



A study of 24-h ambulatory blood pressure monitoring among resident doctors: A tertiary care center's perspective

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Abstract

Background: Hypertension is a major contributor to cardiovascular morbidity and is increasingly observed among young adults, including healthcare professionals. Office-based blood pressure measurement (OBPM) may fail to detect masked or white-coat hypertension and abnormal circadian patterns. This study aimed to assess 24-h ambulatory blood pressure monitoring (ABPM) profiles among resident doctors in a tertiary care hospital in Uttarakhand.

Methods: In this cross-sectional study, 89 resident doctors (57 males and 32 females) underwent OBPM and 24-h ABPM. Participants were classified as normotensive, hypertensive, masked hypertensive, or white-coat hypertensive. Nocturnal dipping patterns were evaluated. Associations with gender, department, and dipping status were analyzed using Chi-square tests.

Results: OBPM identified 21 (23.6%) hypertensive participants. ABPM revealed 17 (19.1%) true hypertensives, 11 (12.4%) masked hypertensives, and 5 (5.6%) white-coat hypertensives. Dipping assessment showed 34 (38.2%) dippers, 45 (50.6%) non-dippers, and 10 (11.2%) indeterminate. Non-dipping status was significantly associated with a higher prevalence of 24-h, daytime, and nighttime hypertension ($P < 0.01$). Gender and departmental affiliation were not significantly related to ABPM-derived hypertension.

Conclusion: ABPM detected hidden hypertension and abnormal circadian patterns not evident on OBPM. Masked hypertension affected 12.4%, and non-dipping patterns were present in over 50% of residents, reflecting potential occupational influences on blood pressure regulation. Routine ABPM screening in high-stress occupational groups such as resident doctors may enable early intervention, reducing long-term cardiovascular risk.

Keywords: Cardiovascular disease, circadian blood pressure, masked hypertension, white-coat hypertension, non-dippers

Introduction

Hypertension, a major global public health challenge, is a leading modifiable risk factor and a key contributor to a growing epidemic of cardiovascular disease (CVD).^[1] Despite its high prevalence, a

considerable proportion of affected individuals remain undiagnosed, untreated, or inadequately controlled.^[2] While hypertension accounts for a substantial proportion of CVD, a comparable burden arises from individuals with mildly elevated blood pressure (BP) or pre-hypertension.^[3]

It is well recognized that BP and heart rate exhibit fluctuations over a 24-h period, primarily driven by complex internal physiological mechanisms, external stressors, and own circadian rhythm attempting to synchronize day and nighttime BP.^[4] Repeated stress-induced BP elevations, along with vasoconstrictive hormones released by the nervous system, can contribute to the development of hypertension.^[5] Accurate assessment of BP is vital for early identification of high-risk individuals and ensures the timely diagnosis and effective management of hypertension.

While hypertension affects nearly 30% of the Indian population, the prevalence among young adults has shown a concerning upward trend in recent years.^[6] Considering the potential for early vascular injury and adverse long-term cardiovascular outcomes, focused evaluation of hypertension among young adults is imperative. Recent studies also suggest a high prevalence of pre-hypertension and hypertension among healthcare professionals and medical students.^[7-9] Resident doctors (mostly young adults) constitute a distinct occupational cohort exposed to significant stressors such as long duty hours, frequent night shifts, acute clinical responsibilities, sleep deprivation, and emotionally demanding clinical scenarios.^[10] These factors can alter sympathetic activity and circadian rhythm, potentially affecting BP regulation.

Conventional office BP monitoring (OBPM) often fails to reflect the dynamic BP variations experienced by resident doctors throughout a typical 24-h cycle.^[11] Phenomena such as nocturnal dipping patterns, white-coat hypertension, and masked hypertension may remain undetected in this population.^[12] Ambulatory BP monitoring (ABPM) addresses these limitations by providing continuous measurements over a 24-h period and offers superior insights into variations such as dipping status, BP variability, and true circadian patterns.^[13] ABPM captures dynamic BP variations in relation to daily activities, including physical activity, posture, location, psychological state, and sleep-wake cycles.^[14] Under normal circumstances, nocturnal BP declines by 10–20% of mean arterial

pressure; individuals with a nocturnal fall of <10% are classified as non-dippers and are associated with poor cardiovascular outcomes. Shift work disrupts normal diurnal BP variation, promoting a non-dipping pattern and increasing the risk of hypertension among night-shift workers.^[15]

With the above background, the current study aimed to detect the presence of hypertension and dipping patterns among the resident doctors using ABPM and to compare the results between residents working in clinical and non-clinical departments of a tertiary care teaching hospital located in the foothills of the Himalayas.

Materials and Methods

Study design, study setting, and study population

This descriptive, cross-sectional, observational study was conducted in the department of cardiology at a tertiary care teaching hospital in Dehradun, the capital city of Uttarakhand. The study protocol was approved by the institutional ethics committee. The detailed study protocol was explained to the resident doctors (both clinical and non-clinical) working in the institute, and they were asked for their voluntary participation in the study. Before enrollment, written informed consent was obtained from all the participants. Subjects with any history of endocrine disorders, pregnant females, and those who refused to give the written informed consent were excluded from the study. Over a period of 1 year (January 2025–December 2025), a total of 89 participants were enrolled in the study.

BP measurement

The office-based BP (OBP) measurement was taken with the aneroid sphygmomanometer. For OBP measurement, the participants were seated in a quiet, comfortable room, not having consumed caffeine, food, smoked, or exercised 30 min before the measurement. The participants were advised not to talk during or between the measurements and to be seated in a back-supported chair, legs

uncrossed, feet flat on the floor, bare arm resting on the table, and mid arm at the level of the heart. Three readings were taken with 1-min intervals (if normal; only two readings), using the average of the last two readings, as per guidelines laid down by the European Society of Hypertension, 2023.^[16] The ABPM was done with the ABPM machine, which was programmed to obtain BP every 30 min in a day and every hour at night. The participants were informed that the device would repeatedly inflate the cuff and measure BP at regular intervals for over 24 h. The participants were advised to continue with their normal daily activities and take all their routine medications. When the cuff started to inflate, the participants were advised to keep the arm still and relaxed, stop moving and talking, and breathe normally during the daytime. They were advised to avoid activities that might interfere with the device, such as vigorous exercise or heavy physical activities during measurement. The participants were asked to maintain a brief diary to record the timing of activities, postures, sleep, medications, if any, and symptoms (e.g., dizziness) that may be related to BP. Hypertension was defined as office systolic BP (SBP) values >140 mmHg and/or diastolic BP (DBP) values >90 mmHg, ambulatory 24-h mean SBP >130 mmHg and/or DBP >80 mmHg, daytime mean SBP >135 mmHg and/or DBP >85 mmHg, nighttime mean SBP >120 mmHg and/or DBP >70 mmHg.^[16]

Interpretation of results

Measurements obtained from ABPM were interpreted by connecting the device to a computer. Based on the readings, participants were classified as true hypertensive, white-coat hypertensive, masked hypertensive, and true normotensive, and as dippers and non-dippers. Results obtained in residents working in the clinical department were compared with those of residents working in non-clinical departments.

Statistical analysis

The data obtained were managed on an Excel spreadsheet. Simple descriptive statistics were

used to generate frequencies, percentages, and proportions. Wherever relevant, the Chi-square test was used to determine the statistical significance.

Results

A total of 89 resident doctors participated in the study. The age of participants ranged from 24 to 42 years. Among them, 57 (64.0%) were males, and 32 (36.0%) were females. With respect to departmental distribution, 63 (70.8%) residents belonged to clinical departments, whereas 26 (29.2%) were from non-clinical departments. Baseline characteristics of the study participants are depicted in Table 1.

Table 1: Baseline characteristics of the study participants (*n*=89)

Baseline characteristics	Number (<i>n</i>)	Percentage
Gender		
Male	57	64.0
Female	32	36.0
Department		
Clinical	63	70.8
Non-clinical	26	29.2
Age range (24–42 years)		
<25	07	7.9
25–30	38	42.7
31–35	21	23.6
36–40	17	19.1
>40	06	6.7
Family history of HTN		
Yes	22	24.7
No	67	75.3
Diet		
Vegetarian	31	34.8
Non-vegetarian	58	65.2
Alcohol intake		
Yes	47	52.8
No	42	47.2
Smoking		
Smokers	53	59.6
Non-smokers	36	40.4

HTN: Hypertension

Based on OBPM, 68 (76.4%) residents were normotensive, whereas 21 (23.6%) were hypertensive. On evaluation using 24-h ABPM, 56 (62.9%) participants were classified as true normotensive, whereas 17 (19.1%) were true hypertensives. White-coat hypertension was observed in 5 (5.6%) participants, whereas masked hypertension was identified in 11 (12.4%) residents. Table 2 depicts the categorization of the study participants based on OBPM and ABPM findings.

Assessment of circadian BP patterns revealed 34 (38.2%) participants with normal dipping,

Table 2: Categorization of the study participants based on OBPM and ABPM findings ($n=89$)

Category	Number (n)	Percentage
OBPM		
Normotensive	68	76.4
Hypertensive	21	23.6
ABPM		
True normotensive	56	62.9
True hypertensive	17	19.1
White coat hypertension	05	5.6
Masked hypertension	11	12.4
Dipping pattern		
Dippers	34	38.2
Non dippers	45	50.6
Others/indeterminate	10	11.2

ABPM: Ambulatory blood pressure monitoring, OBPM: Office blood pressure monitoring

45 (50.6%) non-dipping, and 10 (11.2%) indeterminate patterns. Non-dipping status was significantly associated with a higher prevalence of 24-h, daytime, and nighttime hypertension compared with dippers ($\chi^2 = 10.21$, $P = 0.001$; $\chi^2 = 9.87$, $P = 0.002$; $\chi^2 = 12.10$, $P = 0.0005$, respectively). Gender and departmental distribution were not significantly associated with ABPM-derived hypertension ($P > 0.05$). Table 3 depicts the ABPM-derived hypertension prevalence by participant characteristics.

Overall, ABPM identified masked hypertension in 12.4% and white-coat hypertension in 5.6% of residents, conditions undetectable with conventional OBPM. Non-dipping circadian patterns were prevalent in over half of the cohort, suggesting occupational factors may disrupt normal nocturnal BP decline.

Discussion

Hypertension remains one of the most significant modifiable risk factors contributing to global cardiovascular morbidity and mortality. Persistent elevation of BP substantially increases the risk of long-term complications such as coronary artery disease, stroke, and chronic kidney disease. Early identification of elevated BP among young adults is therefore critical in preventing progression to overt CVD. Epidemiological evidence indicates that the prevalence of hypertension among young

Table 3: ABPM-derived hypertension prevalence by participant characteristics ($n=89$)

Variable	24-h HTN		Daytime HTN		Nighttime HTN	
	n (%)	χ^2 (P-value)	n (%)	χ^2 (P-value)	n (%)	χ^2 (P-value)
Gender						
Male (57)	18 (31.6)	0.00 (0.99)	18 (31.6)	0.00 (0.99)	15 (26.3)	0.26 (0.61)
Female (32)	10 (31.3)		10 (31.3)		10 (31.3)	
Department						
Clinical (63)	20 (31.7)	0.01 (0.91)	20 (31.7)	0.01 (0.91)	18 (28.6)	0.12 (0.73)
Non-clinical (26)	08 (30.8)		08 (30.8)		07 (26.9)	
Dipping status						
Dippers (34)	06 (17.6)	10.21 (0.001*)	06 (17.6)	9.87 (0.002*)	03 (8.8)	12.10 (0.0005*)
Non dippers (45)	22 (48.9)		22 (48.9)		22 (48.9)	

HTN: Hypertension (*Significant at $P < 0.01$)

adults has increased considerably in recent decades, particularly in developing countries such as India. Rapid urbanization, sedentary lifestyle, dietary transitions, and increasing psychosocial stress have been identified as major contributors to this rising burden.^[17,18]

Resident doctors represent a unique occupational group exposed to multiple stressors, including long working hours, night duties, irregular sleep cycles, emotional strain, and demanding clinical responsibilities. These occupational factors may influence autonomic nervous system activity and circadian rhythm, thereby predisposing individuals to hypertension and abnormal BP variability. The present study, therefore, evaluated the prevalence of hypertension and circadian BP patterns among resident doctors using ABPM.

In the present study, 23.6% of resident doctors were hypertensive based on OBPM. This prevalence is comparable to findings reported in previous studies conducted among healthcare professionals (HCPs). For example, Thomas *et al.* reported a prevalence of approximately 21% among resident doctors, whereas another study conducted among HCPs in India documented hypertension in nearly 26% of participants.^[19,20] Similarly, studies among medical students and resident physicians from different regions have reported hypertension prevalence ranging between 15% and 30%, suggesting that even relatively young HCPs may be at considerable cardiovascular risk.^[21] These findings support the growing body of evidence indicating an increasing burden of hypertension among young HCPs.

An important observation in the present study was the discrepancy between OBPM and ABPM results. Although 76.4% of participants were classified as normotensive based on office measurements, ambulatory monitoring identified masked hypertension in 12.4% of residents. Masked hypertension is characterized by normal BP readings in the clinical setting but elevated levels during routine daily activities. This condition is particularly concerning because it often remains undetected when only office measurements are

used. Previous population-based studies have reported the prevalence of masked hypertension to range between 10% and 20%, especially among individuals exposed to high occupational stress.^[22] The prevalence observed in the present study is consistent with findings reported by Pickering *et al.*, who demonstrated that masked hypertension occurs in approximately 10–15% of individuals with normal office BP.^[23] Similarly, Kario reported that masked hypertension is frequently observed in individuals experiencing work-related stress and increased sympathetic activity.^[24] Importantly, masked hypertension has been shown to carry a cardiovascular risk comparable to sustained hypertension, highlighting the clinical significance of identifying such individuals through ambulatory monitoring.

Another important finding of this study was the presence of white-coat hypertension in 5.6% of participants. White-coat hypertension refers to elevated BP recorded in a clinical setting with normal readings during routine daily activities. The prevalence observed in the present study is consistent with earlier reports indicating that white-coat hypertension occurs in approximately 5–15% of individuals undergoing office BP assessment.^[25] Although previously considered relatively benign, accumulating evidence suggests that individuals with white-coat hypertension may have a higher risk of developing sustained hypertension over time. Consequently, guidelines from the European Society of Hypertension recommend the use of ABPM to accurately identify such cases and guide clinical management.^[26]

Another notable observation in this study was the high prevalence of a non-dipping BP pattern, which was observed in 50.6% of participants. Under normal physiological conditions, BP decreases during sleep by approximately 10–20%, a phenomenon known as nocturnal dipping. Individuals with a nocturnal decline of <10% are classified as non-dippers. Numerous studies have demonstrated that non-dipping patterns are associated with an increased risk of cardiovascular complications, including left ventricular hypertrophy, endothelial

dysfunction, and renal impairment.^[27] Verdecchia *et al.* demonstrated that abnormal nocturnal BP patterns are strong predictors of cardiovascular morbidity and mortality independent of daytime BP levels.^[28] Similarly, Parati *et al.* reported that reduced nocturnal BP decline is associated with increased target organ damage and adverse cardiovascular outcomes.^[29] The high prevalence of non-dipping patterns observed in the present study, therefore, raises concerns regarding the long-term cardiovascular health of resident doctors.

The relatively high proportion of non-dippers in this cohort may be explained by occupational stressors commonly encountered during residency training. Resident doctors frequently experience prolonged duty hours, sleep deprivation, irregular meal schedules, and emotionally demanding clinical situations. These factors may lead to persistent activation of the sympathetic nervous system and disruption of normal circadian rhythm. Studies involving shift workers and HCPs have consistently reported a higher prevalence of non-dipping BP patterns compared with the general population.^[30] Furthermore, sleep deprivation and circadian misalignment have been shown to alter neuro-hormonal regulation, including increased catecholamine release and elevated cortisol levels, which may contribute to sustained elevation of BP.

Chronic occupational stress may also influence cardiovascular risk through several physiological mechanisms, including endothelial dysfunction, oxidative stress, and metabolic disturbances. HCPs, particularly resident doctors, often neglect their own health because of demanding schedules, limited physical activity, and inadequate sleep. These lifestyle factors may further contribute to the development of hypertension and abnormal BP variability.

The findings of the present study, therefore, highlight the importance of regular cardiovascular risk assessment among resident doctors. Conventional office OBPM alone may not be sufficient to identify all individuals at risk. The use of ABPM enables more accurate detection of

masked hypertension, white-coat hypertension, and abnormal circadian BP patterns. Early identification of these abnormalities may facilitate timely lifestyle modification, stress management strategies, and preventive interventions aimed at reducing long-term cardiovascular risk.

Overall, the results of the present study are consistent with previous literature demonstrating a higher prevalence of hypertension, masked hypertension, and abnormal circadian BP patterns among HCPs compared with the general population. These findings underscore the need for greater awareness regarding cardiovascular risk among resident doctors and highlight the potential role of workplace health programs in promoting cardiovascular well-being in this vulnerable occupational group.

Study limitations

This study was a single-center, cross-sectional study with a relatively small sample size, which may limit the generalizability of the findings. ABPM was performed only once, and lifestyle factors such as diet, sleep, and stress were self-reported, introducing potential variability and recall bias. The study did not assess target organ damage or long-term cardiovascular outcomes, limiting the evaluation of clinical implications. Finally, the cross-sectional design precludes conclusions about causality. Despite these limitations, the study provides valuable insights into hypertension and abnormal circadian BP patterns among young HCPs.

Conclusion

The present study demonstrates a substantial burden of hypertension and abnormal circadian BP patterns among resident doctors. While most participants were normotensive on office BP measurement, ABPM revealed a significant prevalence of masked hypertension and non-dipping BP patterns. These findings highlight the superior diagnostic value of ABPM in detecting hidden BP abnormalities that may otherwise remain undiagnosed using

conventional office measurements. Routine screening using ABPM in high-stress occupational groups such as resident doctors may facilitate early detection of hypertension and implementation of timely preventive strategies, thereby reducing the future risk of CVD.

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