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Original Article

Physiology Section

Effects of Sleep Deprivation on the Cognitive Performance of Nurses Working in Shift

DEEPALAKSHMI KALIYAPERUMAL[1], YAAL ELANGO[2], MURALI ALAGESAN[3], ISWARYA SANTHANAKRISHANAN[4]

ABSTRACT

Introduction: Sleep deprivation and altered circadian rhythm affects the cognitive performance of an individual. Quality of sleep is compromised in those who are frequently involved in extended working hours and shift work which is found to be more common among nurses. Cognitive impairment leads to fatigability, decline in attention and efficiency in their workplace which puts their health and patients' health at risk.

Aim: To find out the prevalence of sleep deprivation and its impact on cognition among shift working nurses.

Materials and Methods: Sleep deprivation among 97 female and three male healthy nurses of age 20–50 years was assessed by Epworth Sleepiness Scale (ESS). Cognition was assessed by Montreal Cognitive Assessment (MoCA) questionnaire. Mobile applications were used to test their vigilance, reaction time, photographic memory and numerical cognition. The above said parameters were assessed during end of day shift and 3-4 days after start of night shift.

Results: Poor sleep quality was observed among 69% of shift working nurses according to ESS scores. The cognitive performance was analysed using Wilcoxon signed rank test. The MoCA score was found to be lesser among 66% of nurses during night (25.72) than day (26.81). During the night, 32% made more mathematical errors. It was also found that, 71%, 83% and 68% of the nurses scored lesser during night in the Stroop's colour test, vigilance test and memory tests respectively. Thus, impairment in cognitive performance was statistically significant ($p<0.001$) among shift working nurses.

Conclusion: Cognitive performance was found to be impaired among shift working nurses, due to poor sleep quality and decreased alertness during wake state. Thus, shift work poses significant cognitive risks in work performance of nurses.

Keywords: Circadian rhythm, Night shift, Sleep quality

INTRODUCTION

Sleep plays an integral part in the health and well-being of the individual. Sleep is controlled by the Supra Chiasmatic Nucleus (SCN) of the hypothalamus, endogenous clock which regulates the production of melatonin, a hormone that induces sleep [1]. Physiological systems that follow circadian rhythm like sleep-wake cycle, hormone secretions, core body temperature are influenced by signals from the environment especially light [2]. Altered circadian rhythm results in physiological and psychological variations [3].

The recommended sleep duration for a healthy adult is seven to nine hours per day [4]. Shift work results in a conflict between a days oriented circadian physiology and requirement for work and sleep at the wrong biological time of day. Internally driven circadian biological clocks regulate the periods of sleepiness and wakefulness. Disruption of circadian rhythm and inadequate sleep are associated with derangement of physiological functions and leads to obesity, cardiovascular disease, and cognitive impairment. Thus, shift work, night work, and longer, irregular working hours are associated with reduced sleep duration and poor quality of sleep [5,6].

Sleep Deprivation (SD) is defined as, "obtaining inadequate sleep to support adequate daytime alertness" [7]. Long-term SD has a detrimental effect on cognitive function, attention, learning, and working memory and is associated with exaggerated neural reactivity [8]. Moreover, it is also associated with mal adaptations of physiological and behavioral functions. Sleep deprivation affects the ability of health workers who are involved in multitude of life saving tasks which need more attention and concentration. Extended work shifts of twelve hours or longer is common with nurses, whose insufficient sleep puts patients' health and their health at risk [9]. SD among nurses is the major cause for making an error in patient care and significant decrease in vigilance of the job [10]. The aim of this study was to assess the prevalence of SD among nurses working in shift and its impact on their cognitive performance.

MATERIALS AND METHODS

This cross-sectional study was conducted among staff nurses of Peelamedu Samanaidu Govindasamy Hospitals, Coimbatore, Tamil Nadu, India, who were on a rotating work schedule i.e., staff posted to day shift for one month and the same staff posted to night shift for the next one month during August 2016 to September 2016 after obtaining the ethical clearance from the Institution Ethical Committee.

Sample Size

Hundred staff nurses were chosen whose age ranged from 20 years to 50 years. Sample size (96), was calculated considering prevalence of sleep deprivation among staff nurses as 51% with 20 % precision [11].

Inclusion Criteria

Staff nurses of all departments like Medicine, Surgery, OBG, Paediatrics, etc., who were working eight hours shift a day for six days a week, not suffering from any known medical or mental illness and had a previous work experience of at least one year in rotating shift work, were included.

Exclusion Criteria

Staff nurses with a history of medical illness especially neurological diseases, sleep disorders (insomnia, somnolence, etc.,) and smoking, alcohol, any other drug consumption or any medications (within the last 14 days), those who do overtime and other jobs during off duty were excluded from the study.

The participants were informed about the test procedure and a written consent was obtained from them. The staff nurses were assessed for sleep deprivation using the Epworth Sleepiness Scale (ESS) [12]. The ESS was used to measure day time sleepiness and

hence to diagnose sleep deprivation. The probability of falling asleep of the subject was rated from 0 to 3 during eight different situations in their day to day activities, not necessarily every day. The total score was calculated by adding the scores for the eight questions.

The study participants were assessed for any alterations in their cognitive performance as a result of sleep deprivation by using a series of tests. These tests were conducted twice, at the end of their eight hour duration day shift work and end of eight hour duration night shift work after 3-4 days of the commencement night shift. This ensured enough time for the circadian rhythm to reset according to the changed working hours [13]. The tests assessed general intellectual function, numerical cognition, execution, vigilance and memory.

General Intellect

The Montreal Cognitive Assessment (MoCA) Version 7.3 was used to assess various cognitive domains concerned with visuospatial skill, naming, memory recall, attention, language, abstraction, delayed recall and orientation [14]. This test can be easily completed within 10 minutes. The total possible score is 30 points. The scores obtained during the day shift and night shift hours were compared.

Executive Function (Response Inhibition and Working Memory)

Executive function includes control and coordination of cognitive skills like analytical thinking, working memory, planning, cognitive flexibility, analysing the problem and as well as control over attention and inhibition. In this study, response inhibition and visual working memory was assessed. Mobile applications (Confusing colours (stroop test), Memoryze) were used for this purpose [15,16]. Response inhibition was found using an application that worked on the principle of Stroop effect [15].

Attention (Vigilance)

Attention deficit is more commonly reported in sleep deprivation. Failure of vigilant attention affects the individual's ability to respond to stimuli on time. A mobile application (Vigilance test) which works like the Mackworth clock test was used to assess sustained attention. The application only picked up accuracy in terms of number of targets detected and false alarms [17].

Simple Reaction Time

Simple reaction time is the test to assess the processing speed and motor control of the individual by providing a known stimulus to elicit the response. The participant was asked to press a button as soon as a colour change occurs. This was done using a mobile application (reaction time test) [18].

Numerical Cognition (Mental Speed)

The mental speed was assessed by asking the participants to solve a worksheet having 25 maths problems. This worksheet had problems of addition, subtraction, multiplication and division of 2-digit numbers. The time taken for solving the worksheet at different shift hours was noted and compared [19].

STATISTICAL METHODS

Data was analyzed using SPSS Version 19.0. Prevalence of sleep deprivation was expressed in percentage. A Wilcoxon Signed-Ranks test was used to compare non-parametrical values. The p value < 0.001 was considered statistically significant.

RESULTS

Of the 100 participants, 97 of them were females and the rest were male staff nurses. The mean age of the participants was 25.06 years.

The sleep deprivation was assessed at the end night shift work on day 3 or 4 of the night shift. From the scores obtained from ESS, it was found that 69% had disturbed sleep patterns due to shift work. The average ESS score obtained was 9.37 (± 4.225). Majority of the nurses (42%) had mild SD (ESS scores of 8 to 11 [Table/Fig-1].

The maximum score that was obtained in MoCA during night shift and day shift hours was 29 and 30 respectively. The minimum score was found to be 21 during night and 23 during day. The mean score for general intellect and attention was decreased during night, while the mean scores for mental speed and reaction time were increased during the night hours [Table/Fig-2].

Sleep deprivation	Epworth Sleepiness Score	Prevalence (%)
Normal sleep	Less than 8	31
Mild	8-11	42
Moderate	12-15	17
Severe	16-24	10

[Table/Fig 1]: Prevalence of sleep deprivation (n=100).

A Wilcoxon Signed-Ranks test was used to compare these non-parametrical values. This test indicated that MoCA test score obtained during the day shift hours was statistically significantly higher than the scores of night shift hours (Z=-5.872, p<0.001). Also, the scores obtained for execution (Z=-5.056, p<0.001) and memory tests (Z=-5.241, p<0.001) during the day shift hours were significantly higher than those obtained at night. The time taken to complete the math worksheet was significantly lower during the day than at night (Z=-5.762, p<0.001). The response time for the vigilance test was statistically significantly quicker during the day than at night (Z=-7.241, p<0.001). The number of targets detected was significantly higher during the day shift hours (Z=7.163, p<0.001) and the number of false alarms was significantly higher during the night hours (Z=-7.373, p<0.001) [Table/Fig-2].

Domain		Day Shift		Night Shift		Wilcoxon Signed-Ranks Test	
		Mean	SD	Mean	SD	Z*	p
General intellect (MoCA)		26.81	1.368	25.72	1.590	-5.872	<0.001
Mental speed (Maths)		2.14	0.689	2.34	0.740	-5.672	<0.001
Response Inhibition		8.48	4.602	4.91	3.210	-5.056	<0.001
Simple Reaction time		0.33	0.142	0.54	0.148	-7.241	<0.001
Working Memory		12.66	4.848	8.85	4.398	-5.241	<0.001
Attention (Vigilance)	Targets detected	5.03	1.794	2.53	1.666	7.163	<0.001
	False alarms	1.37	1.195	3.07	0.832	-7.373	<0.001

[Table/Fig 2]: Cognitive performance.
*Based on positive ranks (night shift – day shift) p (2 – tail) < 0.001 is statistically significant.

DISCUSSION

Our present study reported 69% of shift working nurses were affected with sleep deprivation. Thus, the poor quality and inadequate quantity of sleep among the participants in the present study could be due to extended shift work (more than 13 to 14 hours for each shift, including transportation time), irregular sleep wake cycle due to their disrupted circadian rhythms. This is in line with the results observed among physicians having the similar work schedules [20].

There has been increased interest in the effects of sleep deprivation among health care personnel's as it relates to patient care. Moreover, working at night and working excessive hours restrict sleep duration, as a result of fatigue concentration decreases and there will be increase in cognitive defects and also leads to compromised health and safety at work [21,22]. Research conducted among night shift residents' and nurses' reported that poor concentration hinders their efficiency, decision making capacity and also causes increased error rates [23].

Our present study aimed to compare cognitive functions of the shift working nurses at the end of the day shift and night shift hours. Better cognitive ability was be reported among those who have never exposed to shift work compared to those who have exposed

to sleep deprivation, altered circadian rhythm and extended shift work duration [10]. Lower level of scores was observed in general intellectual ability, maths, response inhibition, attention, simple reaction time and working memory. This decline may be due to an increase in prevalence of sleep deprivation among shift working nurses, as sleep deprivation affects the frontal and prefrontal cortex [24].

Partial sleep deprivation had brought about a decline in response inhibition during night shift in the present study indicates the greater vulnerability of frontal lobe to sleep deprivation. This is in line with results of the study conducted among BPO workers in India [25].

Working memory and episodic memory was found to be associated with temporal lobe function. As the shift work is known to produce deleterious effects on mental health, which is responsible for the impairment of memory, concentration and thinking ability. We found that visual working memory was better during the day shift than at night. Thus, memory also becomes enslaved to sleep deprivation [26,27]. Moreover, we observed that the maths problems were solved at a slower pace during the night shift hours. Our findings were consistent with the results of a study conducted among a group of interns in the medical field in US [28].

Furthermore, simple reaction time was found to be delayed during the night hours as a result of SD. Vigilance test showed that there were lesser target detections and more false alarms during the night hours. There are studies which prove that tests of vigilant attention during periods of SD are sensitive to both circadian and homeostatic drives and that SD causes an overall slowing of reaction times, results in increased errors of omission and commission, and enhances the time-on-task effect [29-31].

Overall irregularities in circadian rhythm and natural sleep wake cycle resulted in the impairment of cognitive function during the night shift, than at day. Some studies state that, though day and night shift work are of the same duration, those who work night shift are more liable to have sleep deprivation and hence more vulnerable to its various deteriorating effects [32-34].

LIMITATION

ESS is quite reliable and stable measure of sleep quality, it is not as accurate as an actigraph or actimetry sensor in detection of SD. All domains of cognition were also not tested in this study. Moreover, mobile application software utilized to test cognition were subjected to internal face validation due to resource constraints. Further studies on a larger population are needed with the aid of actigraphy to assess the prevalence of SD and its impact on all the cognitive domains.

CONCLUSION

This study shows that SD is prevalent among staff nurses working in shift. The various cognitive domains like general intellect, reaction time, attention, vigilance and memory are impaired as a result of SD, which increases the chances of error at work place. Hence, it is necessary to incorporate measures like rest breaks, napping, exercise, and bright light at work place.

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PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Physiology, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India.
2. Undergraduate Student, Department of Physiology, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India.
3. Professor, Department of General Medicine, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India.
4. Assistant Professor, Community Medicine, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Murali Alagesan,
Professor, Department of General Medicine, PSG Institute of Medical Sciences and Research, Coimbatore-641004, Tamil Nadu, India.
E-mail: muralimd2000@yahoo.com

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