Influence of shift work on sleep quality and circadian patterns of heart rate variability among nurses

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ABSTRACT

Background: Shift work implementation is essential for providing continuous patient care in hospitals. However, working in shifts on a routine basis may disrupt the circadian pattern and alter the sleep-wakefulness cycle in nurses. Stress due to shift work can influence the adaptability of the cardiovascular system, produce psychophysiological strain and deteriorate work performance in female nurses. **Objective:** This study investigated the effect of morning and night shift work on sleep quality and circadian patterns governing heart rate variability (HRV) in female nurses working in a tertiary care hospital. **Methods:** Thirty-eight healthy female nurses were recruited. Frequency and time domain parameters of HRV were recorded as markers of cardiac autonomic function. A 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 Pittsburgh Sleep Quality Index (PSQI) scores in the two groups. **Results:** Standard deviation of the normal-to-normal interval (SDNN) (msec), total power (ms^2) and high-frequency (HF) band power (ms^2) were significantly reduced in night shift nurses than in morning shift nurses. The low-frequency (LF)/HF ratio was significantly increased in night shift nurses. The differences in standard deviation of the averages of NN intervals (SDaNN) (msec), root mean square of successive differences between adjacent NN intervals (RMSSD), mean NN, very low-frequency (VLF) band power (ms^2) and LF band power (ms^2) were not statistically significant. The global PSQI score was significantly higher among night shift workers than in morning shifts. **Conclusion:** Inadequate sleep can disrupt the body's ability to regulate heart rhythm and increase the risk of cardiovascular diseases and mortality. The research suggests a propensity for autonomic imbalance in night shift workers when compared to their counterparts on morning shifts.

Keywords: Circadian rhythm, insomnia, night shift work, nursing, sleep-wake disorders

Introduction

Healthcare providers such as nurses work in shifts to ensure continuous patient care services in the hospital. The International Labour Organisation describes shift work as the 'extension of duty hours beyond standard daylight' (8:00 a.m. to 5:00 p.m.) where the workers work in succession to one another.[1] The shifts can be morning shifts versus night shifts with the shift duration varying from 12 hours to even longer depending on the hospital staff's availability.[2] However, concomitant sleep disturbances due to frequent night shifts may have 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.[3]

A 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.[4] Moreover, working during the night hours (when the body anticipates rest) may impose an extra burden on the cardiovascular system due to a circadian

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DOI:
10.4103/jfmpc.jfmpc_158_24

How to cite this article: Panwar A, Bagla RK, Mohan M, Rathore BB. Influence of shift work on sleep quality and circadian patterns of heart rate variability among nurses. J Family Med Prim Care 2024;13:3345-9.

misalignment of the work/rest cycle.[5] The irregular sleep patterns associated with rotating night shifts can disturb the body's natural circadian rhythm leading to shifts in the amplitude and timing of melatonin peak levels. Short-term circadian misalignment and sleep deprivation can independently affect insulin sensitivity, immunity, blood pressure (BP) regulation, and cardiac autonomic regulation.[6] If these disruptions persist, they may increase the risk of cardiometabolic diseases over time.

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, disputes in personal relationships, sub-standard work performance and experiencing social isolation.[8] Shift work and the 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 measured using heart rate variability (HRV).

Analysis of HRV is a non-invasive and reliable tool to measure cardiovascular autonomic control in health and disease.[9] Shift workers show a rise in BP and reduced heart-rate variability parameters, factors that may increase the long-term risk of cardiovascular-related mortality and morbidity.[10]

Sleep quality is assessed using the Pittsburgh Sleep Quality Index (PSQI), a self-administered instrument comprising 19 items viz. sleep onset, quality, duration, latency, efficiency, sleep disturbances, sleep medication, and daytime insomnia. The global sleep score ranges between 0 and 21, and higher scores are indicative of poor sleep quality.[11] The Cronbach alpha coefficient score (0.83) meant high internal consistency. When used to identify patients with sleep disorders, a total PSQI score ≥5.0 has 90% sensitivity and 87% specificity.[12]

Although the impact of shift work on the health of hospital nurses has not been extensively studied in existing literature, it is an important area to investigate. This cross-sectional comparative study aimed to explore the effects of shift work on nurses' health by examining differences in HRV and overall sleep quality using both subjective and objective data collection methods.

Materials and Methods

This study was conducted from 10 January 2022 to 12 November 2022 to investigate the impact of working in shifts on nurses' health by analysing the differences in HRV and global sleep scores in morning and night shift nurses.

Participants

The study groups consisted of 38 female healthcare workers aged between 18 and 50 years (mean age: 29.2 ± 6.0) recruited from

casualties and wards of the Government Institute of Medical Sciences, Greater Noida.

Group 1: morning shift nurses (working hours for the morning shift were from 9 a.m. to 2 p.m.)

Group 2: night shift nurses (working hours for the night shift were from 9 p.m. to 9 a.m.)

The female nurses who have worked at least 40 hours per week on the day/night shift for at least one year were recruited for the study. Nurses who were pregnant, smokers, diabetic, with H/o cardiovascular disease, neurological, renal, or any other organic disease were excluded from the study. Also, the nurse administrators were excluded. The method and objective of the study were explained to the subjects. The study commenced after obtaining written informed consent from the subjects and clearance from the Government Institute of Medical Sciences (GIMS) research committee and institutional ethics committee.

Data collection

Data including name, age, if married or not, have children or not, the experience of work (in years), and the working department were collected. After recording height, weight, body mass index (BMI), details of medication, and personal history, subjects were allowed 10 min supine rest on the couch. Basal supine BP and heart rate were measured with a digital BP monitor. Following the short-term HRV recording, sleep quality was assessed using the PSQI.

Short-term HRV: The subjects were requested to relax on a couch for 10 minutes to alleviate anxiety. A ten-minute electrocardiogram (ECG) recording was done for short-term HRV analysis as recommended by the task force on HRV in 1996.[13] For this purpose, an HRV recording device (LabChart Pro 8, ADInstruments, Harvard Apparatus Ltd., UK) was connected, and a lead II ECG was taken. The data were then transferred to a Windows-based PC. Ectopics and artefacts were removed, and the RR tachogram was extracted from the edited 300-s epoch using the R wave detector and 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), and standard deviation of the normal-to-normal interval (SDNN). Frequency domain parameters like the 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.

PSQI[11] is a self-administered scale to check sleep quality. On the basis of 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 are open-ended and the remaining are 0–3 Likert-type scales. A global score of 5 or more is indicative of poor sleep quality.

Statistical analysis

The data were exported to the Statistical Package of Social Sciences version 20.0 and analysed for descriptive statistics using frequency and proportions. A 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 at a 5% level of significance and a *P* value of 0.05 was considered statistically significant.

Results

Participant demographics

Age, BMI, education level, marital status, and work experience are included in Table 1. The total number of study subjects was 38 female nurses aged between 18 and 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. Moreover, 78.6% of the participants had 1–2 years of work experience in the hospital, while 21.4% (nine) had >2 years of

work experience. Most of the participants (78.6%) were married and only nine (21.4%) were unmarried.

Table 2 depicts differences in mean values of HRV variables between day and night shift nurses. SDNN (msec), TP (ms²) and HF band power (ms²) were significantly decreased in night shift nurses compared to morning shift nurses. The LF/HF ratio was significantly increased in night shift nurses. The differences in all other HRV parameters – standard deviation of the averages of NN intervals (SDaNN) (msec), RMSSD, mean NN, VLF band power (ms²) and LF band power (ms²) – were not statistically different.

Average scores for psychometric measures of sleep among morning and night shift nurses in Table 3, it is obvious that sleep latency time was longer in the night shift compared to morning shift workers. This difference was statistically significant, *P* < 0.001. The night shift worker group exhibited significantly higher PSQI global scores (7.0 ± 4.1 versus 3.0 ± 3.0 with *P* < 0.001), longer total sleep time (7.6 ± 1.2 versus 7.2 ± 1.5 hours with *P* < 0.001), and greater use of sleeping medication (1.3 ± 0.9 versus 0.4 ± 0.7 with *P* < 0.0001) as compared to day shift workers.

Discussion

Quality sleep is fundamental for physical health, cognitive function, emotional well-being, and overall quality of life. Disturbances of the sleep-wake cycle may cause sympathovagal imbalance and undesirable health consequences.[4] The study aimed to investigate sleep quality and HRV 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 negatively impacted HRV parameters in both time and frequency domains. Our study findings are consistent with the study[4] done by Shen SH, in which the incidence of abnormal HRV among the participants was statistically significant. This was also in agreement with another study,[8] 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

Table 1: The study population's demographic characteristics

Parameters	Total nurses (*n*=38) Mean±SD	Morning shift nurses (*n*=19)	Night shift nurses (*n*=19)
Age (years)	26.24±3.52	24.14±2.02	22.34±1.52
BMI (kg/m²)	23.8±4.33	24.38±5.20	23.48±3.83
Education level			
Graduate	30 (71.4%)	10 (66.7%)	20 (74.1%)
Postgraduate	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%)

BMI=Body mass index

Table 2: Depicts differences in mean values of HRV variables between morning and night shift nurses

	Morning shift nurses *n*=19 (Mean±SD)	Night shift workers *n*=19 (Mean±SD)	*t*	*P* (morning time versus night time)
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 (ms²)	6017.62±5030.21	3728.51±3496.66	2.43	0.03
VLF (ms²)	1082.06±159.79	1046.22±267.25	0.78	NS
LF (ms²)	1040.66±1365.08	1439.89±965.6	1.57	NS
HF (ms²)	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 five-minute segments of the entire recording; RMSSD: square root of the mean squared differences of successive NN intervals

Table 3: Components of the Pittsburgh Sleep Quality Index (PSQI) components of morning and night shift nurses				
Characteristic Pittsburgh Sleep Quality Index (PSQI)	Morning shift nurses (*n*=15) mean±SD	Night shift nurses (*n*=27) mean±SD	Mann-Whitney test	*P* Morning shift versus night shift
Global PSQI score	3.0±3.0	7.0±4.1	80.97	<0.001
Sleep duration score	7.6±1.2	7.2±1.5	7.49	<0.001
Sleep latency score	1.0±0.9	2.0±0.9	65.69	<0.001
Last month had trouble sleeping	1.0±0.9	0.6±1.0	28.37	<0.001
Last month's intake of medicine to sleep	1.3±0.9	0.4±0.7	79.49	<0.001
Last month's trouble staying awake	0.6±1.0	0.1±0.4	44.66	<0.001
Last month's overall sleep quality	0.2±0.5	0.8±1.1	36.62	<0.001
Last month's intake of medicine to sleep	0.4±0.7	1.3±0.9	79.49	<0.001

detrimental effects on the 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 following the studies done by Wehrens *et al.* in shift workers[15] and Cebeci *et al.*[16] in medical doctors. Similarly, Garde *et al.*,[17] concluded in their study that the shift work system caused adverse effects on the physical and mental health of nursing staff.

Niu *et al.*[18] found shift work impairs HRV 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 those of Ito *et al.*[19] studies, where HRV variables did not differ between day and night shifts.

In our research, the mean scores 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 Suzuki *et al.*[20] and Matheson *et al.*,[14] in which shift work causes poor sleep quality in nurses. However, the results differed from the study[7] 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 study,[6] 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 per 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 shifts.[20]

Many hospitals adopt shift systems to ensure uninterrupted patient care. Continuously working under a night shift system causes adverse effects on the health of nurses. Thus, it is necessary to monitor the hazards of work rotation or sleep deprivation on sleep quality and HRV parameters. If appropriate timely measures are not taken, nursing service quality may deteriorate and some nurses may even opt to quit the job.

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 a five-minute 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 extended by increasing the number of subjects and the duration of the study.

Conclusion

Addressing the inherent challenges of shift work in healthcare remains an ongoing concern for both healthcare providers and policymakers. Healthcare institutions may implement strategies to mitigate the negative impacts of shift work on nurses, such as providing adequate breaks, offering support services like counselling and wellness programs, and implementing flexible scheduling options where possible. Flexible scheduling options can allow nurses to control their work hours and strike a better balance between work and personal life. By implementing such strategies, healthcare institutions can enhance job satisfaction and improve patient care by ensuring that nurses are psychologically prepared to deliver high-quality care to patients.

Conflicts of interest

There are no conflicts of interest.

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