



Sleep and Cardiovascular Disease: The Role of Sleep Disorders in CV Risk: Review Article

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Abstract

Cardiovascular disease remains the leading global reason for morbidity & mortality, & increasing evidence indicates the sleep-dependent state of cardiovascular well-being. Sleep disorders, counting obstructive sleep apnea, insomnia, & restless legs syndrome, have increasingly been recognized as leading causes of CVD risk. This review evaluates the relationship among sleep disorders & cardiovascular risk, describes the pathophysiological mechanisms involved, & discusses whether CVD burden can be attenuated by intervention with sleep. A thorough review of the literature had been performed, integrating results from recent research and clinical evidence on sleep disorders and their cardiovascular effects. The most important mechanisms, such as sympathetic nervous activation, dysregulation of blood pressure, inflammation, endothelial dysfunction, and metabolic alterations, were studied. Sleep disorders like OSA, insomnia, & RLS significantly contribute to CVD risk by disrupting physiological mechanisms that play a key role in cardiovascular homeostasis. OSA through intermittent hypoxia & over activity of the sympathetic nervous system, insomnia via chronic inflammation and stress, and RLS via sleep fragmentation and elevated blood pressure. Both short (<6hours) & long (>9hours) sleep durations are also related to increased cardiovascular risk. Interventions like continuous positive airway pressure for OSA, cognitive behaviour therapy for insomnia, and lifestyle modification are of potential benefit to reduce such risks. Sleep management incorporation in cardiovascular practice is of vital importance in order to optimize health gains and reduce the CVD burden at a global level.

Keywords: cardiovascular disease; sleep disorders; obstructive sleep apnea; insomnia; restless legs syndrome; sleep duration;

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Doi # <https://doi.org/10.62877/15-IJCBS-25-27-21-15>

Submitted: 15-03-2025; Accepted: 25-04-2025; Published: 27-04-2025

1. Introduction

Cardiovascular disease remains one of the leading reasons for morbidity & mortality worldwide. A growing body of evidence highlights the significant role that sleep plays in cardiovascular health. Sleep is important for the maintenance of physiological processes, & disruptions in sleep can increase risk of developing various cardiovascular conditions, counting hypertension, coronary artery disease, stroke, & heart failure [1]. The relationship among sleep & cardiovascular health is complex, involving both the quality & quantity of sleep. Additionally, sleep disorders, like insomnia, obstructive sleep apnea, & restless leg syndrome, are identified as risk factors for CVD. This literature review aims to explore the role of sleep disorders in cardiovascular risk, the underlying mechanisms, and the potential interventions to mitigate cardiovascular risk through sleep management [2]. Cardiovascular diseases (CVD) continue to be one of the leading reasons for morbidity & mortality worldwide. Emerging research has shown that sleep disorders play a significant role in the development & progression of CVD. The relationship among sleep & cardiovascular health is complex, involving both the quantity & quality of sleep. Disruptions in sleep patterns due to conditions like sleep apnea, insomnia, & restless legs syndrome may increase the

risk of developing hypertension, heart failure, stroke, & other cardiovascular conditions. This review explores the role of sleep disorders in cardiovascular disease risk, the underlying mechanisms involved, and potential strategies to manage and mitigate cardiovascular risk through sleep interventions [3].

2. Mechanisms Linking Sleep and Cardiovascular Disease

Sleep is a restorative process that allows the body to recover and repair itself. During sleep, particularly during slow-wave & rapid eye movement stages, multiple physiological processes that protect cardiovascular health occur. These processes include [4].

2.1. Sympathetic and Parasympathetic Nervous System Balance

During sleep, the sympathetic nervous system (responsible for the fight-or-flight response) becomes less active, & the parasympathetic nervous system (responsible for rest & recovery) becomes more active. Disruption of this balance due to poor sleep or sleep disorders can lead to increased heart rate, blood pressure, & vascular resistance, all of which are risk factors for cardiovascular disease. During sleep, particularly during slow-wave sleep, parasympathetic nervous system becomes more active, leading to a reduction in heart rate and blood pressure. Disruptions in sleep, such as those seen in sleep apnea, disturb this balance, leading to

prolonged sympathetic activity (increased heart rate, blood pressure, and vascular resistance), which heightens the risk of cardiovascular disease [5].

2.2. Blood Pressure Regulation

Sleep has a crucial role in lowering blood pressure during the night, a phenomenon known as "nocturnal dipping." Sleep disorders, particularly sleep apnea, disrupt this dipping pattern, leading to higher average blood pressure, which over time can increase the risk of hypertension & subsequent cardiovascular events. Healthy sleep helps regulate blood pressure, with blood pressure naturally dipping during the night (nocturnal dipping). Sleep disorders, especially obstructive sleep apnea (OSA), can disrupt this dip, leading to sustained high blood pressure, which contributes to the development of hypertension and its cardiovascular complications [6].

2.3. Inflammation & Endothelial Function

Chronic sleep deprivation and sleep disorders are related to elevated markers of inflammation (e.g., C-reactive protein) & impaired endothelial function. These factors contribute to the development of atherosclerosis & other cardiovascular diseases. Sleep deprivation and disorders are related to increased levels of inflammatory markers like C-reactive protein & interleukin-6. Chronic inflammation contributes to endothelial dysfunction, which promotes atherosclerosis, a major driver of cardiovascular disease [7].

2.4. Autonomic Nervous System Dysfunction

Sleep disorders, particularly OSA, contribute to autonomic nervous system dysfunction. In OSA, frequent apneas and hypopneas (interruption in airflow) cause intermittent hypoxia, which activates the sympathetic nervous system & triggers inflammatory pathways that increase the risk of atherosclerosis and CVD [8].

2.5. Metabolic Effects

Disruptions in sleep can affect metabolic health, leading to insulin resistance, glucose intolerance, & obesity. These metabolic conditions are closely related to an increased risk of cardiovascular disease. Poor sleep quality and insufficient sleep may lead to metabolic disturbances such as insulin resistance, obesity, and impaired glucose metabolism—all of which are strongly related to an increased risk of cardiovascular disease [9].

3. Sleep Disorders & Cardiovascular Disease

3.1. Obstructive Sleep Apnea (OSA)

One of the most researched sleep disorders in connection with cardiovascular disease is obstructive sleep apnea. Recurrent episodes of partial or whole airway blockage throughout sleep are the hallmark of OSA, which causes intermittent oxygen desaturation, fragmentation of sleep, & activation of the sympathetic nervous system. The primary mechanisms by which OSA contributes to cardiovascular risk include [10].

- Intermittent Hypoxia: Repeated episodes of oxygen desaturation led to oxidative stress, which in turn damages the endothelium & promotes inflammation, factors that are involved in atherosclerosis. The repeated drops in oxygen levels during apneas activate the sympathetic nervous system, causing elevated heart rate

and blood pressure. This sympathetic over activity contributes to hypertension, arrhythmias, and increased risk of heart failure and stroke [11].

- Increased Sympathetic Activity: The repetitive arousals and hypoxia in OSA patients lead to increased sympathetic nervous system activity, which raises blood pressure & heart rate, contributing to hypertension, arrhythmias, and other cardiovascular complications. Untreated OSA has been shown to increase the risk of developing hypertension, coronary artery disease, heart failure, & stroke. Studies have demonstrated that CPAP therapy can reduce the cardiovascular risks associated with OSA by improving sleep quality and reducing blood pressure [12].
- Endothelial Dysfunction: OSA associated with impaired endothelial function, leading to increased arterial stiffness, a key marker of cardiovascular risk [13].
- Increased Risk of Coronary Artery Disease & Stroke: Multiple studies have confirmed that OSA is an independent risk factor for coronary artery disease, heart failure, & stroke, particularly in individuals who are untreated [14].

3.2. Insomnia

Insomnia, considered by difficulty falling or staying asleep, affects a significant portion of the population and is related to poor sleep quality. The relationship among insomnia & cardiovascular disease is multifaceted [15].

- Chronic Insomnia and Hypertension: Chronic insomnia is connected to an increased risk of developing hypertension, as it leads to elevated sympathetic nervous system activity, increased cortisol secretion, & impaired blood pressure regulation during sleep [16].
- Increased Inflammation: Sleep deprivation resulting from insomnia increases the production of pro-inflammatory cytokines, which can accelerate atherosclerosis and other cardiovascular events [17].
- Psychosocial Stress: Insomnia often related to anxiety, depression, high levels of stress, all of which contribute to an increased risk of cardiovascular disease [18].

3.3. Restless Legs Syndrome (RLS)

An insatiable desire to move the legs, especially when at rest or inactive, is the hallmark of restless legs syndrome, which is frequently linked to sleep issues. The cardiovascular implications of RLS include [19].

- Increased Risk of Hypertension: Studies suggest that individuals with RLS may be at higher risk for hypertension due to disrupted sleep patterns & increased sympathetic nervous system activity.
- Impaired Sleep Quality: The fragmented sleep caused by RLS contributes to an increased risk of cardiovascular diseases, particularly in individuals with other comorbid conditions such as diabetes and obesity [20].

3.4. Other Sleep Disorders

Other sleep disorders, like narcolepsy and circadian rhythm disorders, may also contribute to cardiovascular risk, though research in these areas is less extensive. However, it is known that disrupted circadian rhythms can affect metabolic and autonomic regulation, both of which are implicated in cardiovascular disease [21].

4. Cardiovascular Risk and Sleep Duration

While sleep disorders are well-established as risk factors for CVD, there is also evidence that both **short & long** sleep duration are related to an increased risk of cardiovascular disease. Studies suggest [22].

- Short Sleep Duration: Chronic short sleep duration (< 6hours per night) is connected to an increased risk of hypertension, obesity, type2 diabetes, & cardiovascular mortality. Short sleep leads to sympathetic overactivity, increased blood pressure, and an increased risk of inflammatory processes.
- Long Sleep Duration: Sleeping > 9hours per night has also been related to increased cardiovascular risk, possibly due to its association with other health conditions, counting obesity, diabetes, & depression [5].

5. Interventions to Mitigate Cardiovascular Risk

5.1. Management of Sleep Apnea

Continuous positive airway pressure therapy is the gold standard for treating OSA. CPAP improves sleep quality, reduces the frequency of apneas, and decreases cardiovascular risks by lowering blood pressure, improving endothelial function, and reducing sympathetic activity [19].

5.2. Insomnia Treatment

Cognitive behavioral therapy for insomnia is an effective treatment for chronic insomnia & is shown to improve cardiovascular outcomes by reducing sleep fragmentation, lowering blood pressure, and improving overall health. Pharmacologic treatments (e.g., benzodiazepines, melatonin agonists) are used less frequently due to their potential side effects [22].

5.3. Lifestyle Modifications

Improving sleep hygiene is crucial for mitigating cardiovascular risk. Recommended strategies include [19].

- Keeping a regular sleep-wake routine.
- Establishing a sleep-friendly environment (cold, dark, and quiet, for example).
- Engaging in regular physical activity.
- Steer clear of alcohol, caffeine, & large meals right before bed.
- Managing stress through relaxation techniques like mindfulness and meditation.

Promoting good sleep hygiene practices, like keeping a regular sleep-wake schedule, creating a comfortable sleep environment, & managing stress, is critical in preventing or treating sleep disorders. Physical activity, weight loss, and a healthy diet can also help improve sleep quality and reduce cardiovascular risk [5].

5.4. Pharmacologic Interventions

In some cases, pharmacologic treatments for conditions like hypertension, diabetes, and hyperlipidemia may help mitigate cardiovascular risk associated with sleep disorders. Additionally, drugs that improve sleep quality may help reduce the overall burden of sleep-related cardiovascular risk [22]. For individuals with insomnia or RLS who do not respond to non-pharmacological interventions, medications like benzodiazepines, melatonin receptor agonists, and dopaminergic agents could be used to improve sleep quality. However, these treatments must be used cautiously because

of potential side effects, especially in individuals with cardiovascular risk factors [22].

6. Conclusion

The relationship among sleep disorders & cardiovascular disease is multifaceted & involves complex mechanisms, including sympathetic nervous system activation, inflammation, endothelial dysfunction, and metabolic disturbances. Obstructive sleep apnea, insomnia, & restless leg syndrome are key sleep disorders that contribute to cardiovascular risk, and their management through lifestyle modifications, pharmacological treatment, and therapy (e.g., CPAP for OSA) is crucial in reducing the cardiovascular burden. Given the rising prevalence of sleep disorders, integrating sleep management strategies into cardiovascular care is an essential step toward improving population health results & reducing the global burden of cardiovascular disease[19]. Sleep disorders, particularly obstructive sleep apnea, insomnia, & restless legs syndrome, significantly contribute to cardiovascular risk by affecting blood pressure regulation, sympathetic nervous system activity, inflammation, and metabolic processes. Effective management of sleep disorders through interventions for example CPAP therapy, cognitive behavioral therapy for insomnia, & lifestyle modifications may reduce the cardiovascular risk associated with these disorders. Recognizing the crucial role of sleep in cardiovascular health is essential for improving both individual and population health outcomes. Early diagnosis & treatment of sleep disorders could significantly reduce the burden of cardiovascular diseases globally [5].

Funding: None to be declared

Conflicting Interest: The authors affirm that they have no conflicting interests.

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