

ORIGINAL RESEARCH

The impact of shift work on sleep quality and circadian patterns of heart rate variability among nurses working in a tertiary care hospital

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Abstract

Background: Sleep is a bio-physiological process essential for maintenance of homeostasis. Disturbances of the sleep-wake cycle may cause sympatho-vagal imbalance and influence the adaptability of the cardiovascular system.

Objective: This study investigated the influence of morning and night shift work on sleep quality and circadian patterns of heart rate variability in female nurses working in a tertiary care hospital. **Methods:** Thirty-eight healthy female nurses were recruited. Time and frequency domain parameters of heart rate variability (HRV) were measured and used as markers of cardiac autonomic function. Student t-test was used to investigate differences in HRV between morning and night shift workers. Mann-Whitney non-parametric test was applied for the difference between PSQI scores in the two groups. **Results:** SDNN(msec), Total Power (ms^2) and HF band power (ms^2) were significantly decreased in night shift nurses compared to morning shift nurses. LF/HF ratio was significantly increased in night shift nurses. The differences in all other HRV parameters—SDaNN(msec), RMSSD, mean NN, VLF band power (ms^2) and LF band power (ms^2) were not statistically different. The Global PSQI score was significantly higher among night shift workers than in morning shifts. **Conclusion:** Sleep deprivation can cause autonomic dysregulation among night shift nurses and predispose to cardiovascular morbidity and mortality.

Keywords: Circadian rhythm, Heart rate variability, Insomnia, Shift work, Pittsburgh Sleep Quality Index

Introduction

Healthcare providers such as nurses are bound to work in shifts to ensure continuous patient care services in the hospital. International Labour Organization defines shift work as the 'extension of working hours beyond standard daylight (8:00 AM to 5:00 PM) where the workers work in succession to one another.'¹The shifts can be morning shifts versus night shifts with the shift duration varying from 12 hours or even longer depending on the hospital staff's availability.²However, concomitant sleep disturbances due to frequent night shifts may cause a deleterious impact on the nurse's physical and psychological health leading to increased chances of medical errors and compromised patient care services in the hospital.³A nurse working during the night attempts to sleep during the daytime when her biological clock is adjusted for the awakening phase. Nonetheless, day sleep is less deep, interrupted, and 2-4 hours shorter than night sleep.⁴Moreover, working during night hours (when the body anticipates rest) may impose an extra burden on the cardiovascular system due to a circadian misalignment of the work/rest cycle.⁵ Irregular sleeping patterns due to rotating night shifts can lead to circadian disruption and shift the amplitude and timing of peak melatonin levels. Short-term circadian misalignment and sleep restriction independently impair physiological processes, including insulin sensitivity, energy expenditure, immune function, blood pressure, and cardiac modulation by the autonomous nervous system.⁶ If allowed to persist, these acute effects may lead to the development of cardiometabolic diseases in the long term.

Shift workers recover from work stress during weekends and holidays. If there is an insufficient time gap between the work shifts, it leads to poor recovery causing health issues like hypertension, cardiovascular diseases, gastrointestinal diseases, hormonal disturbances, reduced immunity, and chronic fatigue.⁷ Due to chronic sleep deprivation and persistent sleep debt, they have psychological problems like irritability, depression, and disputes in personal relationships. poor performance at work, job dissatisfaction, and social isolation.⁸Shift work and accompanying disruption of circadian rhythm may shift the autonomic cardiac balance towards sympathetic dominance during both working hours and sleep, this can be non-invasively evaluated using heart rate variability. Heart rate variability (HRV) analysis has been widely used as a non-invasive and reliable tool to evaluate cardiovascular autonomic control in health and disease.⁹ A reduction in HRV is an indicator of an imbalance in autonomic function and could be associated with an increased risk of morbidity and mortality. Shift work has been

associated with elevated blood pressure (BP) and decreased heart-rate variability (HRV), factors that may increase the long-term risk of cardiovascular-related mortality and morbidity.¹⁰The sleep disturbances are assessed using the Pittsburgh Sleep Quality Index (PSQI) a self-administered 19-item instrument that includes seven components assessing sleep quality, onset, latency, duration, efficiency, any disturbance, use of sleep medication, and daytime dysfunction. The global sleep score range ranged between 0–21, with higher scores representing poor sleep quality.¹¹ The Cronbach alpha coefficient for all component scores (0.83) indicated high internal consistency. When used to identify patients with sleep disorders, a total PSQI score ≥ 5.0 has a sensitivity of 90% and a specificity of 87%.¹²The impact of performing shift work on the health of nurses working in hospitals, although not discussed extensively in the literature, is worth exploring. This cross-sectional comparative study was undertaken, using subjective and objective data collection methods, to investigate the impact of working in shifts on nurses' health by analysing the differences in heart rate variability and global sleep scores of nurses working under day and night shifts.

Materials and Methods:

This cross-sectional comparative study was conducted from 10th Jan 2022 to 12th Nov 2022 to investigate the impact of working in shifts on nurses' health by analysing the differences in heart rate variability and global sleep scores of nurses working in morning and night shifts.

Participants

The study groups comprised 38 female healthcare workers aged between 18-50 years (mean age 29.2 ± 6.0) recruited from casualty and wards of Government Institute of Medical Sciences, Greater Noida.

Group 1: Nurses working in morning shifts (working hours for the morning shift were from 9 am to 2 pm)

Group 2: Nurses working in night shift (working hours for the night shift were from 9 pm to 9 am)

The inclusion criteria were the female nurses who have worked at least 40 hours per week in the day/night shift for at least one year. Pregnant, subjects with H/o smoking, chronic alcoholism, frank diabetes, cardiovascular disease, neurological, renal, or any organic disease, or subjects receiving medication for any acute and chronic illness were excluded from the study. Also, the nurse administrators were not included. The purpose and procedure of the study were explained to the subjects. The written informed consent from the subjects and clearance from the GIMS research committee and Institutional ethics committee were obtained before the commencement of the study.

Data collection

Data including name, age, if married or not, have children or not, work experience(years), and working area was noted. After recording height, weight, BMI, details of medication, and personal history, subjects were allowed 10 min supine rest on the couch. Basal supine blood pressure and heart rate were measured by using a digital blood pressure monitor. Following the short-term HRV, sleep quality was measured using the Pittsburgh Sleep Quality Index.

Short-term Heart Rate Variability: The subjects were asked to lie comfortably on a couch and relax for 10 minutes. They were informed about the procedure to alleviate anxiety. ECG recording was done for 10 minutes for short-term heart rate variability (HRV) analysis by following the standard procedure as recommended by Task Force on HRV1996.¹³ For this purpose, an HRV recording device (Lab Chart Pro 8, AD instruments, Harvard Apparatus Ltd. UK) was connected and Lead II ECG was acquired. The data was transferred from the recording device to a Windows-based PC. After removing ectopics and artefacts, the RR tachogram was extracted from the edited 300-sec epoch using the R wave detector and was saved in ASC-II format for HRV analysis. Software version 1.1 Kubois, Finland was used. Time-domain parameters were measured: mean HR, Root Mean Square of Successive Differences between adjacent NN intervals (RMSSD), Standard deviation of normal-to-normal interval (SDNN). Frequency domain parameters like Total power of HRV (TP), Low-frequency (LF) power, High-frequency (HF) power, very low frequency (VLF) power and the ratio of low-frequency to high-frequency power (LF-HF ratio) were recorded.

Pittsburgh Sleep Quality Index (PSQI)¹¹ is an effective self-report questionnaire scale to check sleep patterns and quality in adults. It distinguishes poor from good sleep quality by checking seven measures in the last month: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbances, 6) use of sleeping medications, and 7) daytime dysfunction. The first four questions are open forms and the remaining are 0–3 Likert-type scales. A five or greater score indicates poor sleep quality.

Statistical analysis: The data was exported to the Statistical Package of Social Sciences version 20.0 and analysed for descriptive statistics using frequency and proportions. Student t-test was used to investigate differences in HRV

between morning and night shift workers. Mann-Whitney non-parametric statistical test was applied to test for the difference between scores of PSQI in the two compared groups. All statistical analyses were carried out at a 5% level of significance and a p-value of 0.05 was considered significant.

Results:

Participant demographics :Age, BMI, education level, marital status, and work experience are shown in Table 1. The total number of the study subjects was 38 female nurses aged between 18-50 years (mean age 29.2 ± 6.0).As regards educational status,71.4%(30) were graduates while 12(28.6%) had done post-graduation. 78.6% of the participants had worked for 1-2 years in the hospital while 21.4%(9) had >2 years of work experience. Most of the participants(78.6%) were married and only 9 (21.4%) were unmarried.

Table 1 shows the study population’s demographic characteristics

Parameters	Total population(n=38)	Morning shift nurses (n=19)	Night shift nurses(n=19)
	Mean± SD		
Age(years)	26.24 ±3.52	24.14 ± 2.02	22.34 ± 1.52
BMI(Kg/m ²)	23.8 ± 4.33	24.38± 5.20	23.48 ± 3.83
	n(%)		
Education level			
Graduate	30(71.4%)	10(66.7%)	20(74.1%)
Post Graduate	12(28.6%)	5(33.3%)	7(25.9%)
Marital status			
Unmarried	33(78.6%)	14(93.3%)	19(70.4%)
Married	9(21.4%)	1(6.7%)	8(29.6%)
Work experience			
1-2 years	33(78.6%)	14(93.3%)	19(70.4%)
>2 years	9(21.4%)	1(6.7%)	8(29.6%)

Table2 depicts differences in mean values of HRV variables between day and night shift nurses. SDNN(msec),Total Power (ms²) and HF band power (ms²) were significantly decreased in night shift nurses compared to morning shift nurses. LF/HF ratio was significantly increased in night shift nurses. The differences in all other HRV parameters– SDaNN(msec), RMSSD, mean NN, VLF band power (ms²) and LF band power (ms²) were not statistically different.

Table 2 depicts differences in mean values of HRV variables between morning & night shift nurses

	Morning shift nurses n=19	Night shift nurses n=19	t	P value (morning versus night shift)
	Mean ± SD	Mean ± SD		
Mean HR (bpm)	85.50 ± 12.62	86.18 ± 6.14		0.870
SDNN (msec)	72.35 ± 15.76	62.18 ± 11.58	2.52	0.02
SDaNN	73.24 ± 44.71	62.14 ± 40.07	0.96	NS
RMSSD (ms)	73.19 ± 44.61	63.21 ± 37.82	1.09	NS
Total Power (ms ²)	6017.62± 5030.21	3728.51 ± 3496.66	2.43	0.03
VLF (ms ²)	1082.06 ± 159.79	1046.22 ± 267.25	0.78	NS
LF (ms ²)	1040.66 ± 1365.08	1439.89 ± 965.6	1.57	NS
HF (ms ²)	2485.82 ± 3103.02	985.07 ± 1289.08	2.89	0.01
LF/HF ratio	1.76 ± 0.58	2.18 ± 0.92	2.16	0.04

VLF: Very Low-Frequency Spectral Power (0.003–0.04 Hz); LF: Low-Frequency Spectral Power (0.04–0.15 Hz); HF: High-Frequency Spectral Power (0.15– 0.4); LF/HF: Ratio Between Low and High Frequency Components; Total Power-Sum of VLF, LF, and HF; SDNN: Standard Deviation of the NN intervals; SDANN: Standard Deviation of the averages of NN intervals in all 5-minute segments of the entire recording; RMSSD: Square root of the mean squared differences of successive NN intervals

Table: 3 shows Pittsburgh Sleep Quality (PSQI) components of Morning and Night shift Nurses

Pittsburg Sleep Quality Index (PSQI) components	Morning shift nurses (n = 19) Mean (± SD)	Night shift nurses (n = 19) Mean (± SD)	Mann whitney test	p-value: Morning shift versus night shift
Global PSQI score	3.0 ± 3.0	7.0 ± 4.1	80.97	<0.001
Sleep duration score	7.2± 1.5	7.6 ± 1.2	7.49	<0.001
Sleep latency score	1.0 ± 0.9	2.0 ± 0.9	65.69	<0.001
Last month trouble sleeping	1.0 ± 0.9	0.6 ± 1.0	28.37	<0.001
Last month intake of medicine to sleep	1.3 ± 0.9	0.4 ± 0.7	79.49	<0.001
Last month trouble staying awake	0.6 ± 1.0	0.1 ± 0.4	44.66	<0.001
Last month overall sleep quality	0.2 ± 0.5	0.8 ± 1.1	36.62	<0.001
Last month intake of medicine to sleep	0.4 ± 0.7	1.3 ± 0.9	79.49	<0.001

As shown in table 3, the mean score of all components of PSQI (last month overall sleep quality, sleep latency, actual sleep, sleep hours, last month trouble sleeping, last month intake of medicine to sleep and last month trouble staying awake) were significantly higher among night shift workers than those with morning shifts. In addition, the Global PSQI score was significantly higher among workers with night shifts than those with morning shift (7.0 ± 4.1 versus 3.0 ± 3.0).

Discussion

Sleep is a bio-physiological process essential for sound health and homeostasis. Disturbances of the sleep-wake cycle may cause sympatho-vagal imbalance and cause undesirable health consequences. The study aimed to investigate sleep quality and Heart Rate Variability parameters as an indicator of autonomic function among female nurses employed in morning and night shifts in a tertiary care hospital. According to our study, Shift work caused a negative impact on HRV parameters in both time and frequency domains. Our study findings are consistent with study⁴ done by Shen SH in which the incidence of abnormal HRV among the participants was statistically significant. This was also in agreement with another study⁸ where significant inter-group differences were noted in LF, HF, TP, and SDNN power and the study conducted by Matheson et al.¹⁴ where shift work caused detrimental effects on physical and psychological health of the nurses. We reported a high LF/HF ratio and a decrease in other parameters of HRV among night shift workers in accordance with the studies done by Wehrenset al. in shift workers¹⁵ and Cebeci et al¹⁶ in medical doctors. Similarly, Garde et al.,¹⁸ concluded in their study that the shift work system was one of the main factors causing adverse effects on the physical and mental health of nursing staff. Niu et al¹⁹ found shift work impairs heart rate variability and increases the risk of cardiovascular disease. The impact of working in shift systems on participants' parasympathetic activity was statistically significant. However, our findings were dissimilar to Ito et al.²⁰ studies, where Heart Rate Variability variables and did not differ between day and night shifts. In our research, the mean score of all components of PSQI and global scores were significantly higher among night shift workers than those with morning shifts. Our results are similar to the findings of Shu-Hua Shen et al.¹⁷ and Matheson et al.¹⁴ in which shift work causes poor sleep quality in nurses. However, the results differed from the study⁷ where no major differences were reported in the symptoms of sleep.⁷ may be due to circadian adaptation to duty hours among night shift nurses. In yet another study⁶, workers with good sleep quality represent 79.7% of the non-shift group compared to only 32.4% of the shift group. This finding is in accordance with what has been reported in a study conducted in Japan that showed that Nurses working rotating shifts experienced more sleeping problems and sleepiness at work than nurses working continuous day/night shifts¹⁷. Many hospitals adopt shift systems to ensure round-the-clock patient care in the hospitals. Continuously working under a night shift system causes adverse effects on the health of nurses. Thus it is necessary to pay attention to and monitor the hazards of work rotation or sleep deprivation on sleep quality and HRV parameters. If appropriate timely measures are not taken, the quality of nursing services may deteriorate and some nurses may even choose to quit.

Strength and Limitations: The main strength of our study is the objective measurement of HRV parameters as a measure of autonomic dysregulation in nurses. The short-term HRV using 5 min ECG recording at the end of the shift was recorded. However, 24-hour ECG recording would yield more accurate findings. The limitations of the study also include missing the details of shift work- frequency and duration. Shift work status was asked using a single question, whether they worked in morning or night shift. Also, future research can be extrapolated by increasing the number of subjects and duration of the study

Conclusion

Many hospitals adopt shift systems to ensure continuous nursing care and increase efficiency in arranging nurses' work schedules. The night shift work system is one of the main factors causing adverse effects on the physical and mental health of nurses, with the shift workers, years of service, and nurses' status as a parent significantly intensifying the incidence of anxiety and abnormal parasympathetic activity. If nurses continue to work in stressful environments, which may cause adverse health effects in the long run, the quality of nursing services may decrease and some nurses may even choose to leave the profession. Hence, Knowledge about shift work arrangements and understanding how to mitigate the negative effects of shift work is crucial for safety and disease prevention in shift workers.

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