

Sleep Quality and its Longitudinal Effects on Cardiovascular Health in Adults: An Observational Study

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Abstract:

Background: Sleep quality has emerged as a significant factor influencing cardiovascular health, yet longitudinal studies elucidating this relationship remain scarce. This study aimed to explore the longitudinal effects of sleep quality on cardiovascular health in adults.

Methods: A cohort of 100 adults from Kadapa, Andhra Pradesh, was followed over 24 months. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and cardiovascular health was monitored through clinical assessments. Statistical analyses included logistic and linear regression models to evaluate the association between sleep parameters and cardiovascular events and markers, adjusted for confounders.

Results: Poor sleep quality, indicated by higher PSQI scores, was associated with a 12% increase in cardiovascular event odds (Odds Ratio: 1.12, 95% CI: 1.04-1.21, p=0.004). A decline in sleep quality over the study period was observed, with sleep duration and efficiency particularly impacting cardiovascular risk. The effects of poor sleep were more pronounced in individuals under 45 years of age and males. Socioeconomic status also modulated the relationship between sleep quality and cardiovascular health.

Conclusion: This study highlights the significant impact of sleep quality on cardiovascular health and suggests that improving sleep quality could be a beneficial component of cardiovascular disease prevention strategies, especially among younger adults and lower socioeconomic groups.

Keywords: Sleep quality, Cardiovascular health, Longitudinal study, PSQI, Socioeconomic status.

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Introduction

Sleep quality significantly influences overall health and well-being, serving as a cornerstone for both mental and physical health. Emerging evidence suggests a profound connection between sleep quality and cardiovascular health, implicating poor sleep patterns in the pathogenesis and progression of various cardiovascular diseases (CVDs) [1]. This observational study aims to elucidate the longitudinal effects of sleep quality on cardiovascular health in adults, contributing to a growing body of research underscoring the importance of sleep as a pivotal component of cardiovascular risk assessment and management.

The relationship between sleep and cardiovascular health is complex and multifaceted, encompassing various dimensions of sleep, including duration, continuity, and architecture. Epidemiological studies have consistently shown that both short and long sleep durations are associated with an increased risk of cardiovascular events, including myocardial infarction, stroke, and hypertension [2-4]. The mechanisms underlying these associations are diverse, involving dysregulation of the autonomic nervous

system, inflammation, metabolic disturbances, and endothelial dysfunction [5].

Sleep quality encompasses more than just sleep duration. It includes sleep efficiency, latency, disturbances, and daytime dysfunction. Poor sleep quality has been independently linked to a higher prevalence of traditional cardiovascular risk factors, such as obesity, hypertension, diabetes, and dyslipidemia [6,7]. Moreover, emerging evidence suggests that sleep disorders, including insomnia and sleep-disordered breathing, contribute significantly to cardiovascular risk, independent of traditional risk factors [8,9].

Longitudinal studies offer valuable insights into the temporal relationships and potential causality between sleep quality and cardiovascular outcomes. For instance, a prospective cohort study with a decade-long follow-up reported that individuals with poor sleep quality had a significantly higher risk of developing coronary artery disease than those with good sleep quality [10]. Similarly, another longitudinal study found that sleep disturbances were associated with an increased risk of heart failure [11].

The interplay between sleep quality and cardiovascular health may also be influenced by gender, age, and socioeconomic factors. Research indicates that the adverse effects of poor sleep on cardiovascular health may be more pronounced in women and older adults [12,13]. Additionally, socioeconomic disparities in sleep quality, stemming from factors such as occupational stress, environmental noise, and access to healthcare, further complicate the relationship between sleep and cardiovascular health [14].

This observational study contributes to the existing literature by providing a comprehensive analysis of the longitudinal effects of sleep quality on cardiovascular health in a diverse adult population. By incorporating a wide range of sleep parameters and controlling for potential confounders, this study aims to deepen our understanding of the sleep-cardiovascular nexus and inform the development of targeted interventions to improve cardiovascular outcomes through the enhancement of sleep quality.

Aims and Objectives

The primary aim of this observational study was to investigate the longitudinal effects of sleep quality on cardiovascular health among adults. Specifically, the study sought to determine the relationship between various dimensions of sleep quality, including duration, efficiency, latency, and disturbances, and the incidence of cardiovascular diseases (CVDs) over a two-year period. The objectives were to quantify the impact of poor sleep quality on the risk of developing CVDs, identify potential gender and age disparities in sleep-related cardiovascular risk, and explore the moderating effects of socioeconomic factors on the relationship between sleep quality and cardiovascular health.

Material and Methods

The study was conducted in Kadapa, Andhra Pradesh, from January 2022 to December 2023. A cohort of 100 adult patients was meticulously selected based on specific inclusion and exclusion criteria. The inclusion criteria mandated participants to be adults aged 18 years or older, residents of Kadapa, and willing to participate in the study for its entire duration. Exclusion criteria were established to omit individuals with pre-existing diagnosed sleep disorders, such as obstructive sleep apnea or insomnia, chronic use of sleep medication, and those with a history of cardiovascular diseases to ensure the observed outcomes were primarily influenced by natural variations in sleep quality.

Participants were recruited through local community health centers, and informed consent was obtained prior to enrollment. The study employed a longitudinal observational design, with sleep quality and cardiovascular health indicators measured at baseline and every six months thereafter, concluding at 24 months.

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a comprehensive measure that evaluates seven domains of sleep over the previous month. Cardiovascular health was monitored through clinical assessments, including blood pressure measurements, electrocardiograms, and blood tests for lipid profiles, at each bi-annual visit. Socioeconomic status was determined based on income, education, and occupation, collected through structured questionnaires at baseline.

The sample size of 100 patients was calculated to provide sufficient power to detect significant relationships between sleep quality parameters and cardiovascular health outcomes, accounting for potential dropouts and non-response rates. Statistical analysis was performed using SPSS software. Continuous variables were analyzed using linear and logistic regression models to examine the association between sleep quality and cardiovascular health outcomes, adjusting for potential confounders such as age, gender, and socioeconomic status.

In ensuring the rigor of the study, all procedures and assessments were conducted by trained healthcare professionals. Data confidentiality was maintained throughout the study, with all participants' information being anonymized and securely stored. The study protocol received approval from the local ethical review board, adhering to the Declaration of Helsinki guidelines for human research.

Results

The observational study aimed to explore the longitudinal effects of sleep quality on cardiovascular health in adults over a 24-month period in Kadapa, Andhra Pradesh, with a cohort of 100 participants. This section presents the detailed results derived from the analysis of sleep quality parameters, their changes over time, and their association with cardiovascular events and markers.

The baseline characteristics of the study population revealed an equal distribution between males and females (50% each), with an average age of 45 ± 12 years. Socioeconomic status was categorized as low (30%), middle (40%), and high (30%). The mean body mass index (BMI) was reported at 26.5 ± 4.2 kg/m². Average baseline blood pressure readings showed systolic and diastolic pressures of 120 ± 15 mm Hg and 80 ± 10 mm Hg, respectively. Total cholesterol levels averaged 200 ± 35 mg/dL, and the baseline Pittsburgh Sleep Quality Index (PSQI) score was 6 ± 3 , indicating moderate sleep quality disturbances among participants.

The distribution of sleep quality parameters at baseline highlighted an average sleep duration of 6.5 ± 1.2 hours, with a sleep efficiency of $85 \pm 10\%$. Sleep latency averaged 20 ± 15 minutes, and participants reported an average of 3 ± 2 sleep disturbances, with 10% using sleep medication. The overall PSQI score

at baseline reinforced the initial findings of moderate sleep disturbances.

Over the 24-month study period, the incidence of cardiovascular events was as follows: myocardial infarction (5%), stroke (3%), and hypertension (20%). These events underscore the potential impact of sleep quality on cardiovascular health.

The study meticulously tracked changes in sleep quality parameters over time. By the 24-month follow-up, a slight decrease in sleep duration to 6.2 ± 1.4 hours and a reduction in sleep efficiency to $82 \pm 13\%$ were observed. Sleep latency increased to 23 ± 18 minutes, and sleep disturbances rose to 4 ± 3 events on average. These changes indicate a gradual decline in sleep quality among participants over the study period.

Further analysis revealed a statistically significant relationship between baseline sleep quality and the incidence of cardiovascular events. Specifically, each point increase in the overall PSQI score was associated with a 12% increase in the odds of cardiovascular events (Odds Ratio: 1.12, 95% CI: 1.04-1.21, $p=0.004$). Sleep duration and efficiency emerged as critical factors, with shorter sleep duration and lower efficiency correlating with higher cardiovascular risk.

Longitudinal analyses shed light on the association between changes in sleep quality parameters and cardiovascular health markers. Notably, a decrease

in sleep duration was significantly associated with adverse changes in blood pressure and lipid profiles (β Coefficient for sleep duration: -0.10 , $p<0.001$).

Subgroup analyses revealed that the impact of poor sleep quality on cardiovascular risk was more pronounced in individuals under 45 years of age and was somewhat more significant in males than in females. These findings suggest that younger adults and males with poor sleep quality might be at a higher risk and could benefit from targeted interventions.

The influence of socioeconomic status on the relationship between sleep quality and cardiovascular health was also examined. Participants from lower socioeconomic backgrounds showed a stronger negative association between poor sleep quality and cardiovascular health, as indicated by a β Coefficient of -0.12 ($p=0.04$).

In summary, this study highlights the significant impact of sleep quality on cardiovascular health, with poor sleep quality associated with an increased incidence of cardiovascular events. The observed longitudinal decline in sleep quality parameters further emphasizes the need for interventions aimed at improving sleep to potentially mitigate cardiovascular risk. The findings also underscore the importance of considering age, gender, and socioeconomic factors in the management and prevention strategies for cardiovascular disease.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Total Participants (n=100)
Age (years), mean \pm SD	45 ± 12
Gender, n (%)	
- Male	50 (50%)
- Female	50 (50%)
Socioeconomic Status, n (%)	
- Low	30 (30%)
- Middle	40 (40%)
- High	30 (30%)
BMI (kg/m^2), mean \pm SD	26.5 ± 4.2
Systolic BP (mm Hg), mean \pm SD	120 ± 15
Diastolic BP (mm Hg), mean \pm SD	80 ± 10
Total Cholesterol (mg/dL), mean \pm SD	200 ± 35
Baseline PSQI Score, mean \pm SD	6 ± 3

Table 2: Distribution of Sleep Quality Parameters at Baseline

Sleep Quality Parameter	Mean \pm SD
Sleep Duration (hours)	6.5 ± 1.2
Sleep Efficiency (%)	85 ± 10
Sleep Latency (minutes)	20 ± 15
Sleep Disturbances (n events)	3 ± 2
Use of Sleep Medication, n (%)	10 (10%)
Overall PSQI Score	6 ± 3

Table 3: Incidence of Cardiovascular Events during the Study Period

Cardiovascular Event	Incidence, n (%)
Myocardial Infarction	5 (5%)
Stroke	3 (3%)
Hypertension	20 (20%)

Table 4: Changes in Sleep Quality Parameters Over Time

Time Point	Sleep Duration	Sleep Efficiency	Sleep Latency	Sleep Disturbances
Baseline	6.5 ± 1.2	85 ± 10	20 ± 15	3 ± 2
6 Months	6.6 ± 1.1	86 ± 9	19 ± 14	2 ± 2
12 Months	6.4 ± 1.3	84 ± 11	21 ± 16	3 ± 3
18 Months	6.3 ± 1.2	83 ± 12	22 ± 17	4 ± 2
24 Months	6.2 ± 1.4	82 ± 13	23 ± 18	4 ± 3

*p < 0.05 for changes over time in sleep efficiency and sleep disturbances.

Table 5: Relationship Between Baseline Sleep Quality and Incidence of Cardiovascular Events

PSQI Component	Odds Ratio (95% CI)	p-value
Overall Score	1.12 (1.04-1.21)	0.004
Sleep Duration	0.89 (0.80-0.99)	0.03
Sleep Efficiency	1.15 (1.05-1.26)	0.002

*Adjusted for age, gender, and socioeconomic status.

Table 6: Longitudinal Analysis of Sleep Quality and Cardiovascular Health Markers

Sleep Quality Parameter	β Coefficient (95% CI)	p-value
Sleep Duration	-0.10 (-0.15 to -0.05)	<0.001
Sleep Efficiency	0.20 (0.10 to 0.30)	<0.001

*Models adjusted for baseline characteristics.

Table 7: Subgroup Analyses by Gender and Age

Gender/Age Group	Relationship (β Coefficient)	p-value
Male	-0.15	0.01
Female	-0.10	0.02
<45 years	-0.20	<0.001
≥45 years	-0.08	0.03

Table 8: Impact of Socioeconomic Status on the Relationship Between Sleep Quality and Cardiovascular Health

Socioeconomic Status	β Coefficient	p-value
Low	-0.12	0.04
Middle	-0.09	0.07
High	-0.05	0.15

Table 9: Summary of Major Findings and Their Clinical Implications

Finding	Statistical Significance	Clinical Implication
Poor sleep quality is associated with increased cardiovascular event incidence.	p < 0.05	Emphasizes the need for screening and managing sleep quality in cardiovascular risk assessment.
Sleep efficiency decline correlates with worsening lipid profiles.	p < 0.001	Suggests targeted interventions to improve sleep efficiency could benefit cardiovascular health.
The impact of poor sleep is more pronounced in individuals under 45.	p < 0.001	Indicates younger adults with poor sleep quality may require early interventions to prevent cardiovascular diseases.

Discussion

The findings of this observational study contribute valuable insights into the complex relationship between sleep quality and cardiovascular health in adults. The study's results, indicating a significant association between poor sleep quality and an increased incidence of cardiovascular events, align

with and extend upon existing research in this domain. Notably, the longitudinal aspect of this study allowed for the observation of changes in sleep parameters over time and their correlation with cardiovascular health markers, providing a more nuanced understanding of this relationship.

The observed increase in the odds of cardiovascular events with each point increase in the PSQI score (Odds Ratio: 1.12, 95% CI: 1.04-1.21, $p=0.004$) is consistent with previous findings. For instance, a meta-analysis by Cappuccio et al. (2011), which highlighted a direct association between short sleep duration and cardiovascular risk, supports the detrimental effects of poor sleep quality on cardiovascular health [15]. However, our study further elucidates the role of sleep efficiency and disturbances, aspects less extensively covered in earlier research.

The slight but consistent decline in sleep quality over the 24-month period, particularly in terms of sleep duration and efficiency, mirrors trends observed in the general population. The Sleep Heart Health Study found similar associations between reduced sleep efficiency and increased cardiovascular risk, emphasizing the importance of sleep quality, not just quantity, in cardiovascular health [16].

Our findings regarding the differential impact of poor sleep quality on various demographic groups also warrant discussion. The more pronounced effect of poor sleep quality on cardiovascular risk among individuals under 45 years of age and males suggests a potential vulnerability in these populations. This is in partial contrast to some earlier studies, such as that by Mallon et al. (2005), which suggested a stronger association in older adults [17]. The discrepancy may be due to differing methodologies or population characteristics, highlighting the need for further research to elucidate these age-related differences.

The relationship between socioeconomic status and the impact of sleep quality on cardiovascular health observed in our study adds to the growing body of literature on the social determinants of health. Lower socioeconomic status has been linked to both poor sleep quality and higher cardiovascular risk in various studies, suggesting that socioeconomic factors may exacerbate the negative effects of poor sleep on cardiovascular health [18].

Limitations of this study include its observational design, which, while powerful for detecting associations, cannot establish causality. Furthermore, the reliance on self-reported measures of sleep quality and socioeconomic status may introduce bias. Future research could benefit from incorporating objective measures of sleep, such as polysomnography, and exploring interventions aimed at improving sleep quality to determine their effect on cardiovascular outcomes.

This study underscores the significant impact of sleep quality on cardiovascular health and highlights the importance of considering sleep in the assessment and management of cardiovascular risk. The findings suggest that interventions to improve sleep quality, particularly among younger adults and those

of lower socioeconomic status, could be beneficial in reducing cardiovascular risk.

Conclusion

The observational study conducted over a 24-month period in Kadapa, Andhra Pradesh, provides substantive evidence on the longitudinal effects of sleep quality on cardiovascular health in adults. The study's findings underscore the significant association between poor sleep quality, as quantified by the Pittsburgh Sleep Quality Index (PSQI), and an increased incidence of cardiovascular events. Specifically, a notable aspect of the study was the identification of a 12% increase in the odds of cardiovascular events with each point increase in the PSQI score (Odds Ratio: 1.12, 95% CI: 1.04-1.21, $p=0.004$). Furthermore, the study illuminated the gradual decline in sleep quality over time and its potential impact on cardiovascular health, highlighting sleep duration and efficiency as critical components.

Distinctively, the analysis revealed differential impacts of poor sleep quality across demographic groups, with younger adults under 45 years of age and males exhibiting a higher susceptibility to sleep-related cardiovascular risks. Additionally, the influence of socioeconomic status on the relationship between sleep quality and cardiovascular health emphasizes the role of social determinants in this dynamic.

These findings advocate for the integration of sleep quality assessment in cardiovascular risk evaluation and management frameworks. They also call for targeted interventions aimed at improving sleep quality, particularly among vulnerable populations, to mitigate cardiovascular risk. Future research should focus on longitudinal intervention studies to establish causality and explore the effectiveness of sleep improvement strategies on cardiovascular outcomes.

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