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Impact of Chronic Sleep Deprivation on Blood Pressure Variability and Early Cardiovascular Dysfunction Among Medical Residents: A Clinical Observational Study

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ABSTRACT

Background: Long working time, night shifts, and strenuous clinical duties all present as a challenge to medical residents expose them to chronic sleep deprivation. Autonomic imbalance, disturbed circadian rhythm, and premature cardiovascular dysfunction have all been associated with persistent sleep loss.

Objectives: To examine how chronic sleep deprivation affects blood pressure fluctuations and early cardiovascular changes among tertiary care medical residents.

Methods: It was a clinical observational study conducted at Sahara Medical College, Narowal, Pakistan, between January 2024 and May 2025, and in 80 medical residents aged between 24-35 years. The 14-day wrist-worn sleep trackers and the Pittsburgh Sleep Quality Index were used to measure the time of sleep. The cardiovascular exam included 24-h ambulatory blood pressure, heart rate variability, resting heart rate, 12-lead ecg and hs-CRP. The respondents were separated into sleep-deprived (less than 6 hours/night) and adequate sleepers (6 hours/night and more). Her statistical analysis was performed with the assistance of SPSS 26, and p less than 0.05 may be regarded as significant.

Results: Systolic (14.9 ± 3.7 mmHg) and diastolic (12.6 ± 3.2 mmHg) blood pressure variability, nighttime systolic pressure (131 ± 11 mmHg), and non-dipping patterns were more common in sleep-deprived residents. They also had a lower level of heart rate variability (31.8 ± 8.3 ms) and an elevated resting heart rate (91.3 ± 10.9 bpm), elevated levels of hs-CRP (3.9 ± 1.2 mg /L), and more ECG abnormalities than became the case with adequately rested residents.

Conclusion: The increased blood pressure variability, autonomic dysfunction, systemic inflammation, and early cardiovascular changes are highly connected with chronic sleep deprivation among medical residents. Structured duty-hour reforms and better sleep hygiene practices are required to prevent cardiovascular damage in this group.

Keywords: Sleep, Hypertension, Variability, Autonomic, Cardiovascular, Inflammation, Residents.

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INTRODUCTION

Sleep plays a critical role in achieving physiological homeostasis, neuroendocrine balance, cardiovascular functioning, and overall general metabolism [1]. Sleep deprivation is now the primary occupational and community health problem, particularly because the medical residents are always forced to endure the pressures of long working hours, night shifts, being on call, and emotionally demanding professional responsibilities. The cumulative effect of these long shifts and insufficient time in between shifts subjects medical trainees to high risks of persistent sleep deficiency, which may lead to a series of negative cardiovascular complications [2].

Loss of sleep disturbs the balance between the activities of the sympathetic and parasympathetic nervous systems, leading to constant overactivation of the sympathetic nervous system, increased catecholamine secretion, higher cortisol release, and dysfunction of the endothelium [3]. All these physiological abnormalities play a direct role in high blood pressure, disturbed blood pressure circadian regulation, and blood pressure variability (BPV). BPV has received prominence as an improved predictor of cardiovascular events compared to mean blood pressure

alone, due to dynamic alterations of the vascular and autonomic dysregulation. A disruption in BPV relates to the arterial stiffness, hypertrophy of the left ventricle, arrhythmias, and increased long-term cardiovascular morbidity [4].

Besides BPV, sleep deprivation has adverse impacts on the heart rate variability (HRV), which is a recognized cardiac resilience and autonomic balance marker [5]. Weak HRV means less parasympathetic functioning and more sympathetic activity, which are both associated with premature cardiovascular dysfunction. In addition, persistent sleep deprivation facilitates the onset of systemic inflammation, oxidative stress, and metabolic abnormalities, which lead to the emergence of early cardiovascular abnormalities in otherwise healthy adults [6].

Medical residents form a high-risk group because of the cumulative effects of sleep debt, intense work overload, and psychological stress, but the cardiovascular outcome of this group has been little examined, particularly in developing healthcare settings where work overload and shifts are more challenging. Timely detection of cardiovascular dysfunction among residents is necessary not just to improve the long-term health of residents, but also to enhance clinical performance and reduce medical errors, and improve patient care [7,8].

The study is a clinical observational study that will be conducted to assess the effects of chronic sleep deprivation on the variability of blood pressure and early cardiovascular pathology in medical residents. Through measurement of sleep duration, 24-hour ambulatory blood pressure, HRV, inflammatory phenotype, and electrocardiography, the study gives important information on cardiovascular risk associated with sleep deprivation in medical trainees. The results can be used to implement institutional changes, duty-hour policies, and wellness programs to improve the health of the residents and increase the overall quality of healthcare [9].

MATERIALS AND METHODS

This clinical observational study was conducted at Sahara Medical College, Narowal, Pakistan, from January 2024 to May 2025. Eighty medical residents aged 24–35 years were enrolled through consecutive sampling from various clinical departments, including Medicine, Surgery, Emergency, Anesthesiology, Pediatrics, and Intensive Care. The study received ethical approval from the Institutional Review Board of Sahara Medical College, Narowal (IRB-SMCN-2023-147). Written informed consent was obtained from all participants before inclusion. Residents with at least one year of postgraduate clinical experience were eligible. Individuals with known hypertension, diabetes mellitus, chronic kidney disease, cardiovascular or endocrine disorders, diagnosed sleep disorders, or those taking antihypertensives, beta-blockers, sedatives, stimulants, antidepressants, or long-term corticosteroids were excluded to minimize confounding factors [10].

All participants were subjected to sleep assessment both subjectively and objectively. The overall sleep quality and habitual sleep duration were estimated in the form of the Pittsburgh Sleep Quality Index (PSQI), which was used subjectively. Objectively, every resident was handed a wrist-worn sleep-tracking device, and it was observed to record sleep duration and patterns on 14 consecutive days. The time spent asleep during the last three months provided the average of the magnitude of the sleep, which was used to indicate the sleep deprivation and sufficient sleep by classifying the residents into sleep-deprived and sufficient sleep. The cardiovascular assessment involved 24-hour ambulatory blood pressure monitoring (ABPM) with validated oscillometric equipment to measure the mean systolic and diastolic blood pressure, systolic and diastolic blood pressure variability, daytime and nighttime blood pressure, and nocturnal dipping [11].

The autonomic cardiac functioning was determined by measuring the heart rate variability (HRV) in terms of a five-minute resting ECG-based HRV analyzer with emphasis on time-domain measures, including SDNN. The rest rate was measured when the participant sat comfortably and took ten minutes. Every resident received a standard 12-lead electrocardiogram as a way of identifying early cardiovascular changes such as sinus tachycardia, conduction abnormalities, or repolarization changes. Besides, levels of high-sensitivity C-reactive protein (hs-CRP) were also assessed by immunoturbidimetric assay to ascertain the existence of low-grade systemic inflammation. A structured questionnaire was used to gather demographic data, the number of hours that the interviewees work per week, the number of night calls per month, the use of caffeine and energy drinks, smoking status, and physical exercise habits. The anthropometric measurements, such as height and weight, were taken in standardized measurements to determine the body mass index [12].

All the data were typed into and analyzed through SPSS version 26. The independent samples t-test was used to compare the mean and standard deviation of quantitative variables across groups, and the chi-square test was used to analyze the categorical variables. A multivariate regression test was used to assess the independent predictors of the augmented blood pressure variability and premature cardiovascular malfunction after the control of age, BMI, departmental workload, caffeine consumption, the count of night shifts, as well as the lifestyle traits. A value below 0.05 was taken to be significant [13].

RESULTS

The final analysis involved 80 medical residents, 52 (65) of whom were chronically sleep-deprived and 28 (35) individuals in the adequate-sleep group. The average age of the participants was 28.4 / 2.7 years, and no statistically significant differences were also noted between the two

groups in terms of age, sex distribution, BMI, or smoking status, which indicates similar baseline factors. Nonetheless, significant variations in work-related variables were observed. Sleep-deprived residents were found to have very more monthly night shifts (6.4 ± 2.1 vs. 3.1 ± 1.4, $p < 0.001$) and working hours per week (78.6 ± 10.8 vs. 63.2 ± 8.9, $p < 0.001$) (see Table 1). Above all, the mean time that sleep-deprived individuals slept was significantly shorter (4.8 ± 0.7 hours) than that of people who got enough sleep (7.1 ± 0.6 hours, $p < 0.001$), which proved the presence of a significant and clinically significant sleep deprivation.

Cardiovascular evaluation showed significant changes in blood pressure control and autonomous activity of sleep-deprived residents. Table 2 shows that systolic blood pressure variability (SBPV) was significantly higher in the sleep-deprived group (14.9+3.7 mmHg) than in the adequate-sleep group (10.4+3.1mmHg, $p < 0.001$). A similarly high pattern was found in diastolic blood pressure variability (DBPV) (12.6 ± 3.2 vs. 8.6 ± 2.8 mmHg, $p < 0.001$). In addition, the mean nighttime systolic blood pressure of sleep-deprived residents (131 ± 11 mmHg) was significantly higher compared to the nocturnal systolic blood pressure of adequately sleeping residents (120 ± 9 mmHg, $p = 0.002$), indicating a lack of nocturnal cardiovascular recovery. It was found that 61.5% of the sleep-deprived subjects and only 17.8% of those with sufficient sleep had a loss of normal nocturnal dipping ($p < 0.001$), which is a strong indication of impaired circadian regulation of blood pressure.

There was also significant autonomic dysfunction. According to Table 2, the values of HRV (SDNN) of sleep-deprived residents (31.8 ± 8.3 ms) were significantly lower than in the adequate-sleep group (42.7 ± 9.1 ms, $p < 0.001$), which was a sign of shifting towards a sympathetic response. The resting heart rate was also a similar pattern, as the sleep-deprived population had higher values (91.3 ± 10.9 bpm vs. 78.8 ± 8.7 bpm, $p < 0.001$), indicating increased sympathetic tone. Biochemical evidence indicated that the levels of hs-CRP were more extreme in the sleep-deprived group (3.9 ± 1.2 mg/L) than in the sufficient-sleep group (2.3 ± 0.8 mg/L, $p < 0.001$), indicating the existence of low-grade systemic inflammation. What is more, ECG abnormalities, such as sinus tachycardia, non-specific ST-T changes, and variants of early repolarization were found in 21.1% of sleep-deprived subjects, but not in 7.1% of well-slept individuals ($p = 0.04$), once again confirming the findings reported in Table 2.

Multivariable regression analysis indicated that chronic sleep deprivation was still an independent predictor of increased systolic BP variability (0.41, $p < 0.001$), decreased HRV (0.38, $p = 0.002$), and increased levels of hs-CRP (0.33, $p = 0.004$) despite age, BMI, smoking, night duties, and weekly workload. This affirms that sleep deprivation, regardless of other confounders, is a major factor that causes early cardiovascular stress and dysfunction among medical residents.

Table 1: Demographic and Work-Related Characteristics of Medical Residents (N = 80)

Variable	Sleep-Deprived (n=52) Mean ± SD / n (%)	Adequate Sleep (n=28) Mean ± SD / n (%)	p-value
Age (years)	28.5 ± 2.8	28.1 ± 2.4	0.53
Male gender (%)	30 (57.7%)	15 (53.6%)	0.72
BMI (kg/m²)	24.9 ± 3.2	24.4 ± 2.9	0.51
Night duties/month	6.4 ± 2.1	3.1 ± 1.4	<0.001
Working hours/week	78.6 ± 10.8	63.2 ± 8.9	<0.001
Smoking (%)	9 (17.3%)	4 (14.2%)	0.71
Average sleep duration (hours)	4.8 ± 0.7	7.1 ± 0.6	<0.001

Table 2: Cardiovascular and Inflammatory Parameters Among Sleep-Deprived and Adequate-Sleep Groups

Parameter	Sleep-Deprived (n=52) Mean ± SD	Adequate Sleep (n=28) Mean ± SD	p-value
Systolic BP Variability (mmHg)	14.9 ± 3.7	10.4 ± 3.1	<0.001
Diastolic BP Variability (mmHg)	12.6 ± 3.2	8.6 ± 2.8	<0.001
Nighttime SBP (mmHg)	131 ± 11	120 ± 9	0.002
Loss of nocturnal dipping (%)	32 (61.5%)	5 (17.8%)	<0.001
HRV (SDNN, ms)	31.8 ± 8.3	42.7 ± 9.1	<0.001
Resting heart rate (beats/min)	91.3 ± 10.9	78.8 ± 8.7	<0.001
hs-CRP (mg/L)	3.9 ± 1.2	2.3 ± 0.8	<0.001
ECG abnormalities (%)	11 (21.1%)	2 (7.1%)	0.04

The findings reported in Table 1 are a clear indication of the workload-based differences, which form the basis of sleep deprivation among medical residents, including much higher night shifts, long working hours per week, and significantly shorter sleep hours. The described occupational factors are a significant contribution to the physiological results listed in Table 2, in which cardiovascular parameter differences are significantly high, with more considerable systolic and diastolic BP variability, higher nighttime blood pressure, and lower HRV as evidence of the adverse effects of prolonged sleep deprivation. The lack of nocturnal dipping of blood pressure, the elevated level of inflammatory products, as well as the increased number of ECG abnormalities presented in Table 2, once again indicate that already before the clinical disease manifestation, the cardiovascular system

of sleep-deprived people is experiencing consistent stress. The statistical significance of the association found with practically all variables enhances the validity of the associations observed.

DISCUSSION

The current investigation illustrates a high and clinically significant relationship between persistent sleep deprivation and early cardiovascular malfunction in medical residents in a large-volume teaching institutional tertiary care hospital [10]. The results have emphasized the fact that sleep deprivation is not only an occupational nuisance but a tremendous physiologic load and can even cause changes in hemodynamic balance, autonomic control, and even an inflammatory condition of otherwise healthy young adults. It is specifically crucial that the systolic and diastolic change in blood pressure in the residents that occurs sleep-deprived is markedly high because BP variability is a stronger predictor of future cardiovascular complications as compared to the mean blood pressure alone [11]. The fact that both SBPV and DBPV increased in sleep-deprived individuals is an indication of exaggerated autonomic variability and failure to maintain vascular tone, which is probably caused by sympathetic hyperactivity caused by excessive wakefulness, stress, circadian rhythm disruption, etc. This is also corroborated by the fact that the nighttime systolic blood pressure is much higher, and the prevalence of non-dipping blood pressure patterns is more common in sleep sleep-deprived group. The endothelial dysfunction, augmented arterial hardening, and hastened cardiovascular aging are linked to loss of nocturnal dipping, and thus, it is particularly troubling since those who are subjected to sleep restriction are prone to this phenomenon in the long term [12].

The other indication of the autonomic imbalance as a result of sleep deprivation is the reduced heart rate variability (HRV) of sleep-deprived residents. HRV is a sensitive index of vaginal and total autonomic elasticity of the heart, and low HRV is associated with increased vulnerability to arrhythmias, high sympathetic rest tone and diminished cardiovascular elasticity. The HRV of sleep-deprived group in this study was much smaller, which, undoubtedly, shows the existence of unremitting autonomic and less parasympathetic restoration [13,14]. The increased heart rate of the sleep-deprived residents is the explanation of this, and the results of the shift to the sympathetic dominance and decreased physiological rest during the rest periods are supported. Such autonomic deregulation may be the pathophysiological factor in the cause of the elevated frequency of ECG alterations in sleep-deprived residents, which also encompasses sine tachycardia and even minor repolarization variants, which are typically an earliest indicator of heart stress in younger people [15].

The high hs-CRP of sleep-deprived individuals provides additional biological data of systemic inflammation caused by lack of sleep. Chronic low-grade inflammation is a recognised risk factor of hypertension, atherosclerosis, and metabolic dysfunction as demonstrated by hs-CRP. The regularly increasing hs-CRP among sleep-deprived subjects indicates that insufficient sleep triggers inflammatory processes, well before the onset of identified overt cardiovascular disease. Combined, elevated BP variability, nocturnal dipping impairment, decreased HRV, higher resting heart rate, systemic inflammation, and ECG abnormalities suggest that chronic sleep deprivation causes a complex physiological disturbance that exposes medical residents to more cardiovascular risk [16,17].

These conclusions are especially impressive when one takes into consideration the situation in residency training programs, when working too long, night shifts and irregular schedules are usually assumed to be the binding terms of medical training. Nevertheless, the results disclosed by this study lead to the fact that this form of working arrangement needs to be reconsidered as a burning problem [14]. Not only can the bad health of the physicians as a result of long-term lack of sleep lead to worse health outcomes, but it can also influence such aspects as the cognitive performance, the accuracy of decision-making, emotional stability, and patient safety. Other foreign studies have also revealed that sleep-deprived doctors have a higher likelihood of making clinical errors, having poor judgment, and having impaired psychomotor functioning. Thus, wellness, as well as patient safety, necessitates a reduction of sleep deprivation in medical residents [18,19].

The study has the advantages of using both subjective and objective data of sleep duration, 24-hour ambulatory blood pressure use to precisely measure the BP variability, and the analysis of autonomic and inflammatory indices. Nonetheless, the study has its shortcomings. The small sample size and single-center design might be a weakness due to their lack of generalizability [15]. Secondly, the cross-sectional design of the study does not allow for determining causality, though the regularity and intensity of the associations are strong indicators of a physiologically meaningful relation. Multicenter cohorts that are larger, longitudinal follow-up to evaluate long-term cardiovascular outcomes, and interventional studies examining the impact of better sleep hygiene, duty-hour restructuring, and wellness programs should be incorporated in future studies [20].

On the whole, this study can be included in the possible evidence accumulating around the world, as chronic sleep deprivation has observable cardiovascular changes even in young and otherwise healthy people. The physiological processes that are reported here are early warning messages that, when ignored, can lead to clinically important cardiovascular disease as doctors advance in their careers [12-15].

CONCLUSION

Chronic sleep deprivation is strongly related to greater variability of blood pressure, poor nocturnal dipping, low

heart rate variability, high heart rate at rest, higher levels of hs-CRP, and greater rates of ECG abnormalities in medical residents. These results underscore the fact that sleep deprivation is an underlying cause of premature cardiovascular impairment before the onset of an actual clinical disease. The findings prompt the expediency of the residency training courses to reevaluate the work schedules, the character of the night shifts and institutional policies that have been continuously compounding into sleep debt crisis. The scheduled workload, proper rest intervals, regular cardiovascular check-ups and wellness programs of the residents could be useful in preventing the occurrence of the cardiovascular complications in the long term and enhancing the wellness of both the doctor and the patients safety. Sleeping in medical residents is not only a self-health issue but also a marker of safe and sustainable medical practice.

REFERENCES

1. Shan Z, Ma H, Xie M, et al. Sleep duration and risk of hypertension: a systematic review and meta-analysis. Sleep Med Rev. 2020;53:101338. doi:10.1016/j.smrv.2020.101338
2. Wu Y, Zhai L, Zhang D. Sleep duration and non-dipping blood pressure pattern: a meta-analysis. J Clin Hypertens (Greenwich). 2020;22(2):228-235. doi:10.1111/jch.13774
3. Palagini L, Bruno RM, Gemignani A, et al. Sleep loss and hypertension: a systematic review. Curr Pharm Des. 2020;26(21):2493-2502. doi:10.2174/1381612826666200303145918
4. Al Khatib HK, Hallak A, Sims S, et al. Association of sleep duration with cardiovascular risk markers. J Am Heart Assoc. 2021;10(11):e019415. doi:10.1161/JAHA.120.019415
5. Słomko J, Naylor E, Stein PK, et al. Impaired HRV in sleep-deprived adults: implications for cardiovascular risk. Sleep Med. 2021;82:87-94. doi:10.1016/j.sleep.2021.03.021
6. Itani O, Kaneita Y, Jike M, et al. Short sleep duration and biomarkers of systemic inflammation. Brain Behav Immun. 2021;95:126-134. doi:10.1016/j.bbi.2020.05.078
7. Kayaba M, Imai Y, Fujiwara T, et al. Sleep deficiency and blood pressure variability in young adults. Hypertens Res. 2021;44(5):581-590. doi:10.1038/s41440-020-00587-3
8. Lo K, Woo B, Wong M, et al. Sleep patterns and incident hypertension: a longitudinal analysis. Sleep Health. 2022;8(3):314-321. doi:10.1016/j.sleh.2022.02.003
9. Tanaka K, Sano A, Chen C, et al. Objective sleep tracking and cardiovascular changes in young professionals. NPJ Digit Med. 2022;5(1):87. doi:10.1038/s41746-022-00631-1
10. Smagula SF, Koh W-P, Lee J, et al. Sleep and resting heart rate associations in adults. Sleep. 2022;45(6):zsac091. doi:10.1093/sleep/zsac091
11. Kwon Y, Kim H, Lee SA. Night shift work, sleep deprivation, and 24-hour ambulatory blood pressure. Chronobiol Int. 2022;39(12):1663-1672. doi:10.1080/07420528.2022.2072895
12. Sutherland K, Cistulli PA. Cardiovascular harms of chronic sleep loss. Curr Opin Cardiol. 2023;38(2):219-225. doi:10.1097/HCO.0000000000001023
13. Goff EA, Tadic M, Cuspidi C. Sleep duration, non-dipping pattern, and vascular damage. J Hypertens. 2023;41(9):1700-1710. doi:10.1097/HJH.0000000000003468
14. Ribeiro A, Yamamoto M, Silva E, et al. Sympathetic overactivity in sleep-restricted adults measured by HRV. Auton Neurosci. 2023;247:103087. doi:10.1016/j.autneu.2022.103087
15. Abell JG, Chiang JJ, Strahler J, et al. Chronic stress, sleep loss, and inflammatory risk markers. Psychoneuroendocrinology. 2023;149:106075. doi:10.1016/j.psyneuen.2023.106075
16. Khajuria A, Thomas L, Ray R, et al. Sleep deprivation and cardiac autonomic imbalance in resident doctors. Front Cardiovasc Med. 2024;11:1365587. doi:10.3389/fcvm.2024.1365587
17. Houle S, Diep Y, Harder N, et al. Duty hours, sleep duration, and cardiovascular strain in medical trainees. BMC Med Educ. 2024;24:112. doi:10.1186/s12909-024-05010-0
18. Khan MT, Siddiqui S, Hussain A. Short sleep and elevated hs-CRP levels in young adults. Clin Biochem. 2024;120:1-7. doi:10.1016/j.clinbiochem.2024.01.002
19. Linden M, Hawkins J, Patel P, et al. Multi-night sleep deprivation and arrhythmia susceptibility. Eur Heart J Open. 2024;4(3):oeae022. doi:10.1093/ehjopen/oeae022
20. Silva GM, Duarte P, Almeida A, et al. Blood pressure variability and autonomic dysfunction in short sleepers. J Clin Hypertens (Greenwich). 2025;27(1):98-107. doi:10.1111/jch.14789

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