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EFFECTS OF PARTIAL SLEEP DEPRIVATION ON HEALTH PROFESSIONALS

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ABSTRACT

Current research shows that shift work is associated with partial sleep deprivation and changes in circadian rhythms. The desynchronisation of these rhythms leads to an imbalance in physiological functions, which in turn can lead to the development of pathological conditions. This study compared the sleep quality of night workers with that of

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day workers. The results were compared with urinary cortisol levels in day workers. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. The results showed poor sleep quality in the night worker group, as well as complaints of anxiety, depression and hypertension. The desynchronisation caused by shift work may have negative effects on the body's homeostasis. These findings point to the need for forms of discipline that can improve the general health of night workers.

Keywords: Sleep deprivation. Circadian rhythms. Sleep quality.

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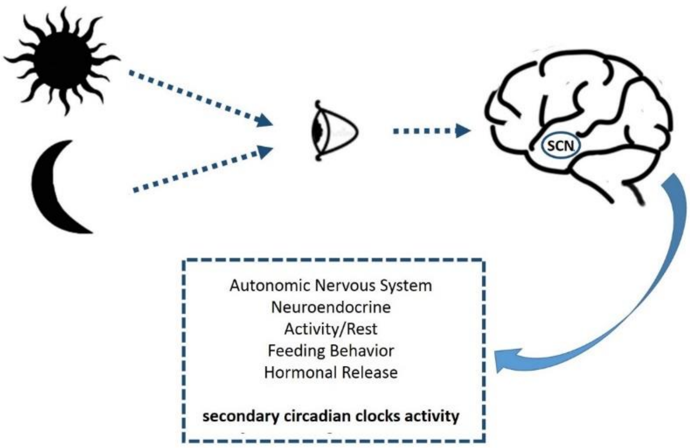
INTRODUCTION

Circadian rhythmic oscillations directly modulate behavioral phenomena, resulting in several standard behaviors such as rest and activity, feeding and fasting, body temperature, neural activity, and hormone production and release (e.g., cortisol and melatonin) (Schibler et al., 2015). These rhythms persist regardless of meal times, activity levels, sleep and body posture, suggesting that they are driven by an internal temporal control system (Voogel et al., 2001).

The synchronization and long-term maintenance of these events allows the organism to better adapt physiologically and anticipate internal and external events (Qian and Scheer, 2016). On the other hand, desynchronization can lead to a pathological misalignment between the environment, behavioral actions and the biological clock - the suprachiasmatic nucleus (SCN) and its peripheral clocks. As a result, studies link circadian dysfunction to the appearance of pathological signs (Lateef & Akintubosun, 2020; Suzuki et al., 2025).

The light/dark cycle is the major environmental variation that synchronizes the endogenous biological rhythms of humans and other animals (Figure 1). Thus, the most distinct circadian event identified and controlled by the SCN in different species is the sleep-wake cycle (LeGates et al., 2014).

Figure 1. Simplified schematic of the environmental cues of light and dark that synchronise the hypothalamic suprachiasmatic nucleus (SCN). Light and dark information, and various neural factors that transmit SCN output signals to secondary clocks, directly modulate behavioural phenomena that in turn result in various patterned actions such as rest and activity, feeding and fasting, body temperature, neural activity, and hormone production and release.



Sleep is an extremely complex behavior in which all the body's functions and physiological changes are orchestrated by the sleep pattern (Brown et al., 2010). It is an important condition, not only for the brain, but for the entire functioning of the organism, characterizing a phenomenon that is critical for survival and incompatible with long-term deprivation (Everson, 1995).

Sleep health guidelines aim to achieve the ideal sleep duration for humans and the regularity of sleep schedules. In other words, in addition to the number of hours of sleep, the consistency or daily regularity of the schedule contributes to the health and longevity of individuals (Windred et al., 2024). The recommended healthy amount of sleep per night for humans is 8 to 10 hours to maintain physical health, emotional well-being and cognitive performance (Chawla et al., 2024).

Sleep deprivation can result from sleep disorders such as insomnia, behavioral sleep deprivation and obstructive sleep apnea. Another reason is related to professionals who work reversed shifts to meet socio-economic demand, where they perform strenuous work routines that affect the quality of their sleep (Lateef & Akintubosun, 2020).

Night shift workers often complain of reduced sleep quality, fragmented sleep periods and symptoms of insomnia (Paech et al., 2010). One of the most common complaints of night shift workers is the inability to meet certain sleep needs during the day after a night shift, and this complaint is particularly pronounced at the beginning of shift work (Sallinen & Kecklund, 2010).

Prolonged exposure to sleep deprivation contributes to stress, a condition that acts directly on the hypothalamic-pituitary-adrenal (HPA) axis. The HPA, which is a communication pathway for the release of cortisol, when activated by stimuli such as prolonged stress, as seen in these reverse shift workers, promotes tissue damage and damage to body systems (Tyagi et al, 2023).

Cortisol is one of the most potent hormones in human physiology, with almost all cells in the body being potential targets. It is involved in the distribution of circadian signals originating in the SCN to all peripheral tissues and organs of the body, controlling certain biological cyclic functions, including cardiovascular functions (Benarroch, 2008).

The post-awakening cortisol peak may play a specific role in synchronising the body in a series of non-genomic acts for the sleep-wake and light-dark cycles (Karachaliou et al., 2023). Thus, cortisol levels are influenced by circadian rhythms as they fluctuate throughout the 24 hours of an individual's day.

The desynchronization found in these workers has already been associated with cardiometabolic and reproductive dysfunction, sleep disturbances and serious physiological consequences such as endocrine disorders, metabolic dysregulation, cancer, immunological and cardiovascular disorders (Amihaesei & Mungiu, 2012; Lateef & Akintubosun, 2020).

Since biological rhythms modulate virtually all physiological processes in mammals, and the desynchronization of these rhythms reflects an imbalance in physiological functions, which in turn may lead to an increased risk of pathological conditions, this study sought to characterize the parameters of sleep quality in these individuals (night worker), associated with cortisol levels, in addition to in addition to guiding forms of intervention that may lead to improvements in the overall health status of individuals.

MATERIALS AND METHODS

This project is a clinical study that used the parameters of the Pittsburgh Sleep Quality Index (PSQI) in professionals from an emergency care unit that has been reversed. The work activities of these individuals start at 19:00 and end at 7:00, with 12 hours of activity and 1 hour of rest.

The inclusion criteria adopted related to individuals working reversed shifts (night worker), where their work activities started at 19:00 and ended at 7:00, with 12 hours of activity and 1 hour of rest. Forty people of both sexes, aged between 20 and 50 years, without renal complications, with adequate dietary habits and daily hydration participated in this project. Participants with a history of chronic kidney complications were not selected for the study.

The total number of 40 participants was divided into two analysis groups, the control group - group A - with 20 participants who work during the day and do not work in reversed shifts, and 20 participants who work in reversed shifts - group B (night worker) - with 20 participants.

Individuals' participation was confirmed by signing the free and informed consent form, according to the recommendations of the National Health Council Resolution (CNS 466/2012) on guidelines and regulatory standards for research involving human subjects, approved by the Research Ethics Committee (CEP 6,269,574). Data collection commenced only after consent was obtained from the volunteers.

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ADMINISTRATION OF THE SLEEP QUESTIONNAIRE - PSQI.

A sleep questionnaire was administered to the participants in Group A and Group B to assess the quality of the individual's sleep. The PSQI consists of seven questions: sleep quality, sleep onset time, sleep efficiency, sleep disturbances, hypnotic use and daytime dysfunction. Each sub-item is worth 3 points, and a score > 7 can be considered indicative of the presence of a sleep disorder. The higher the score, the more severe the sleep disorder (Buysse et al., 1989).

URINE COLLECTION

Two groups of participants (control - day workers and night workers) were given a sterile universal collector and opened it only during the appropriate periods of day and night activity. Each participant collected the entire bladder volume in the collector without the need to clean their genitalia. Samples were aliquoted and identified in opaque polystyrene tubes and frozen at ≥ -20ºC.

IMMUNOBIOCHEMICAL ANALYSIS

For the biochemical analysis of cortisol, the urine samples of the two groups were compared. The ARCHITECT CORTISOL and ARCHITECT Na^+, K^+ and Cl^- kits were used. The ABBOTT automated instrument, model ARCHITECT ci8200, performs turbidimetric, photometric (e.g. chemiluminescence), potentiometric and integrated multisensor test methods, with compatibility for whole blood, serum, plasma and urine samples, using an average of 7.2 µL for immunobiochemical analysis.

ANALYSIS OF RESULTS

The results were analyzed using appropriate statistical methods. The Shapiro-Wilk test was used to assess normality between the control and night worker groups, Levene's F test to assess homogeneity between groups, Student's t-test and descriptive statistics. The statistical programmers used were Biostat 5.3 and ActionSTAT.

RESULTS

SLEEP QUESTIONNAIRE

Using the sleep questionnaire, it is possible to assess the sleep quality of groups A (control) and B (night worker) using the PSQI, as described in Table 1. All participants

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answered the PSQI sleep questionnaire, which was prepared electronically in Google Forms.

The result of the sleep questionnaire shows that group A has 95% of objective sleep quality (between good and very good), 70% have a sleep latency of 16 to 30 minutes, 90% have a sleep duration > 7 hours, 90% have a sleep efficiency > 85%, 100% have at least one sleep disorder per week, 100% use sleep medication once or more times per week and 75% have daytime sleepiness and dysfunction at least once per week (Table 1).

The results of the sleep questionnaire show that in group B, 70% have an objective sleep quality (between good and very good), 60% have a sleep latency > 60 minutes, 65% have a sleep duration < 5 hours, 55% have a sleep efficiency < 74%, 95% have at least one sleep disorder per week, 80% take sleep medication once or more times per week and 90% have daytime sleepiness and dysfunction at least once per week (Table 1).

Table 1: Pittsburgh Sleep Quality Index of participants in group A (control) and group B (night worker).

PSQI	CLASSIFICATION	Group A (%)	Group B (%)
sleep quality	Very good	55	40
	Good	40	30
	Bad	5	20
	Very bad	0	10
sleep latency	≤ 15 minutes	5	0
	16 to 30 minutes	70	10
	31 to 60 minutes	25	30
	> 60 minutes	0	60
sleep duration	> 7 hours	90	10
	6 to 7 hours	10	10
	5 to 6 hours	0	15
	< 5 hours	0	65
sleep efficiency	> 85%	90	35
	75 a 84%	10	10
	65 a 74%	0	15
	< 65%	0	40
sleep disorder	Never	0	0
	Less than once a week	50	15
	Once or twice a week	50	75
	Three or more times a week	0	10
sleep medication	Never	0	20
	Less than once a week	0	30
	Once or twice a week	55	25
	Three or more times a week	45	25
	Never	5	10

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daytime sleepiness and dysfunction	Less than once a week	75	35
	Once or twice a week	20	20
	Three or more times a week	0	35

Pittsburgh Sleep Quality Index values

Another piece of data assessed by the questionnaire is the Global PSQI Index, which shows the sleep quality of each participant who took part in the survey. It was found that 100% of participants in both groups A and B had poor sleep quality (sum of the seven scores, where > 5 indicates poor sleep quality, < 5 indicates good sleep quality), as shown in Table 2.

Statistical analysis of the Global PSQI Index shows that there was a significant difference between groups A and B, indicating that although both groups have poor sleep quality, it is clear that group B (night worker) has worse sleep quality compared to group A (control). Sleep quality is poor in both groups, with the worst rating in group B.

Table 2 - Total PSQI score of participants in group A (control) and group B (night worker), with statistical difference between groups (p-value <0.05). Poor sleep quality (>5) as assessed by the total PSQI score of all participants in groups A and B.

Participants Group A	Global PSQI Value Group A	**Participants Group B**	Global PSQI Value Group B	**p-value**
1	8	1	13	0,0001
2	5	2	13	
3	5	3	11	
4	9	4	11	
5	7	5	13	
6	8	6	14	
7	7	7	11	
8	7	8	11	
9	9	9	13	
10	6	10	10	
11	6	11	18	
12	7	12	15	
13	6	13	7	
14	6	14	14	
15	7	15	14	
16	9	16	13	
17	7	17	16	
18	7	18	11	
19	9	19	8	
20	6	20	16	

Global Pittsburgh Sleep Quality Index

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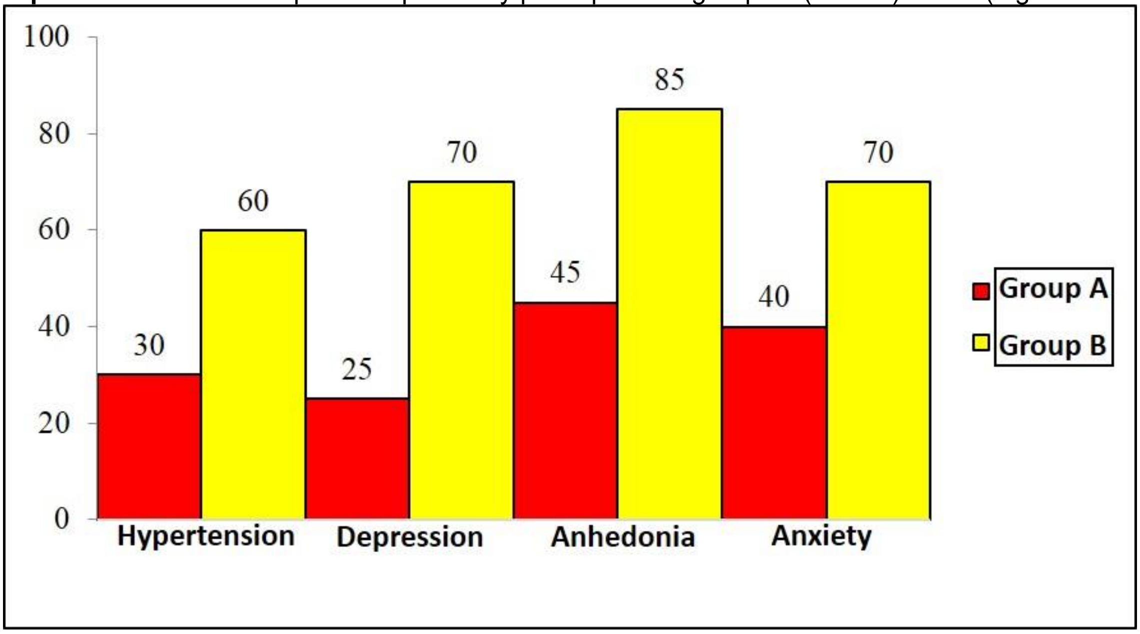
COMPLAINTS RELATED TO POOR SLEEP QUALITY

In parallel with the collection of data from the sleep questionnaire, the presence of other complaints associated with poor sleep quality was investigated. Conditions such as discomfort due to continuous high blood pressure, constant sadness, loss of pleasure and anxiety were observed in two groups analyzed. According to graph 1, group B (night worker) reported the highest number of complaints compared to group A, with 60% using some antihypertensive medication, 70% feeling or having felt permanent sadness, 85% loss of pleasure and 70% having felt anxiety.

Graph 1. List of main complaints reported by participants in groups A (control) and B (night worker).



List of main complaints added to the sleep questionnaire of participants in group A (control) and group B (night worker) in (%)

CORTISOL ANALYSIS

Comparative urinary cortisol measurements were performed for both groups A (control) and B (night worker). Statistical differences were observed between the groups analysed. Group B showed elevated values compared to group A. Participants 1, 2, 3 and 4 (20% of group A) were below the reference values according to the package insert (2.10 to 88.0 µg/dL), with results of 0.80 µg/dL, 1.50 µg/dL, 1.60 µg/dL and 1.60 µg/dL, respectively, as shown in Figure 4. The same characteristic was observed in 4 participants of group B (20% of group B) with results below the reference values, with results of 0.20 µg/dL, 0.30 µg/dL, 0.88 µg/dL and 1.70 µg/dL, respectively, as shown in graph 4. The shift reversal may

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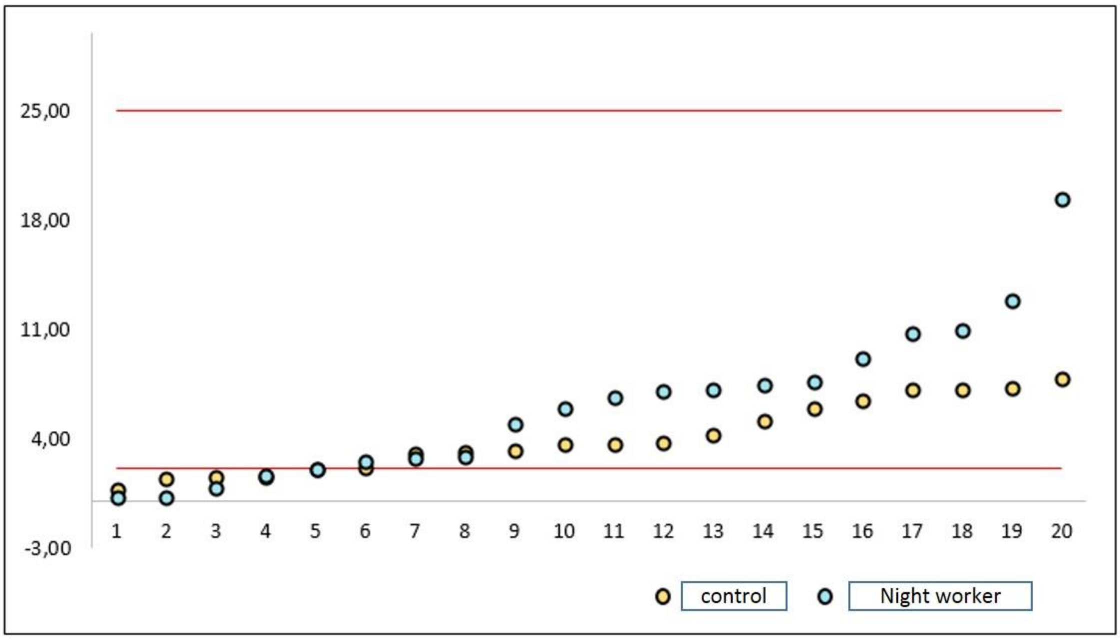
have affected the functioning of the hypothalamic-pituitary axis, resulting in a slight increase in cortisol levels (Graph 2).

Graph 2: Biochemical measurements of urinary cortisol µg/dL in group A (control) and group B (night worker).



Comparative analysis of urinary cortisol levels.

DISCUSSION

Night shift work is associated with partial sleep deprivation and alterations in circadian rhythms, which in turn often have consequences in terms of physiological dysfunction (Liew & Aung, 2022). Chronic partial sleep deprivation is an important risk factor for the development of several diseases in these workers, mainly cardiovascular diseases (Amihaesei & Mungiu, 2012; Lateef & Akintubosun, 2020), metabolic syndrome (Kecklund & Axelsson, 2016), gastrointestinal disorders (Lu et al., 2006), diabetes mellitus and cancer (Hansen & Stevens, 2012; Hansen et al., 2016). In this study, individuals working night shifts showed changes in sleep quality compared to the predicted values for day workers.

In general terms, although we found differences in the values of urinary analytes between groups A (day shift) and B (night worker), the values remained at physiological basal levels, indicating no significant changes between the groups studied. These data suggest the most significant variations in the group of night workers, and are associated with possible changes in the rhythmic pattern of sounds linked to the PSQI questionnaire.

It is now known that mental health can also be affected by the sustained stimulation of the HPA axis due to frequent exposure to external stressors in night workers, leading to high stress response reactivity. In the long term, night work may increase the risk of mental disorders, particularly depression and anxiety (Mealer et al., 2012).

The stability of the circadian rhythm, regulated by the production of melatonin and the release of cortisol, is essential to align biological activities with the light-dark cycle, allowing hormonal processes such as the secretion of steroids and other regulators of electrolyte balance to occur in an orderly manner (Tsang; Rosa-Neto, 2024).

Analyzing the PSQI, it was evident that the sleep quality of groups A (control) and B (night worker) was classified as poor, but with greater complaints in the night worker group. Sleep quality plays a fundamental role in maintaining human health, affecting complex systems for the proper functioning of the body, such as the immune system, energy metabolism and cognitive performance (Nollet et al., 2020).

The poor sleep quality of group B was associated with complaints of persistent sadness (70% of individuals), anhedonia (loss of pleasure) (85% of individuals) and anxiety (70% of individuals). These data suggest a psychosomatic effect of chronic partial sleep deprivation in these reverse shift workers.

The mental health may also be affected by the sustained stimulation of the HPA axis due to frequent exposure to external stressors in night workers, leading to high stress response reactivity (Kalmbach et al., 2015). In the long term, night work may increase the risk of mental disorders, particularly depression and anxiety (Mealer et al., 2012).

It appears that the individuals subjected to partial sleep deprivation in this study have poor sleep quality, which is reflected in the difficulty of sleep recovery. Poor sleep quality may induce "circadian misalignment" in these night workers (Boivin & Boudreau, 2014), as indicated by a lack of synchronisation of homeostasis with nocturnal activity (Czeisler & Buxton, 2010).

Sleep homeostasis is well regulated, as the same loss of sleep time can be compensated later by additional sleep periods, and no clinically relevant sleep disturbance develops (Drake et al., 2004). To improve sleep problems of higher quality, napping before the night shift reduces sleep pressure and slow-wave activity during subsequent sleep periods (Werth et al, 1996).

Other suggestions for improving poor sleep quality in these individuals include the use of enriched blue light in the work environment (Sletten et al., 2017; Sunde et al., 2020), which has been suggested to improve nocturnal activity after workers are exposed to bright light (Jensen et al., 2016), and paves the way for a combined light intervention to improve performance and reduce fatigue (Olson et al., 2020).

The use of exogenous melatonin has become increasingly common and one option would be to administer it in the morning due to its ability to promote restorative sleep (Sharkey et al, 2001), which in this case would be daytime recovery. In addition to sleep regulation, the mechanism of action of melatonin has been studied in various processes such as mood, anxiety, thermogenesis, appetite, metabolism, immune responses, cardiovascular functions and other endocrine functions (Arendt & Skene, 2005; Xia et al., 2008; Scheer et al., 2009; 2014).

The signs of poor sleep quality, complaints of depression, anxiety and difficulty in re-establishing sleep, observed predominantly in individuals with partial sleep deprivation due to reverse shift work, may be early signs of the development of more common physiological dysfunctions in the body, making it necessary to develop strategies to promote a better quality of life in these individuals.

ETHICS STATEMENT

The recommendations of the National Health Council Resolution (CNS 466/2012) on guidelines and regulatory standards for research involving human subjects were followed, and the study was approved by the Research Ethics Committee (CEP 5.729.149).

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data and all supplementary materials associated with this article are available on request from can be obtained from the corresponding author on request.

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