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RESEARCH ARTICLE

Influence of altered circadian rhythm on quality of sleep and its association with cognition in shift nurses

Nagalakshmi Vijaykumar[1], Shashank Kiran[2], Karne S L[1]

[1]Department of Physiology, SDM College of Medical Sciences and Hospital, Dharwad, Karnataka, India, [2]MBBS Student, SDM College of Medical Sciences and Hospital, Dharwad, Karnataka, India

Correspondence to: Nagalakshmi Vijaykumar, E-mail: drlakshmi26@yahoo.com

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ABSTRACT

Background: Exposure to shift works and especially to night shifts goes against the circadian rhythm of the social man which brings about a multitude of disruptive effects on health such as sleep disturbances, day sleepiness, decreased cognitive performance, fatigue, increased risk of accidents, poor quality of life, and vigilance troubles. **Aims and Objectives:** Evaluate sleep quality and its association with cognition among hospital shift working nurses. **Materials and Methods:** This is a cross-sectional study to investigate the quality of sleep and association with cognition among shift working nurses. 50 of each night, day shift workers and those who never exposed to shift work participated in this study (n = 150). Sleep quality and seven domains of sleep, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction were assessed using the Pittsburgh sleep quality index (PSQI) questionnaire. Cognitive performance was ev aluated using reaction time (RT) test. Inter- and intra-group analysis was done using ANOVA and Tukey's *post hoc* analysis using SPSS 20 software. **Results:** Global score of PSQI, subjective sleep quality, sleep duration, and sleep medication was statistically high among night shift nurses suggesting poor sleep quality compared to day shift and controls (P = 0.021, P = 0.021, P = 0.00, P = 0.00). Intragroup analysis shows that simple visual RT and choice visual RT are significantly high in night shift nurses when compared to day shift and controls (P = 0.00). Positive correlationwas found between global PSQI score with RT (r = 0.096). **Conclusion:** Night shift workers have poor quality of sleep when compared to day shift workers and those who were never exposed to shift work. Our study also concludes that poor quality of sleep has strong association with reduced cognition.

KEY WORDS: Biological Clock; Intellectual Function; Shift Workers; Sleep Latency

INTRODUCTION

Sleep is an important biological function; it plays a role in various physiological processes of organisms.[1] Restful sleep provides the basis for physical, mental, and psychological well-being in humans, and sleep deprivation is associated with less productive behavior.[2] Despite common wisdom that sleep is important for sustaining performance, in the daily bustle of life, sleep is sometimes considered to be something of a minor nuisance a perfunctory part of the daily routine, akin to bathing, oral hygiene, and waste elimination. Insufficient sleep is often the norm among many professions, such as medical residents, military personnel, and shift-workers.[3] Technological, economic and social pressures have led to an increase in the number of shift workers.[4] The exposure to shift works and especially to night shifts

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goes against the circadian rhythm of the social man which brings about a multitude of disruptive effects on health such as sleep disturbances, day sleepiness, decreased cognitive performance, fatigue, and increased risk of accidents.[5,6] Night-shift work influences the quality of sleep.[7] Several studies have reported that impaired sleep is a common problem among nurses.[8] Among the dramatic effects of night shift are sleep and vigilance disorders, the alteration of the mental health and the quality of life of the exposed person.[9] Among night workers, 60% complain of sleep disorders and 30% of insomnia.

The term "Sleep Quality Measurement" includes assessing the quantitative aspects of sleep, such as sleep duration, sleep latency, and number of arousals as well as subjective aspects such as depth and restfulness of sleep. The Pittsburgh sleep quality index (PSQI) is a self-rated questionnaire which assesses sleep quality and disturbances over a month time interval.[10]

Cognition is "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses."[11] Cognition is complex and higher order capacities often build on more elementary cognitive functions, such as simple alertness, vigilance, and attention.[3] Reaction time (RT) test is related to cognitive function in healthy subjects and patients. Choice RT test is related to more components of cognitive function. Thus, simple and choice RT tests could serve as bedside measurements reflecting cognitive function.[12] RT is defined as an interval of time between presentation of stimulus and appearance of appropriate voluntary response in subject. RT has physiological significance and is a simple and non-invasive test for peripheral as well as central neural structures.[13] Without some degree of alertness and attention it is not possible to engage in complex cognitive processing. Interestingly, alertness and vigilance also appear to be the cognitive capacities most consistently and dramatically impacted by insufficient sleep.[14] When the envelope of continuous wakefulness is pushed beyond about 16 h, most individuals show a substantial slowing of RT and worsening of performance accuracy on tests of psychomotor vigilance.[15]

Shift work is highly prevalent in industrialized societies (>20%) but, when it includes night work, it has pronounced negative effects on sleep, subjective and physiological sleepiness, performance, accident risk, as well as on health outcomes such as cardiovascular disease and certain forms of cancer. Factors that negatively impact work shift sleepiness and accident risk include long duration shifts >12 h and individual vulnerability for phase intolerance that may lead to a diagnosis of shift work disorder.[16] Studies have shown the impact of shift work on the psychological and physical health of nurses and compared between rotating night shifts and day shifts. The instrument used for data collection was the "standard shift work index," they reported the lowest mean score in the items of job satisfaction, quality and quantity of sleep, with more frequent chronic fatigue, psychological, and cardiovascular symptoms in comparison with the day shift workers, in a statistically significant way.[17] The effects of shift work on sleeping quality, hypertension and diabetes in retired workers were done by Guo *et al.*, after adjusting potential confounders in the logistic regression models, they showed shift work was associated with poor sleeping quality, diabetes, and hypertension independently. They observed significant effects of shift work on poor sleeping quality, diabetes, and hypertension.[18]

Various studies conducted by Machi *et al.* shows the relationship between shift work, sleep, and cognition in career emergency physicians. They have assessed cognition on memory using University of Southern California repeatable episodic memory test, the trail making test, and the Stroop Color-Word Test; their data indicate the high incidence of disturbed sleep in this population leading to decline in short-term memory after day and overnight shifts.[19] Reza *et al.* demonstrated effects of night shifts on cognition in relation to melatonin levels among control room operators (CORs) using a number of objective tests, including continuous performance test, n-back test, and their data suggested to plan for an appropriate number of consecutive night shifts for improving alertness and to ensure safety.[20] We hypothesized that the quality of sleep will be affected in night shift workers which in turn alter their cognition using RT, as there are very less number of works conducted in hospital shift nurses, who bound to shift work by their profession having altered circadian rhythm, we conducted the study aiming to assess influence of altered circadian rhythm on quality of sleep and its association with cognition using RT in shift nurses.

MATERIAL AND METHODS

It is a cross-sectional case-control study which was conducted in the Department of Physiology and hospital after obtaining the Institutional Ethical Clearance.

Sample Size

The study was conducted on three groups of people. Group I was shift nurses doing night shift duty from past 1 week (n = 50) of age group (25–50). Group II was shift nurses who are doing day shift duty from past 1 week (n = 50) of the age group (25–50). Group III was those females who are not exposed to shift work (n = 50) of the age group (25–50) considered as controls. Sample size was decided based on previous references.[16,17] Groups I and II were selected randomly from nursing department based on willingness to participate in the study. Group III was selected randomly from general population. Females with a history of psychoactive substance use, pregnancy, H/O of metabolic disorder, history of consumption of central nervous system

affecting drugs, history of color blindness were excluded from the study.

Study Design

An informed consent was taken before conducting the study. The consent was provided in English and local languages stating that the values and the report will be kept confidential and will be used only for study basis. History of any sleep-related disorders was taken. The test was explained to the subjects and usual history taken.

Assessment of Sleep Quality

PSQI was used to assess subjective sleep quality.[10] Subjects were asked to assess their sleep condition in the previous month. The PSQI is a self-rated questionnaire and comprises questions to assess seven domains of sleep, including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each domain is rated on a 4-point scale (0–3), which generates a total score ranging between 0 and 21. In the questionnaire, 0 points indicated "no problems" while three points indicated a serious problem. The scores for the seven components were added to form one global score.

Assessment of Cognition

Using RT we assessed cognitive function. RT in milliseconds (ms) was measured using RT apparatus (ANAND AGENCIES, 1433/A, SHUKAWAR PETH, PUNE-411002). The visual and auditory stimulus was used to determine simple RT and choice RT. The simple visual reaction involves the stimulus in the form of red light which glows after a brief adjustable fore period (1.5 ms). On perceiving the stimulus (i.e., the red light), the subjects were instructed to press a button with a right finger. The timer starts recording just after the fore period and stops when the button is pressed. The RT is displayed on a LED screen measured in ms.

Similarly, the choice visual reaction involves two stimuli one red and another green light. Either of the two lights glows randomly as controlled by the operator. On perceiving the green light, the subjects were asked to press the right button, and if the red light is seen to glow, subjects were asked to press the button on the left. Both simple and choice auditory RT (in ms) using beep tone and click were determined. Both these procedures were repeated for 3 times, and three readings which appeared on the display were noted. The least reading of the three was taken as subject's best auditory RT and visual RT and recorded in the subject's pro forma.

Statistical Analysis

It is a cross-sectional study conducted to assess the influence of altered circadian rhythm on quality of sleep and its association with cognition in shift nurses. Statistical analysis was performed using SPSS software version 20. Values were expressed as mean ± standard deviation (SD). Statistical analysis was performed by analysis of variance. Intra- and inter-group analysis was performed using Tukey's *post hoc* analysis. $P < 0.05$ was considered as statistically significant and <0.01 as highly significant. Pearson's correlation was used to assess the correlation between quality of sleep with cognition.

RESULTS

It is a cross-sectional study conducted to assess the quality of sleep among shift workers. Values are expressed as mean ± SD. Table 1 demonstrating the demographical characteristics of the participants. The mean age group of night shift nurses, day shift nurses and controls who were never exposed to shift work were 33.50 ± 4.00, 31.23 ± 5.70, and 32.67 ± 5.00 years, respectively. The night shift nurses were on night shift working for an average of 10.98 ± 1.43 h since an average of 6.75 ± 2.65 days. The day shift nurses were on the day shift working for an average of 8.34 ± 1.32 h since an average of 7.43 ± 1.23 days. All the three groups were age-matched.

Table 2 demonstrating the quality of sleep and its various components assessed using PSQI questionnaire among participants. Table shows that global score of PSQI is statistically significant among the three groups. Intragroup analysis shows that global score is significantly high in night shift nurses when compared to day shift and controls.

Table 2 also demonstrating the seven components of sleep compared between three groups. It shows that C1 subjective sleep quality, C3 sleep duration, and C6 sleep medication is statistically significant among the three groups. Intragroup analysis shows that C1 value is significantly high in night

Table 1: Demographical characteristics of the participants (*n*=150)

Characteristics	Night shift nurses (*n*=50)	Day shift nurses (*n*=50)	Controls (*n*=50)
Age (years)	33.50±4.00	31.23±5.70	32.67±5.00
Duration of shift (No of days)	6.75±2.65	7.43±1.23	Nil
Duration of shift (h)	8.00 pm–8.00 am (average 10.98±1.43)	8.00 am–5.00 pm (average 8.34±1.32)	Nil

Values are expressed as mean±SD. SD: Standard deviation

Table 2: Quality of sleep and its various components assessed using PSQI questionnaire among participants (*n*=150)

	Night shift nurses (*n*=50)	Day shift nurses (*n*=50)	Controls (*n*=50)	*F*	*P*	Intragroup analysis
PSQI global score	7.02±1.31	5.40±1.03	4.36±1.54	3.95	0.02*	NVsD-0.03* NVsC-0.05* DVsC-0.98
Subjective sleep quality (C1)	2.04±0.44	1.84±0.50	0.80±0.40	3.96	0.02*	NVsD-0.07 NVsC-0.02* DVsC- 0.90
Sleep latency (C2)	1.18±0.62	1.04±0.49	1.00±0.00	2.09	0.12	NVsD-0.28 NVsC-0.12 DVsC-0.90
Sleep duration (C3)	2.00±0.67	0.50±0.48	0.56±0.50	12.31	0.00**	NVsD-0.00** NVsC-0.00** DVsC-0.75
Habitual sleep efficiency (C4)	0.44±0.57	0.46±0.54	0.24±0.65	2.09	0.12	NVsD-0.98 NVsC-0.21 DVs C-0.15
Sleep disturbances (C5)	1.90±0.50	1.06±0.73	0.92±0.27	1.29	0.27	NVsD-0.30 NVsC-0.98 DVsC-0.40
Sleep medication (C6)	1.10±0.30	1.04±0.19	0.30±0.16	8.05	0.00**	NVsD-0.65 NVsC-0.01* DVsC-0.04*
Daytime dysfunction (C7)	0.42±0.19	0.52±0.12	0.66±0.47	2.67	0.07	NVsD-0.60 NVsC-0.05 DVsC-0.37

N: Night shift nurses, D: Day shift nurses, C: Controls. Values are expressed as mean±SD, *P*<0.05 *considered significant. SD: Standard deviation

shift nurses when compared to controls, C3 is significantly high in night shift nurses when compared to controls and day shift, and C6 is significantly high in night shift nurses when compared to controls.

Table 3 demonstrates cognition assessed using RT (simple and choice visual and auditory) among participants. Table demonstrates that simple visual RT and choice visual RT (SVRT and CVRT) is statistically significant among the three groups. Intragroup analysis shows that SVRT and CVRT is significantly high in night shift nurses when compared to day shift and controls. The difference between CVRT and SVRT is statistically significant among the three groups. Intragroup analysis shows that difference between CVRT and SVRT is significantly high in night shift nurses when compared to day shift. Table also demonstrates that CART is statistically significant among the three groups. Intragroup analysis shows that CART is significantly high in night shift nurses when compared to controls.

Table 4 and Figure 1 demonstrating correlation between cognition using RT and global sleep quality index (global PSQI score) among participants. Table shows a positive correlation between differences of CVRT and SVRT with global PSQI score which is not statistically significant.

DISCUSSION

The present study carried out to observe the influence of altered circadian rhythm on quality of sleep and its association with cognition in shift nurses.

Our study demonstrates the quality of sleep assessed using standard PSQI questionnaire among shift work nurses. Sleep quality was evaluated by the overall score of PSQI which is known to evaluate sleep quality during the month preceding the study. It was used in many other surveys.[21] Our study demonstrates global score is significantly high in night shift nurses when compared to day shift and controls ($P = 0.02$*). It also demonstrates that various components of sleep such as subjective sleep quality sleep duration and sleep medication also significantly high in night shift nurses compared to those who were never exposed to shift work. Our study also demonstrates effect of shift work on cognition using RT in relation to sleep quality. Study shows that increased RT both simple and choice visual and auditory in night shift nurses when compared to controls and day shift workers ($P = 0.01$*) suggesting reduced cognition in night shift nurses which have association with the quality of sleep.

Results of our study are comparable to work done by Kazemi *et al*. who showed that mean final scores of PSQI related to the

Table 3: Cognition assessed using reaction time (simple and choice visual and auditory) among participants (*n*=150)

Reaction time (s)	Night shift nurses (*n*=50)	Day shift nurses (*n*=50)	Controls (*n*=50)	*F*	*P*	Intragroup analysis
SVRT	0.43±0.13	0.30±0.09	0.31±0.05	29.18	0.00**	NVsD-0.00** NVsC-0.00** DVs C-0.70
CVRT	0.55±0.15	0.42±0.12	0.42±0.06	17.55	0.00**	NVsD0.00** NVsC-0.00** DVsC-0.99
CVRT-SVRT	0.12±0.09	0.16±0.10	0.12±0.05	4.37	0.01**	NVsD-0.02* NVsC-0.96 DVsC-0.04*
SART	0.39±0.09	0.36±0.13	0.35±0.03	1.81	0.16	NVsD-0.52 NVsC-0.14 DVsC-0.69
CART	0.56±0.11	0.56±0.15	0.50±0.08	4.37	0.01*	NVsD-0.96 NVsC-0.02* DVsC-0.04*
CART-SART	0.20±0.11	0.18±0.08	0.15±0.06	4.63	0.01*	NVsD-0.37 NVsC-0.00* DVsC-0.21

SVRT: Simple visual reaction time, CVRT: Choice visual reaction time, SART: Simple auditory reaction time, CART: Choice auditory reaction time. Values are expressed as mean±SD. *P*<0.05 considered as significant. SD: Standard deviation

Table 4: Correlation between cognition using RT and global PSQI (global PSQI score) among participants (*n* = 150)

Cognition values using RT	Global PSQI score
CVRT-SVRT (s)	*r*=+0.09 *P*=0.24
CART-SART (s)	*r*=+0.05 *P*=0.21

r=+(positive correlation), *P*<0.05 considered significant.
PSQI: Pittsburgh sleep quality index, RT: Reaction time,
SART: Simple auditory reaction time, SVRT: Simple visual reaction time, CVRT: Choice visual reaction time. CART: Choice auditory reaction time

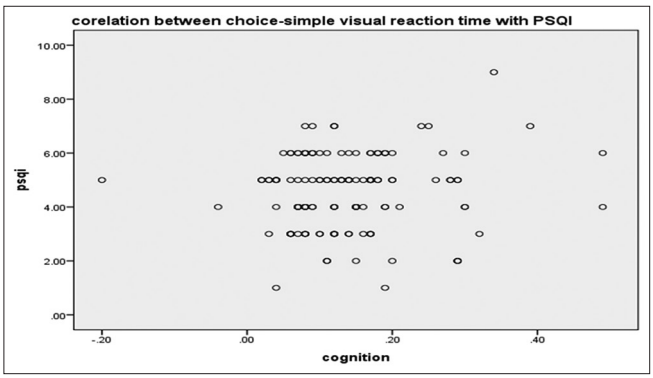

Figure 1: Scatter diagram showing the correlation between reaction time and global Pittsburgh sleep quality index score

day and night shift workers were 8.32 and 9.03, respectively, which are higher than the cutoff point reported by other scholars. This indicates low sleep quality in the petrochemical CORs. However, their study showed no significant difference between the day and night shifts with respect to the final PSQI scores but showed that sleep quality and quantity were lower during the day rather than the night shift. They have also assessed cognitive performance in night shift workers using continuous performance test, n-back test, and simple RT test and demonstrated induced cognitive performance decline at the end of both day and night shifts, and increased sleepiness in night shift.[5] Machi *et al*. used PSQI questionnaire to evaluate sleep quality among shift emergency physicians and indicated that a significant percentage of the participants suffered from poor sleep quality. Sleep quality was worse in emergency physicians (mean PSQI = 4.8, SD ± 2.5) compared to the normal population, with 31% of subjects reporting poor sleep quality. Their data suggest that sleep disruption continues routinely beyond training years and maybe a widespread issue among healthcare providers. They also demonstrated reduced cognition in terms of decline short-term memory after day and overnight shifts and confirms the high incidence of disturbed sleep in this population.[19] A study was done by Kazemi *et al.* set out to measure the quality of sleep after different consecutive night shifts (7 vs. 4) among CORs. Sleep quality and quantity, as well as PSQI score, were compared between the two shift types. There was no difference between participants in the two shifts in terms of sleep quality and sleep quantity ($P > 0.05$). Nevertheless, the PSQI score in the 4N shift participants was higher than that in their 7N shift counterparts.[20] Zhang *et al.* demonstrated sleep quality among female hospital staff nurses. The Chinese version of the PSQI (C-PSQI) was used to assess subjective sleep quality. Among the staff nurses, 75.8% had a PSQI score of ≥5 and 39.8% had an inadequate stable sleep ratio on subjective measures.[8] Hemamalini *et al.* evaluated cognition using neurophysiological and neuropsychological

tests in rotating night shift workers who did rotating night shifts for at least for 6 months. Student's unpaired *t*-test showed a significant difference in the various neuropsychological tests and the latency of P300 between night- and day-shift workers. The study demonstrated that night-shift workers who are prone to circadian rhythm alteration will have impaired cognitive performance.[22]

Postulated Mechanisms

Sleep is the main function disturbed by night shift. There is reduction of sleep duration among night workers due to the obligation to sleep during the usual early hours, especially when the surrounding conditions are unfavorable (light, noise, and temperature).[23] Study was done by Rutenfranz *et al.* found that almost 70% of night workers complain of sleep disorders, assessing their sleep as insufficient, unsatisfactory, and little restorative.[24] Light and rapid eye movement sleep seems to be the phases most affected. Night workers' most reported subjective complaints are early morning waking and the sensation of unrefreshing sleep.[24] A study was done by Wided *et al.* showed hospital night shift among nurses leading to poor quality of sleep, the quality of life, and vigilance troubles because night shift goes against the circadian rhythmicity of the social man, which brings about a multitude of disruptive effects on health.[25] The decline in cognition could be attributed to irregularities of circadian rhythmicity in shift workers as well as the fatigue caused by long working time.[26] As demonstrated in several studies, fatigue is among the main disadvantages of 12-h shifts that can impair cognitive performance, reduce alertness level, and increase the risk of accidents.[27] The results of this study also showed that the parameters related to attention would be more negatively affected on the night rather than the day shift. The reason may lie in the relationship between cognitive performance and frontal lobe as well as the frontal part of the brain that is vulnerable to sleep deprivation, in general, and night sleep, in particular.[28] Sleep deprivation interferes with the functioning of certain brain areas and thus impairs cognitive performance. This approach is also referred to as the "sleep-based neuropsychological perspective." Perhaps the most famous theory in this category is the prefrontal vulnerability hypothesis, suggests that sleep deprivation especially impairs cognitive performances that depend on the prefrontal cortex. These include higher functions, such as language, executive functions, divergent thinking, and creativity.[29]

Limitations of Study

Less sample size is one of the limitations of the study; measurement of melatonin levels should have done to prove poor quality of sleep.

CONCLUSION

Our study concludes that night shift workers have a poor quality of sleep when compared to day shift workers and those who were never exposed to shift work. Our study also concludes that poor quality of sleep has strong association with reduced cognition.

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