Impact of Night Shift Work Routine on Cardiac Autonomic Control in Nursing Professionals

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Abstract

The impact of night shift work routine on cardiac autonomic control in nursing professionals was evaluated in a cross-sectional observational study of 52 nursing professionals. Participants were allocated into two groups based on shift routine. Heart rate variability (HRV) was assessed in a laboratory environment by recording the RR intervals from the electrocardiogram for 10 minutes in the supine position. A time series of 256 of the most stable points was selected for HRV analysis to obtain linear (spectral analysis [high frequency (HF) and low frequency (LF)], expressed in absolute and normalized units (nu)) and nonlinear indices [Shannon entropy (SE), conditional entropy (CE [complexity index (CI), normalized CI (NCI)]), and symbolic analysis (SA [0V, 1V, 2LV and 2UV)]. Only the complexity index of conditional entropy was significantly higher in the day shift routine (0.56±0.16) than in the night shift routine (0.45±0.03) ($p<0.003$). Professionals who work during the day exhibit greater complexity compared to those who work at night. Therefore, night work may have negative impacts on cardiac autonomic control.

1. Introduction

Shift work plays an essential role in maintaining the continuous operations of our society, although it may entail negative consequences for workers' health [1]. Nurses are one of the most studied groups regarding shift work [2].

A meta-analysis comprising four studies involving nurses demonstrated that shift work is associated with a 26% increased risk of coronary heart disease morbidity and an approximately 20% increased risk of CVD mortality. The association was particularly evident after the first five years of shift work, with the risk increasing by 7.1% for each additional five years of exposure [1].

Previous studies [1], [3], [4] have documented an association between night shift work routines and adverse health outcomes. One of them is related to the deregulation of the circadian cycle, since the body's natural defenses are diminished during the nighttime period and, combined with sleep deprivation and a feeling of fatigue, reduce work efficiency and increase the likelihood of errors and injuries [5], [6]. This chronic circadian disruption directly impacts the autonomic nervous system, which regulates vital functions, including cardiac function [7].

In this context, objective measures such as the assessment of heart rate and heart rate variability (HRV), can be used to understand certain cardiovascular risks and to adequately monitor workers [8], [9], [10]. Measuring RR intervals through HRV is a non-invasive method which enables evaluating cardiac autonomic modulation, serving as a complementary tool in the clinical assessment of cardiac function. Alterations in HRV can indicate a loss of cardiovascular system adaptability, serving as an early indicator of the subclinical effects that circadian disruption imposed by night work exerts on the heart [10], [11].

Considering this evidence, the present study aimed to investigate the effects of night shift work on cardiac autonomic regulation in nursing professionals using HRV analysis as the primary indicator.

2. Methods

2.1 Study design and sample selection

This is a cross-sectional observational study, approved by the Research Ethics Committee of the University of Pernambuco (UPE) (Report Number -5.711.090).

2.2 Eligibility criteria

The study included nurses and nursing technicians of both sexes, aged 18–65 years, engaged in care services with night and/or day shift routines, working at least 24 hours per week, and employed at the hospital for a minimum of six months. Exclusion criteria comprised pregnancy, fever on the day of assessment, any physical limitation preventing the performance of functional tests, and allergy to adhesives. Additionally, one male participant was excluded from the analysis to minimize potential confounding effects related to sex-specific differences in HRV.

Baseline characteristics were collected, including anthropometric data, chronic disease history, alcohol consumption, smoking status, and physical activity levels. Additionally, cardiorespiratory fitness was assessed by determining maximal oxygen consumption (VO_{2max})

during a Cardiopulmonary Exercise Test on a cycle ergometer.

2.3 Experimental protocol

The participants attended the Cardiopulmonary Physiotherapy Laboratory at the University of Pernambuco (Petrolina Campus) for Heart HRV assessment. RR intervals (RRi) were recorded for 10 minutes in a supine position using a 10-lead electrocardiogram (Wincardio, Micromed, Brasília-DF). The measurement was performed for 10 minutes in the supine position. Participants were instructed to avoid consuming caffeinated and alcoholic beverages and to refrain from strenuous exercise before the evaluation.

The collected RRi were then transferred to a computer and processed through automated and manual review to remove ectopic beats and artifacts, ensuring that corrections did not exceed 5% of the sample. The final HRV analysis was conducted using linear and nonlinear routines developed by Dr. Alberto Porta.

HRV was quantified using both linear and nonlinear analyses. Linear indices were computed in the time domain (mean and variance of RRi) and the frequency domain, which included the low-frequency (LF) and high-frequency (HF) components expressed in absolute and normalized units (nu). Nonlinear analysis involved calculating the complexity index (CI) and normalized complexity index (NCI) from conditional entropy, which reflect new information in the current RRi not predictable from previous intervals. Shannon entropy was also computed. Symbolic analysis was additionally performed to quantify the distribution of RRi patterns, classifying them into four categories: 0V (no variation; sympathetic modulation), 1V (one variation; mixed autonomic influences), 2LV (two like variations; parasympathetic modulation), and 2UV (two unlike variations; parasympathetic modulation). Within this framework, HF, 2LV, and 2UV were interpreted as markers of parasympathetic modulation, whereas LF and 0V were considered sympathetic modulation markers.

2.4 Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics (v. 22.0). After confirming data normality with the Kolmogorov-Smirnov test, a t-test was used to compare the day and night shift groups. Data are presented as mean ± standard deviation, with statistical significance set at $p < 0.05$

3. Results

The study sample comprised 52 female nursing professionals, who were allocated into two groups: the Day Shift Group (G1; n=27) and the Night Shift Group (G2; n=25). The groups were considered homogeneous regarding their baseline characteristics, presenting comparable clinical and demographic profiles, as detailed in Table 1.

Table 1. Clinical characteristics of nursing professionals in Petrolina, PE (n = 52).

	G1 (n=27)	**G2 (n=25)**
Age	44.07± 7.16	45.60 ± 7.25
BMI	30.92 ± 4.42	29.21± 4.58
WC	94.20 ± 15.40	93.20 ± 11.88
Years of work	12.88 ± 5.92	11.74 ± 6.96
Smoker	1 (3.7%)	2 (4%)
Alcohol consumption	12 (44.4%)	7 (28%)
SAH	3 (11.1%)	3 (12%)
SAH + DM	1 (3.7%)	1 (4%)
Heart disease	1(3.7%)	1.
Others	6 (22.2%)	1 (4%)
Physical activity	9 (33.3%)	6 (24%)
VO_{2max} (ml/kg/min)	17.4 ±2.31	17.67 ±5.07

Data are expressed as mean ± SD. BMI: Body Mass Index, WC: Waist Circumference, SAH: Systemic Arterial Hypertension, DM: Diabetes Mellitus, VO_{2max}: Maximum oxygen consumption.

Regarding the HRV data, the analysis revealed that only the CI differed significantly between the groups among all evaluated indices. The Day Shift Group (G1) exhibited a significantly higher CI value (0.56 ± 0.15) compared to the Night Shift Group (G2) (0.45 ± 0.35; p = 0.001). No significant differences were found between the groups for any other linear or nonlinear HRV indices. The detailed results of this comparison are presented in Table 2.

Table 2. Comparison of HRV indices between groups (n = 52).

	G1 (n=27)	**G2 (n=25)**	***P***
RR	777.78 ± 97.17	750.94 ± 78.13	0.36
SDNN	554.11 ±304.20	693.99 461.70	0.34
LF	189.08 ± 155.02	219.78±202.98	0.28
LF nu	48.99 ± 18.24	45.77 ± 19.64	0.56
HF	162.93± 154.97	220.36 ± 227.70	0.16
HF nu	43.37 ±18.96	41.55 ± 22.49	0.11
CI	0.56 ±0.15	0.45 ±0.35	0.001*
CIN	1.07 ±0.13	1.02 ±0.10	0.16
SE	3.55 ± 0.44	3.48 ± 0.48	0.78
0V	18.38 ± 11.94	19.90 ± 15.18	0.38
1V	46.88 ± 7.56	47.32 ± 7.88	0.58
2LV	13.37 ±6.77	12.97 ± 6.59	0.79
2UV	21.36 ±11.45	19.79 ± 9.61	0.37

Data expressed as mean ± SD. Abbreviations: RR, interval between consecutive heartbeats (ms); SDNN, standard deviation of all RR intervals (ms^2); LF, low-frequency power (ms^2); LF nu, normalized low-frequency power (nu); HF, high-frequency power (ms^2); HF nu, normalized high-frequency power (nu); CI, complexity index; NCI, normalized complexity index (dimensionless); SE, Shannon entropy (bits); 0V, patterns with no variation (%); 1V, patterns with one variation (%); 2LV, patterns with two like variations (%); 2UV, patterns with two unlike variations (%). *p < 0.05.

4. Discussion

This study evaluated the association between the night shift work routine and the cardiac autonomic control of nursing professionals using both traditional and complexity-based HRV metrics. Although the literature has already explored the deleterious effects of shift work on the autonomic nervous system, our findings reinforce the relevance of complexity indicators as a potentially sensitive tool to capture subtle changes in autonomic modulation that are not detected by traditional linear metrics [11], [12].

The main contribution of the present study lies in demonstrating that only the CI was able to discriminate between the day and night shift groups, with significantly lower values in night shift workers. This reduction may reflect a loss in the adaptability of the autonomic system in response to physiological demands, which could be related to cumulative dysfunctions imposed by night work. Higher complexity and normalized complexity indices indicate greater complexity and lower regularity of the cardiac signal, reflecting better autonomic function [12], [13].

The dynamics of heart rate are inherently complex and influenced by a multitude of factors [14]. A reduction in physiological complexity, a hallmark of both aging and disease, is consistently associated with the impairment of underlying regulatory mechanisms [15], [16]. Furthermore, the short-term complexity of heart period dynamics is directly tied to the state of the autonomic nervous system, diminishing in response to increased sympathetic modulation. While these alterations are frequently observed in pathological conditions, they are also a common feature of the aging process [15]. Accordingly, our findings support the hypothesis that the CI could serve as a valuable metric for characterizing the effects of night work on autonomic regulation, providing a more nuanced assessment that reveals changes not captured by conventional HRV measures

However, as this is a cross-sectional study and only one metric reached statistical significance, this interpretation must be approached cautiously. It is not possible to establish a causal relationship, and the possibility of a chance finding or sample variability cannot be excluded. Thus, the idea that CI is inherently more sensitive than linear metrics should be regarded as a hypothesis supported by our data, but requiring confirmation [17], [18].

Similar to our findings, a study with 40 nurses per shift using short-term linear metrics found no statistically significant differences in HRV indices when comparing day and night shifts. However, this study did not explore nonlinear metrics. However, the findings did reveal significant differences in HRV parameters between sexes [19].

The absence of differences in indices such as HF, LF, and Shannon entropy may be explained by adaptive mechanisms over the worker's exposure time. Recent studies suggest that chronic exposure to night work may lead to partial accommodation of the autonomic system, masking changes that would be evident in the early stages of exposure [20]. Recent evidence also indicates that long-term exposure to night shifts may attenuate HRV differences through adaptation mechanisms [21].

Another relevant point concerns the timing of data acquisition. Recordings were carried out in the laboratory, always during the daytime shift, for both the night and day shift groups. This approach aimed to standardize the collection context; however, it does not eliminate potential circadian biases. The literature recognizes that HRV varies throughout the day, and these fluctuations may be exacerbated by sleep restriction or fatigue, which are common after night shifts [22]. This factor should be considered when interpreting the findings and reinforces the importance of future longitudinal analyses with strict control over the time of day and the wakefulness state of participants.

In addition, the female composition of the sample limits generalization of the results related to the well-known sex differences in HRV [23]. Although homogeneous in terms of sex, the sample may also limit the variability needed to identify additional effects. Moreover, no statistical correction for multiple comparisons was applied, which increases the risk of type I error when interpreting the isolated significance of CI.

Conclusion

Nursing professionals on the night shift showed a lower Complexity Index compared to day shift workers, suggesting a possible reduction in their autonomic adaptability. However, as this was the only significant finding and given the study's limitations, this conclusion is preliminary and should be interpreted with caution, requiring further research for confirmation.

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