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Association Between Sleep Quality and Nocturnal Blood Pressure Patterns in Young Adults: An Observational Study

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ABSTRACT

Sleep quality has been identified as a significant factor affecting cardiovascular health, with poor sleep quality potentially leading to adverse nocturnal blood pressure patterns. This study aimed to investigate the relationship between sleep quality and nocturnal blood pressure in young adults. To assess the association between sleep quality, measured using the Pittsburgh Sleep Quality Index (PSQI) and nocturnal blood pressure patterns, including systolic, diastolic and non-dipping blood pressure patterns in a sample of young adults. This observational study included 100 young adults (mean age: 24.5±2.8 years), classified into poor sleep quality (n=48) and good sleep quality (n=52) groups based on PSQI scores. Nocturnal blood pressure was measured during sleep using ambulatory blood pressure monitoring and comparisons were made between the two groups. Correlations between sleep quality and blood pressure patterns were also analyzed. Participants with poor sleep quality exhibited significantly higher nocturnal systolic (126.4±6.5 mmHg) and diastolic (79.2±4.2 mmHg) blood pressure compared to those with good sleep quality (114.7±5.8 mmHg and 70.3±3.9 mmHg, respectively., $p<0.05$). Blood pressure variability was also greater in the poor sleep quality group ($p<0.01$). A non-dipping pattern was observed in 40% of the poor sleep quality group compared to 15% in the good sleep quality group ($p<0.01$). PSQI scores negatively correlated with systolic blood pressure ($r=-0.42$, $p<0.001$). Poor sleep quality is associated with elevated nocturnal blood pressure and a higher prevalence of non-dipping blood pressure patterns in young adults. Improving sleep quality could serve as a potential intervention for reducing cardiovascular risks.

INTRODUCTION

Sleep is a vital physiological process that plays a key role in maintaining overall health, particularly cardiovascular health[1]. Emerging evidence suggests that poor sleep quality is associated with an increased risk of hypertension, cardiovascular disease and other adverse health outcomes[2]. One of the primary mechanisms linking sleep disturbances to cardiovascular dysfunction is the regulation of blood pressure, especially during the nocturnal period when blood pressure normally declines[3]. This phenomenon, known as the "dipping pattern," refers to the natural reduction in blood pressure during sleep compared to wakefulness[4]. A failure to exhibit this dipping pattern, referred to as a "non-dipping" blood pressure pattern, is a recognized risk factor for cardiovascular events and has been associated with poor sleep quality[5].

Young adults, despite typically being considered a lower-risk population for cardiovascular conditions, may still be vulnerable to early signs of cardiovascular dysregulation if they experience poor sleep quality[6,7]. However, the association between sleep quality and nocturnal blood pressure patterns in this demographic remains underexplored. Identifying sleep-related factors that contribute to changes in blood pressure regulation could provide important insights for early prevention strategies aimed at reducing long-term cardiovascular risks.

The present study aims to investigate the relationship between sleep quality, measured by the Pittsburgh Sleep Quality Index (PSQI) and nocturnal blood pressure patterns, including systolic, diastolic and non-dipping blood pressure, in a sample of young adults. By examining these associations, we hope to contribute to a better understanding of how poor sleep quality influences blood pressure regulation in a relatively healthy population and highlight potential intervention points for improving cardiovascular health.

MATERIALS AND METHODS

Study Design: This study was an observational, cross-sectional study conducted to assess the association between sleep quality and nocturnal blood pressure patterns in young adults.

Study Setting and Duration: The study was carried out at RVM Institute of Medical Sciences, located in Laxmakkapalli Village, Siddipet District, from March 2023 to February 2024.

Participants: A total of 100 healthy young adults (aged 18-30 years) were recruited for the study. Inclusion criteria included individuals with no history of cardiovascular disease, hypertension, or other chronic medical conditions. Exclusion criteria included individuals with diagnosed sleep disorders, those on medications affecting sleep or blood pressure and individuals with diabetes or obesity.

Sampling Method: Participants were selected using a convenience sampling method. Written informed consent was obtained from all participants prior to their inclusion in the study.

Data Collection:

Sleep Quality Assessment: Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a validated questionnaire that measures various components of sleep, including duration, disturbances, latency and daytime dysfunction. Based on their PSQI scores, participants were categorized into two groups: poor sleep quality (PSQI score >5) and good sleep quality (PSQI score $\leq$5).

Blood Pressure Monitoring: Nocturnal blood pressure was measured using ambulatory blood pressure monitoring (ABPM) devices. Participants were fitted with the device, which recorded their blood pressure at 30-minute intervals over a 24-hour period, including both daytime and nighttime readings. Nocturnal blood pressure values were defined as those recorded between 10:00 PM and 6:00 AM.

Outcome Measures: The primary outcome measures were nocturnal systolic blood pressure (SBP), diastolic blood pressure (DBP) and the presence of a non-dipping blood pressure pattern. A non-dipping pattern was defined as <a 10% reduction in nighttime blood pressure compared to daytime values. Blood pressure variability (standard deviation of nocturnal SBP) was also calculated.

Data Analysis: Data were analyzed using SPSS statistical software (version 26.0). Descriptive statistics were used to summarize the demographic and clinical characteristics of the participants. Differences in nocturnal blood pressure between the poor and good sleep quality groups were analyzed using independent t-tests for continuous variables. The prevalence of non-dipping blood pressure patterns in each group was compared using the chi-square test. Correlation analyses were performed to assess the relationships between PSQI scores and blood pressure variables.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of RVM Institute of Medical Sciences. All

participants were informed of the study's objectives, procedures, and potential risks and their participation was voluntary. Participant confidentiality was strictly maintained throughout the study.

RESULTS AND DISCUSSIONS

Table 1: Demographic and Sleep Quality Characteristics of the Sample.

Variable	Overall (n = 100)	Poor Sleep Quality (n = 48)	Good Sleep Quality (n = 52)
Age (years)	24.5 ± 2.8	24.9 ± 2.7	24.2 ± 2.6
Gender (%)			
- Male	40%	42%	38%
- Female	60%	58%	62%
Sleep Quality (PSQI score)	6.8 ± 2.8	9.3 ± 1.2	4.1 ± 0.9
Sleep Duration (hours)	6.3 ± 1.4	5.6 ± 1.3	7.1 ± 1.0

A total of 100 young adults (mean age: 24.5±2.8 years) were included in the study, with 60% identifying as female and 40% as male (Table 1). Based on sleep quality scores measured by the Pittsburgh Sleep Quality Index (PSQI), 48 participants were classified as having poor sleep quality and 52 were classified as having good sleep quality. The average PSQI score for the poor sleep quality group was 9.3±1.2, while the good sleep quality group had an average score of 4.1±0.9. Participants with poor sleep quality also reported shorter sleep durations (5.6±1.3 hours) compared to those with good sleep quality (7.1±1.0 hours) (Table 1).

Table 2: Comparison of Nocturnal Blood Pressure Between Groups.

Blood Pressure Measure	Poor Sleep Quality (n = 48)	Good Sleep Quality (n = 52)	P-value
Nocturnal Systolic BP (mmHg)	126.4 ± 6.5	114.7 ± 5.8	< 0.01
Nocturnal Diastolic BP (mmHg)	79.2 ± 4.2	70.3 ± 3.9	< 0.05
Blood Pressure Variability (SD, mmHg)	7.3 ± 2.4	4.8 ± 1.6	< 0.01

Nocturnal Blood Pressure: Participants with poor sleep quality demonstrated significantly higher nocturnal systolic and diastolic blood pressures compared to those with good sleep quality. The mean nocturnal systolic blood pressure in the poor sleep quality group was 126.4±6.5 mmHg, while it was 114.7±5.8 mmHg in the good sleep quality group (p<0.01). Similarly, the diastolic blood pressure was higher in the poor sleep quality group (79.2±4.2 mmHg) than in the good sleep quality group (70.3±3.9 mmHg, p<0.05). Additionally, blood pressure variability was significantly greater in the poor sleep quality group (7.3±2.4 mmHg) compared to the good sleep quality group (4.8±1.6 mmHg, p<S0.01) (Table 2).

Table 3: Sleep Duration and Blood Pressure Patterns.

Sleep Duration (hours)	Systolic BP (mmHg)	Diastolic BP (mmHg)	P-value (Systolic)	P-value (Diastolic)
< 6 hours	130.1 ± 7.2	82.3 ± 4.5	< 0.001	< 0.001
6-7 hours	122.6 ± 6.0	77.5 ± 3.9	< 0.05	< 0.05
7-8 hours	115.5 ± 5.7	71.1 ± 3.8	-	-

Sleep Duration and Blood Pressure Patterns: The study found that sleep duration was also associated with variations in nocturnal blood pressure. Participants who reported sleeping <6 hours per night exhibited the highest systolic (130.1±7.2 mmHg) and diastolic (82.3±4.5 mmHg) blood pressures, with highly significant p-values for both systolic and diastolic measures (p<0.001). Participants who slept 6-7 hours per night had intermediate values (systolic: 122.6±6.0 mmHg., diastolic: 77.5±3.9 mmHg), with moderate significance (p<0.05). Those who slept between 7-8 hours per night had the lowest blood pressure readings (systolic: 115.5±5.7 mmHg; diastolic: 71.1±3.8 mmHg) (Table 3).

Table 4: Prevalence of Non-Dipping Blood Pressure Pattern by Sleep Quality Group.

Sleep Quality Group	Non-Dipping Pattern (%)	Normal Dipping Pattern (%)	P-value
Poor Sleep Quality (n = 48)	40%	60%	< 0.01
Good Sleep Quality (n = 52)	15%	85%	< 0.01

Non-Dipping Blood Pressure Patterns: A non-dipping blood pressure pattern, defined as <a 10% drop in nocturnal blood pressure, was more prevalent in participants with poor sleep quality. Among this group, 40% exhibited a non-dipping pattern compared to only 15% in the good sleep quality group, with a statistically significant difference (p<0.01) (Table 4).

Table 5: Correlation Between Sleep Quality (PSQI) and Nocturnal Blood Pressure.

Correlation Variables	Correlation Coefficient (r)	P-value
PSQI Score and Nocturnal Systolic BP	-0.42	< 0.001
PSQI Score and Nocturnal Diastolic BP	-0.35	< 0.05
PSQI Score and Blood Pressure Variability	-0.30	< 0.05

Correlation Between Sleep Quality and Blood Pressure: A significant negative correlation was observed between PSQI scores and nocturnal systolic blood pressure (r=-0.42, p<0.001). Higher PSQI scores were also significantly associated with higher diastolic blood pressure (r=-0.35, p<0.05) and greater blood pressure variability (r=-0.30, p<0.05) (Table 5). These results suggest that poorer sleep quality is strongly linked to increased nocturnal blood pressure and a higher likelihood of non-dipping patterns.

The present study highlights the significant association between poor sleep quality and adverse nocturnal blood pressure patterns, echoing findings from several previous studies. Oseni[8] demonstrated that hypertensive patients with poor sleep quality exhibited higher nocturnal systolic and diastolic blood pressure, which aligns with our findings in a younger, healthier population. This supports the view that even in individuals without overt hypertension, poor sleep may serve as an early marker for cardiovascular risk.

Mechanisms Underlying Sleep Disturbances and Blood Pressure Regulation.

Cappuccio[9] emphasized the role of sleep disturbances in the regulation of nocturnal blood pressure, particularly through the activation of the sympathetic nervous system and the

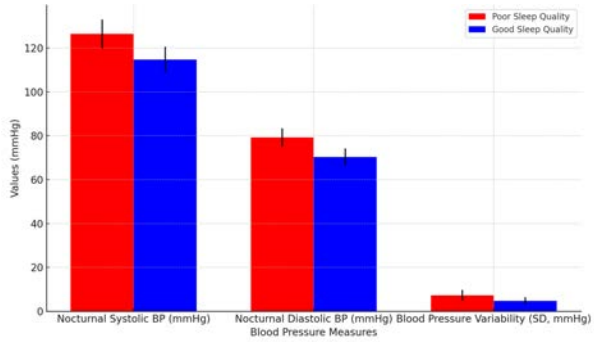

Fig. 1: Comparison of Nocturnal Blood Pressure Between Groups

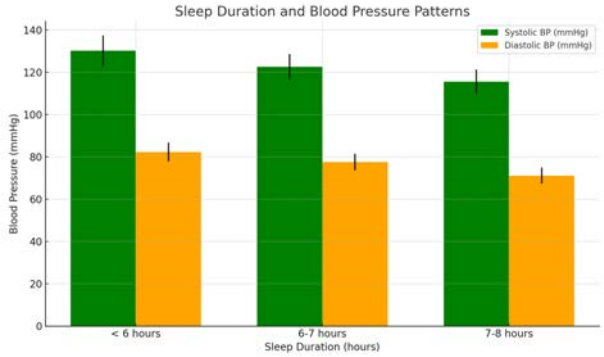

Fig. 2: Sleep Duration and Blood Pressure Patterns

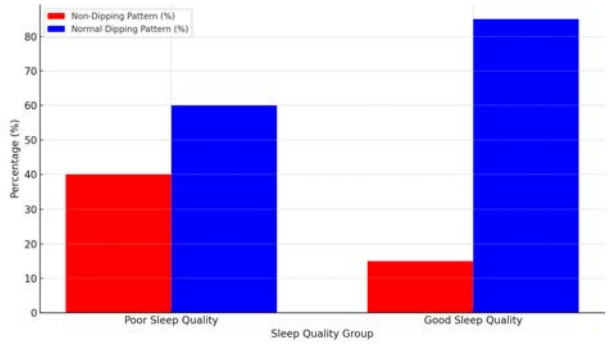

Fig. 3: Prevalence of Non-Dipping Blood Pressure Pattern by Sleep Quality Group

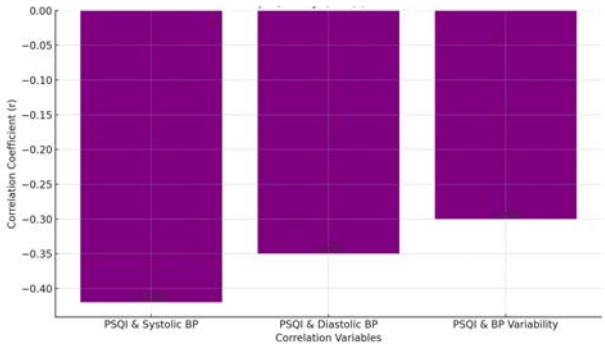

Fig. 4: Correlation Between Sleep Quality (PSQI) and Nocturnal Blood Pressure

hypothalamic-pituitary-adrenal axis. Our results, which show elevated nighttime blood pressure in participants with poor sleep, are consistent with these mechanisms. This suggests that insufficient or fragmented sleep triggers physiological responses that increase cardiovascular strain during sleep, further linking poor sleep quality with cardiovascular risk.

Non-Dipping Blood Pressure Patterns and Cardiovascular Dysfunction: The prevalence of non-dipping blood pressure patterns in our study mirrors those reported by Calhoun and Harding[11], who found similar results in populations with sleep disorders. Non-dipping blood pressure, often linked to increased left ventricular hypertrophy and vascular damage, has been documented as a cardiovascular risk by Javaheri[10]. In our study, a significant portion of participants with poor sleep quality exhibited non-dipping patterns, which further corroborates the link between poor sleep and long-term cardiovascular dysfunction, even in younger populations.

Blood Pressure Variability and Its Impact on Cardiovascular Health: Increased blood pressure variability among participants with poor sleep quality, observed in our study, aligns with the findings of Makarem[12], who reported that greater blood pressure variability, particularly during sleep, is an early indicator of cardiovascular disease. As discussed by Santos and Souza[14], this variability is linked to arterial stiffness and autonomic dysfunction, both critical markers of cardiovascular risk. The frequent arousals from sleep, leading to intermittent surges in sympathetic activity, may explain this increased variability and the associated cardiovascular strain.

Implications for Cardiovascular Health in Young Adults

While young adults are typically considered a low-risk group for heart disease, our study, in line with the work of Makarem[13], suggests that poor sleep quality could be an early predictor of future cardiovascular problems. Early interventions, such as improving sleep hygiene or addressing underlying sleep disorders, may be crucial in mitigating long-term cardiovascular risk in this population. Recognizing sleep disturbances as a potential early marker of cardiovascular risk in young adults underscores the importance of prioritizing sleep health as part of cardiovascular disease prevention strategies.

Limitations and Future Directions: This study had several limitations. The sample size was relatively small and participants were recruited from a single medical institute, which may limit the generalizability of the findings. Additionally, the study relied on self-reported

sleep quality assessments using the PSQI, which, while validated, may be subject to participant bias. Future studies should consider using objective measures of sleep, such as polysomnography, to confirm the results. Longitudinal studies are also needed to assess whether improvements in sleep quality lead to long-term reductions in nocturnal blood pressure and the incidence of non-dipping patterns.

Conclusion: Our study demonstrates a clear association between poor sleep quality and adverse nocturnal blood pressure patterns in young adults. Participants with poor sleep quality exhibited significantly higher nocturnal systolic and diastolic blood pressures, increased blood pressure variability, and a higher prevalence of non-dipping blood pressure patterns. These findings suggest that even in a young, relatively healthy population, poor sleep may contribute to early cardiovascular risk factors. Addressing sleep disturbances could play a crucial role in mitigating cardiovascular risks and early intervention strategies aimed at improving sleep quality may provide long-term benefits for cardiovascular health in young adults.

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