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

Victor R Neves[1], Gerlene G Lira[1], Pedro I L Roriz[1], Camila A Sá[1], Abilene P S Silva, Tereza C Braga, Ádrya A F, Fabianne M N A Dantas[1], Matheus S Silveira[1] and Francisco L Neto[1]

[1]University of Pernambuco, Petrolina, Brazil

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 divided into two groups based on shift routine to day shift (G1) and night shift (G2). 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). Only the CI 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 [6].

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 [7], [8], [9]. 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 [9], [10]

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 female nurses and nursing technicians, aged 18–65 years, who were engaged in care services and divided into a day shift work group (G1) and a night shift work group (G2). Inclusion criteria required participants to work at least 24 hours per week and to have been 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

Participants were attended at Cardiopulmonary Physiotherapy Laboratory at the University of Pernambuco (Petrolina *Campus*) for HRV assessment. The RR intervals (RRi) were recorded in a supine position for 10 minutes using a 10-lead electrocardiograph (Wincardio, Micromed, Brasília-DF). Participants were instructed to abstain from consuming caffeinated and alcoholic beverages and to avoid vigorous exercise for at least 24 hours prior to 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.

The RRi sequence length (n = 256 beats) with the greatest stability was selected for each group. This same segment was utilized for both linear and nonlinear analyses. The mean and standard deviation of the RRi were also calculated. Subsequently, spectral analysis was performed using the autoregressive (AR) model. The spectral analysis indices evaluated were: High-Frequency absolute power (HF abs, 0.15−0.4 Hz) and normalized units (HFnu), reflecting vagal modulation and respiratory influence; and Low-Frequency absolute power (LFabs, 0.04−0.15 Hz) and normalized units (LFnu), which reflects sympathetic modulation [11], [12].

For the nonlinear analysis, the RRi series were quantified into six levels (0 to 5). Each RRi was assigned a symbol corresponding to its quantification level. Subsequently, patterns were formed using three consecutive symbols, and the distribution of these patterns was quantified by Shannon Entropy (SE). When the patterns are uniformly distributed (i.e., a flat distribution), indicating maximum information content, the SE value is large. Conversely, a small SE is observed when the distribution exhibits a high frequency of certain patterns alongside infrequent or absent patterns[13].

Symbolic analysis (SA) was carried out by grouping the patterns into four families: 0V, 1V, 2LV, and 2UV. The 0V family consists of patterns with no variation among their symbols, e.g., 1,1,1 or 2,2,2; 1V consists of patterns that have one variation, with two equal symbols and one different, e.g., 1,2,2 or 3,3,2; 2LV consists of patterns that form an ascending or descending ramp, e.g., 1,2,3 or 3,2,1;and the 2UV family comprises patterns forming a peak or a valley, e.g., (3,1,2) or (1,3,2). The final metric, SA, is the percentage of patterns within each family. The 0V% index reflects sympathetic modulation; 1V% reflects modulation of both branches of the ANS; 2LV% indicates vagal predominance; and 2UV% reflects purely vagal modulation [14]

Furthermore, Conditional Entropy (CE), as described by Porta et al., was utilized as a complexity index. This index was normalized by the RRi's SE to yield the Normalized Conditional Entropy (NCI). The NCI ranges from 0 (null information) to 1 (maximum information). When NCI approaches 1, complexity is higher, and both regularity and predictability are lower[15].

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 (years)	44.07± 7.16	45.60 ± 7.25
BMI (Kg/m²)	30.92 ± 4.42	29.21± 4.58
WC (cm)	94.20 ± 15.40	93.20 ± 11.88
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(0%)
Physical activity	9 (33.3%)	6 (24%)
VO_2max	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 in ml/kg/min. (G1 - Day Shift) e G2 - Night Shift)

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 (ms²); LF, low-frequency power (ms²); LF nu, normalized low-frequency power (nu); HF, high-frequency power (ms²); 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 (%). $^{*}p < 0.05$. (G1 - Day Shift) e G2 - Night Shift).

4. Discussion

The main finding of this study was that the night shift group exhibited a significantly lower CI, The sample's lack of variability may also limit the capacity to identify additional effects. demonstrating greater regularity compared to the day shift group. Furthermore, no significant differences were observed between the remaining linear and nonlinear HRV indices.

This reduction likely reflects an impairment in the autonomic nervous system's function, characterized by a reduced capacity for complex and varied responses to physiological demands, potentially related to cumulative dysfunctions imposed by chronic night work. Technically, higher values of complexity indices (including the CI) indicate greater physiological complexity and lower cardiac signal regularity, reflecting superior autonomic function [13], [14]. The dynamics of heart rate are inherently complex, being influenced by a multitude of interacting regulatory factors [16].

A reduction in physiological complexity, which is a known hallmark of both aging and disease, is consistently associated with the impairment of underlying regulatory mechanisms[17], [18]. Furthermore, the short-term complexity of heart period dynamics is directly tied to the state of the autonomic nervous system, typically diminishing in response to increased sympathetic drive (or stress). While such alterations are frequently observed in pathological conditions, they are also a common feature of the aging process[17]. Accordingly, our findings support the hypothesis that the CI serves as a valuable and sensitive metric for characterizing the effects of night work on autonomic regulation, providing a more nuanced assessment that reveals changes not captured by conventional Heart Rate Variability (HRV) measures.

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 [19].

The absence of differences in linear indices 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].

However, as this is a cross-sectional study where only one metric reached statistical significance, this interpretation must be approached cautiously. Causal relationships cannot be established, and the possibility of a chance finding or sample variability cannot be excluded [17], [18].

Some methodological limitations warrant consideration. First, the timing of data acquisition (daytime collection for both groups) does not eliminate potential circadian biases, as HRV fluctuates throughout the day, exacerbated by fatigue common after night shifts [22]. Future longitudinal analyses with strict control over the time of day and wakefulness state are essential. Second, the female-only composition of the sample limits the generalization of results, given known sex differences in HRV [23].

5. Conclusion

Nursing professionals on the night shift showed a lower Complexity Index compared to day shift workers, suggesting a possible reduction of autonomic nervous control on heart.

Acknowledgments

This work was supported by the Pernambuco Research Support Foundation (FACEPE), grant APQ-0578-4.08/22.

References

[1] L. Torquati, G. I. Mielke, W. J. Brown, and T. Kolbe-Alexander, "Shift work and the risk of cardiovascular disease. A systematic review and meta-analysis including dose-response relationship," 2018. doi: 10.5271/sjweh.3700.

[2] D. Rosa, S. Terzoni, F. Dellafiore, and A. Destrebecq, "Systematic review of shift work and nurses' health," *Occup Med (Chic Ill)*, vol. 69, no. 4, pp. 237–243, Jun. 2019, doi: 10.1093/OCCMED/KQZ063.

[3] M. Korshøj, C. L. Rasmussen, T. de Oliveira Sato, A. Holtermann, and D. Hallman, "Heart rate during work and heart rate variability during the following night: a day-by-day investigation on the physical activity paradox among blue-collar workers," *Scand J Work Environ Health*, vol. 47, no. 5, p. 387, Jul. 2021, doi: 10.5271/SJWEH.3965.

[4] A. Pietroiusti *et al.*, "Incidence of metabolic syndrome among night-shift healthcare workers," *Occup Environ Med*, vol. 67, no. 1, pp. 54–57, Jan. 2010, doi: 10.1136/OEM.2009.046797.

[5] C. M. O. De Almeida and A. Malheiro, "Sleep, immunity and shift workers: A review," *Sleep Science*, vol. 9, no. 3, pp. 164–168, Jul. 2016, doi: 10.1016/J.SLSCI.2016.10.007.

[6] A. Thakur and R. Kishore, "Neurobiology of the circadian clock and its role in cardiovascular disease: Mechanisms, biomarkers, and chronotherapy," *Neurobiol Sleep Circadian Rhythms*, vol. 19, p. 100131, Nov. 2025, doi: 10.1016/J.NBSCR.2025.100131.

[7] M. S. Khan *et al.*, "Heart rate variability in patients with cardiovascular diseases," *Prog Cardiovasc Dis*, Jun. 2025, doi: 10.1016/J.PCAD.2025.06.003.

[8] S. C. Fang, Y. L. Wu, and P. S. Tsai, "Heart rate variability and risk of all-cause death and cardiovascular events in patients with cardiovascular disease: a meta-analysis of cohort studies," *Biol Res Nurs*, vol. 22, no. 1, pp. 45–56, Jan. 2020, doi: 10.1177/1099800419877442.

[9] M. Malik *et al.*, "Heart rate variability: Standards of measurement, physiological interpretation, and clinical use," *Circulation*, vol. 93, no. 5, pp. 1043–1065, Mar. 1996, doi: 10.1161/01.CIR.93.5.1043/FORMAT/EPUB.

[10] A. M. Catai, C. M. Pastre, M. F. de Godoy, E. da Silva, A. C. de M. Takahashi, and L. C. M. Vanderlei, "Heart rate variability: are you using it properly? Standardisation checklist of procedures," *Braz J Phys Ther*, vol. 24, no. 2, p. 91, Mar. 2020, doi: 10.1016/J.BJPT.2019.02.006.

[11] Task Force, "Heart rate variability. Standards of measurement, physio- logical interpretation, and clinical use.," *Eur Heart J*, vol. 17, pp. 354–381, 1996, doi: 10.1161/01.CIR.93.5.1043.

[12] E. Miranda Dantas *et al.*, "Spectral analysis of heart rate variability with the autoregressive method: What model order to choose?," *Comput Biol Med*, vol. 42, no. 2, pp. 164–170, Feb. 2012, doi: 10.1016/J.COMPBIOMED.2011.11.004.

[13] A. Porta *et al.*, "Entropy, entropy rate, and pattern classification as tools to typify complexity in short heart period variability series," *IEEE Trans Biomed Eng*, vol. 48, no. 11, pp. 1282–1291, 2001, doi: 10.1109/10.959324.

[14] Porta A, Tobaldini E, Guzzetti S, Furlan R, Montano N, and Gnecchi-Ruscone T., "Assessment of cardiac autonomic modulation during graded head-up tilt by symbolic analysis of heart rate variability," *Am J Physiol Heart Circ Physiol.*, pp. 702–08, Jul. 2007, doi: 10.1152/ajpheart.00006.2007.

[15] A. Porta *et al.*, "An integrated approach based on uniform quantization for the evaluation of complexity of short-term heart period variability: Application to 24 h Holter recordings in healthy and heart failure humans," *Chaos*, vol. 17, no. 1, 2007, doi: 10.1063/1.2404630.

[16] D. T. Kaplan, M. I. Furman, S. M. Pincus, S. M. Ryan, L. A. Lipsitz, and A. L. Goldberger, "Aging and the complexity of cardiovascular dynamics.," *Biophys J*, vol. 59, no. 4, pp. 945–949, Apr. 1991, doi: 10.1016/S0006-3495(91)82309-8.

[17] A. L. Goldberger, C. K. Peng, and L. A. Lipsitz, "What is physiologic complexity and how does it change with aging and disease?," *Neurobiol Aging*, vol. 23, no. 1, pp. 23–26, Jan. 2002, doi: 10.1016/S0197-4580(01)00266-4.

[18] A. C. M. Takahashi *et al.*, "Aging reduces complexity of heart rate variability assessed by conditional entropy and symbolic analysis," *Intern Emerg Med*, vol. 7, no. 3, pp. 229–235, Jun. 2012, doi: 10.1007/S11739-011-0512-Z/TABLES/3.

[19] P. Cakan and S. Yildiz, "Autonomic nervous system activity under rotational shift programs: effects of shift period and gender," *Ind Health*, vol. 60, no. 1, p. 62, 2021, doi: 10.2486/INDHEALTH.2021-0029.

[20] M. de Zambotti, A. Goldstone, I. M. Colrain, and F. C. Baker, "Insomnia disorder in adolescence: Diagnosis, impact, and treatment," *Sleep Med Rev*, vol. 39, pp. 12–24, Jun. 2018, doi: 10.1016/j.smrv.2017.06.009.

[21] K. H. Barckhan, I. Böckelmann, and S. Sammito, "Influence of night shift work on heart rate variability in an age- and gender-matched study group," *J Cardiovasc Dev Dis*, vol. 11, no. 9, Sep. 2024, doi: 10.3390/JCDD11090280,.

[22] P. Boudreau, G. Dumont, and D. Boivin, "Circadian variation of heart rate variability during different sleep stages," *Sleep Med*, vol. 14, p. e76, Dec. 2013, doi: 10.1016/J.SLEEP.2013.11.154.

[23] J. Koenig and J. F. Thayer, "Sex differences in healthy human heart rate variability: A meta-analysis," *Neurosci Biobehav Rev*, vol. 64, pp. 288–310, May 2016, doi: 10.1016/J.NEUBIOREV.2016.03.007.

Address for correspondence:

PhD. Victor Ribeiro Neves
University of Pernambuco, Avenida Cardoso de Sá, s/n – Campus Universitário – Petrolina/PE – CEP.: 56328-900
e-mail: victor.neves@upe.br