suyama J et al. The relationship between shift work, sleep and cognition in career emergency physicians. *Emergency Med*. 2012; 19(1):85-91.
- Akerstedt T. Shift work and disturbed sleep/wakefulness. *Occupational Medicine, Oxford, England*. 2003; 53:89-94.
- Ayas N, Barger L, Cade B et al. Extended work duration and the risk of self-reported percutaneous injuries in interns. *Journal of the American Medical Association*. 2006; 296:1055-1062.
- Smith L, Folkard S, Tucker P, Macdonald I. Work shift duration: a review comparing eight hour and 12-hour shift systems. *Occupation Environ Med*. 1998; 55(4):217-229.
- Lyznicki JM, Doege TC, Davis RM and Williams WA. Sleepiness, driving, and motor vehicle crashes. *Journal of the American Medical Association*, 1998; 279(23):1908-1913.
- Naitoh P. Signal detection theory as applied to vigilance performance of sleep-deprived subjects. <https://pubmed.ncbi.nlm.nih.gov/6665398/>. (Retrieved on -20/6/2020).
- Germain A, Buisse DJ, Nofzinger E. Sleep-specific mechanisms underlying posttraumatic stress disorder: integrative review and neurobiological hypotheses. *Sleep Med Rev*. 2008; 12(3):185-195.
- Alhola P, Polo-Kantola P. Neuropsychiatric Disease Treat. Sleep deprivation: Impact on cognitive performance. *Neuropsychiatric Disease and Treatment*. 2007; 3(5):553-567.
- Devore EE, Grodstein F, Schernhammer ES. Shift Work and Cognition in the Nurses' Health Study. *American Journal of Epidemiology*. 2013; 178(8):1296-300.

Cite this article as: Rao S and Nirmala SA. The influence of altered circadian rhythm on sleep quality and cognition among shift workers of KLE Hospital: A comparative study. *Al Ameen J Med Sci* 2020; 13(3):185-190.

This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial (CC BY-NC 4.0) License, which allows others to remix, adapt and build upon this work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

*All correspondences to: Dr. Nirmala S. Anand, Assistant Professor, Department of Physiology, Jawaharlal Nehru Medical College, KAHER, Nehru Nagar, Belagavi-590010, Karnataka, India. E-mail: nirmala17april@gmail.com, raosakshi98@gmail.com