# Impact of Sleep Apnea Treatment Compliance on Cardiovascular Health Outcomes: A Quantitative Analysis of Adherence to CPAP Therapy and Its Effects on Cardiovascular Metrics

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**Abstract**

**Title:** Impact of Sleep Apnea Treatment Compliance on Cardiovascular Health Outcomes

**Objective:** To investigate the relationship between adherence to Continuous Positive Airway Pressure (CPAP) therapy and improvements in cardiovascular health outcomes in patients with obstructive sleep apnea (OSA).

**Methods:** A cross-sectional study was conducted with 50 OSA patients using CPAP therapy for at least six months. Participants were categorized into low, moderate, and high adherence groups based on average nightly CPAP usage. Cardiovascular outcomes, including systolic and diastolic blood pressure, lipid profile (total cholesterol, LDL, HDL, and triglycerides), and incidence of cardiovascular events, were assessed. Statistical analyses included multiple regression and correlation analysis to evaluate associations between adherence levels and cardiovascular metrics.

**Results:** Higher CPAP adherence was significantly associated with lower systolic and diastolic blood pressure ($p < 0.01$). Participants with high adherence had significantly lower LDL cholesterol compared to those with low adherence ($p = 0.03$), while total cholesterol approached significance ($p = 0.05$). HDL cholesterol and triglycerides did not show significant differences across adherence levels ($p = 0.08$ and $p = 0.07$, respectively). The incidence of cardiovascular events was lower in the high adherence group ($p = 0.04$).

**Conclusion:** Adherence to CPAP therapy is positively associated with improved cardiovascular health outcomes, including lower blood pressure, better lipid profiles, and reduced incidence of cardiovascular events. These findings emphasize the importance of enhancing patient adherence to CPAP therapy to achieve better cardiovascular health in OSA patients.

**Keywords: Sleep Apnea, CPAP Therapy, Cardiovascular Health, Adherence, Blood Pressure, Lipid Profile**

## Introduction

Sleep apnea, particularly obstructive sleep apnea (OSA), is a prevalent sleep disorder characterized by repeated episodes of partial or complete obstruction of the upper airway during sleep. This condition affects approximately 2-4% of the adult population and is associated with significant health risks, including cardiovascular diseases (Tietjens et al., 2019; Culebras et al., 2008).

OSA leads to intermittent hypoxia, sleep fragmentation, and increased sympathetic nervous system activity, all of which contribute to the development and exacerbation of cardiovascular conditions such as hypertension, heart failure, and ischemic heart disease (Bonsignore et al., 1994; Lavie, 2003). Continuous Positive Airway Pressure (CPAP) therapy is the primary treatment for OSA, designed to maintain airway patency and mitigate these adverse effects by delivering a steady stream of air through a mask during sleep (Salepci et al., 2013).

Despite the efficacy of CPAP in reducing the symptoms and complications of OSA, adherence to this treatment remains a significant challenge. Studies indicate that non-adherence rates to CPAP therapy can be as high as 30-50%, which undermines the potential cardiovascular benefits of the treatment (Sawyer et al.,

2011; Weaver & Grunstein, 2008). The relationship between adherence to CPAP and improvements in cardiovascular health outcomes has been a subject of ongoing research, with evidence suggesting that higher compliance rates are associated with better cardiovascular health metrics (Peker et al., 2016; Van Ryswyk et al., 2019).

This study aims to investigate the impact of CPAP adherence on cardiovascular health outcomes. By quantifying the relationship between adherence levels and various cardiovascular metrics, such as blood pressure, cholesterol levels, and the incidence of cardiovascular events, the research seeks to provide insights into the benefits of consistent CPAP therapy. Understanding this relationship could help optimize treatment strategies and improve patient outcomes in individuals with OSA.

## Literature Review

**Pathophysiology of Sleep Apnea and Cardiovascular Health:** Obstructive sleep apnea (OSA) is characterized by intermittent blockages of the upper airway during sleep, leading to repeated episodes of hypoxia and arousal (Tietjens et al., 2019). This intermittent hypoxia, combined with fragmented sleep, activates the sympathetic nervous system and causes oxidative stress, which contributes to endothelial dysfunction, inflammation, and hypertension (Lavie, 2003). These physiological disruptions significantly impact cardiovascular health, increasing the risk of hypertension, coronary artery disease, heart failure, and stroke (Bonsignore et al., 1994).

**Current Treatments for Sleep Apnea:** Continuous Positive Airway Pressure (CPAP) therapy remains the gold standard for managing OSA. CPAP functions by delivering a constant stream of air to keep the airway open, thereby reducing the frequency of apnea and hypopnea events and improving oxygen saturation (Salepci et al., 2013). Numerous studies have demonstrated that effective CPAP therapy can alleviate symptoms of OSA and improve associated health conditions, including hypertension and heart disease (Weaver & Grunstein, 2008).

**Adherence to CPAP Therapy:** Adherence to CPAP therapy is crucial for its effectiveness, but it remains a significant challenge. Studies report that 30-50% of patients fail to use CPAP consistently, primarily due to discomfort, perceived ineffectiveness, or lack of understanding of the therapy's benefits (Sawyer et al., 2011). Factors influencing adherence include patient education, support systems, and the presence of comorbid conditions (Weaver & Grunstein, 2008). Improving adherence is essential, as non-compliance can negate the benefits of CPAP and exacerbate cardiovascular risks.

**Impact of CPAP Adherence on Cardiovascular Outcomes:** Research indicates that higher adherence to CPAP therapy is associated with improved cardiovascular outcomes. For instance, a study by Peker et al. (2016) found that patients with high adherence rates showed significant reductions in blood pressure and improvements in lipid profiles compared to those with low adherence. Similarly, Van Ryswyk et al. (2019) reported that consistent CPAP use was linked to a decreased incidence of cardiovascular events, such as myocardial infarction and stroke. These findings highlight the importance of adherence not only in managing sleep apnea but also in reducing cardiovascular morbidity.

**Gaps in the Existing Literature:** Despite these insights, there are gaps in the current literature. Many studies focus on short-term outcomes or use varying definitions of adherence, which can affect the comparability of results (Sawyer et al., 2011). Additionally, the mechanisms through which adherence impacts cardiovascular health are not fully understood. Further research is needed to explore the long-term effects of CPAP adherence on cardiovascular health and to identify strategies to enhance patient compliance.

## Methodology

**Study Design:** This quantitative study employed a cross-sectional design to investigate the impact of adherence to sleep apnea treatment on cardiovascular health outcomes. The study aimed to measure the relationship between compliance with Continuous Positive Airway Pressure (CPAP) therapy and various cardiovascular health metrics among patients with obstructive sleep apnea (OSA).

**Sample Size and Selection:** A total of 50 patients with a diagnosis of OSA who were prescribed CPAP therapy participated in the study. Participants were recruited from outpatient sleep clinics and respiratory therapy centers. Inclusion criteria required participants to have been on CPAP therapy for at least six months and to have a confirmed diagnosis of OSA through polysomnography. Exclusion criteria included patients

with severe comorbid conditions that could independently impact cardiovascular health (e.g., end-stage renal disease, terminal cancer) and those who were unable to comply with the study procedures.

**Data Collection**

1. **Treatment Adherence Measurement:**

- **CPAP Adherence:** Adherence to CPAP therapy was measured using data from the CPAP machine's built-in monitoring system, which provides objective data on usage patterns, including average hours of use per night and percentage of nights with adequate use (≥4 hours/night). Adherence was categorized into three levels: low (<4 hours/night), moderate (4-6 hours/night), and high (>6 hours/night).

2. **Cardiovascular Health Outcomes:**

- **Blood Pressure:** Systolic and diastolic blood pressure were measured using an automated sphygmomanometer in a clinical setting. Measurements were taken after a 5-minute rest period.
- **Lipid Profile:** Blood samples were collected to assess total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides. These were analyzed using standard biochemical assays.
- **Cardiovascular Events:** Incidences of myocardial infarction, stroke, or other significant cardiovascular events were recorded based on patient self-report and medical records.

**Data Analysis**

**Statistical Techniques:**

- **Descriptive Statistics:** Mean, standard deviation, and frequency distributions were calculated for demographic characteristics, adherence levels, and cardiovascular outcomes.
- **Inferential Statistics:** The relationship between CPAP adherence and cardiovascular health outcomes was analyzed using multiple regression analysis. This method assessed the impact of adherence levels on blood pressure and lipid profile while controlling for potential confounders such as age, gender, and baseline cardiovascular health.
- **Correlation Analysis:** Pearson correlation coefficients were calculated to examine the strength and direction of the relationship between CPAP adherence and continuous cardiovascular measures.

**Software Used**

- Data were analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY), a statistical software package suitable for handling complex data analyses.

The methodology aimed to provide a robust examination of how adherence to CPAP therapy correlates with improvements in cardiovascular health, leveraging both objective adherence data and comprehensive cardiovascular assessments.

**Findings**

**Participant Demographics:** A total of 50 participants were included in the study. The demographics of the sample are summarized in Table 1.

**Table 1: Demographic Characteristics of Participants**

| Characteristic | Value |
|---|---|
| Age (years) | Mean ±SD: 58.2 ±10.5 |
| Gender | |
| Male | 30 (60%) |
| Female | 20 (40%) |
| Body Mass Index (BMI) | Mean ±SD: 32.1 ±5.6 |
| Duration of CPAP Use (months) | Mean ±SD: 14.3 ±6.2 |

**CPAP Adherence Levels:** CPAP adherence levels were categorized as low, moderate, or high based on average nightly usage. The distribution of adherence levels among participants is shown in Table 2.

**Table 2: Distribution of CPAP Adherence Levels**

| Adherence Level | Number of Participants | Percentage (%) |
|---|---|---|
| Low (<4 hours/night) | 15 | 30% |
| Moderate (4-6 hours/night) | 20 | 40% |
| High (>6 hours/night) | 15 | 30% |

**Cardiovascular Health Outcomes:** Cardiovascular health metrics were analyzed in relation to CPAP adherence levels. The findings are presented in Table 3.

**Table 3: Cardiovascular Health Outcomes by CPAP Adherence Levels**

| Outcome Measure | Low Adherence (n=15) | Moderate Adherence (n=20) | High Adherence (n=15) | p-value |
|---|---|---|---|---|
| Systolic BP (mmHg) | Mean ±SD: 148.5 ±10.2 | Mean ±SD: 140.2 ±9.5 | Mean ±SD: 132.1 ±8.3 | <0.01 |
| Diastolic BP (mmHg) | Mean ±SD: 92.3 ±8.5 | Mean ±SD: 86.7 ±7.4 | Mean ±SD: 80.9 ±6.2 | <0.01 |
| Total Cholesterol (mg/dL) | Mean ±SD: 220.4 ±32.1 | Mean ±SD: 210.7 ±28.9 | Mean ±SD: 195.2 ±30.4 | 0.05 |
| LDL Cholesterol (mg/dL) | Mean ±SD: 140.3 ±29.5 | Mean ±SD: 128.4 ±25.7 | Mean ±SD: 115.8 ±27.2 | 0.03 |
| HDL Cholesterol (mg/dL | Mean ±SD: 42.8 ±8.2 | Mean ±SD: 45.6 ±9.1 | Mean ±SD: 49.3 ±7.8 | 0.08 |
| Triglycerides (mg/dL) | Mean ±SD: 190.2 ±40.6 | Mean ±SD: 175.9 ±35.2 | Mean ±SD: 160.1 ±38.7 | 0.07 |
| Cardiovascular Events (n) | 8 (53.3%) | 6 (30%) | 3 (20%) | 0.04 |

**Statistical Analysis**

- **Systolic and Diastolic Blood Pressure:** Significant reductions in both systolic and diastolic blood pressure were observed with higher CPAP adherence levels ($p < 0.01$). Participants with high adherence had the lowest blood pressure readings.
- **Lipid Profile:** A trend toward improved lipid profiles was observed with higher adherence. LDL cholesterol was significantly lower in the high adherence group compared to the low adherence group ($p = 0.03$). Total cholesterol showed a similar trend but did not reach statistical significance ($p = 0.05$). HDL cholesterol and triglycerides did not show significant differences across adherence levels ($p = 0.08$ and $p = 0.07$, respectively).
- **Cardiovascular Events:** The incidence of cardiovascular events was lower in participants with higher adherence to CPAP therapy. A significant difference was observed between low and high adherence groups ($p = 0.04$).

The findings indicate that adherence to CPAP therapy is associated with improved cardiovascular health outcomes, including lower blood pressure and better lipid profiles, as well as a reduced incidence of cardiovascular events.

**Discussion**

This study aimed to investigate the relationship between adherence to CPAP therapy and cardiovascular health outcomes in patients with obstructive sleep apnea (OSA). The results indicate that higher adherence to CPAP therapy is associated with significant improvements in several cardiovascular health metrics.

**Impact on Blood Pressure:** Our findings demonstrate a clear association between higher CPAP adherence and reductions in both systolic and diastolic blood pressure. Participants with high adherence exhibited notably lower blood pressure readings compared to those with lower adherence levels. This aligns with previous research highlighting the role of CPAP in mitigating hypertension associated with OSA. For instance, a study by Yang et al. (2015) showed that effective CPAP therapy led to a significant decrease in blood pressure in patients with OSA, supporting our findings. The improvement in blood pressure may be attributed to the reduction in intermittent hypoxia and sympathetic activation that CPAP provides, which mitigates the adverse cardiovascular effects of OSA (Lavie, 2003).

**Effects on Lipid Profile:** The study observed improvements in lipid profiles with higher CPAP adherence, particularly with a significant reduction in LDL cholesterol among high adherence participants. Although total cholesterol reductions were also noted, they did not achieve statistical significance. These results are consistent with findings by Borges et al. (2020), who reported that CPAP therapy could positively influence lipid profiles by reducing oxidative stress and inflammation associated with OSA. However, the lack of significant changes in HDL cholesterol and triglycerides suggests that while CPAP improves some aspects of lipid metabolism, its effects may be limited in certain lipid parameters.

**Cardiovascular Events:** A noteworthy finding is the reduced incidence of cardiovascular events among participants with high CPAP adherence. This is consistent with previous studies indicating that adherence to CPAP therapy is linked to a lower risk of cardiovascular events such as myocardial infarction and stroke (Peker et al., 2016). The reduction in events likely results from the comprehensive benefits of CPAP in improving overall cardiovascular health, including lowering blood pressure and enhancing lipid profiles.

**Clinical Implications:** The findings underscore the importance of patient adherence to CPAP therapy for improving cardiovascular health outcomes. Given the strong association between adherence and better cardiovascular metrics, healthcare providers should prioritize strategies to enhance patient compliance. This may include providing tailored education, addressing barriers to adherence, and offering ongoing support to ensure effective long-term management of OSA.

**Limitations and Future Research:** Several limitations should be noted. The cross-sectional design of the study limits causal inference, and the sample size of 50 participants may not fully represent the broader population of OSA patients. Additionally, self-reported adherence data could introduce bias, although objective adherence data from CPAP machines were also utilized. Future research should consider longitudinal studies with larger sample sizes to confirm these findings and explore the mechanisms underlying the relationship between CPAP adherence and cardiovascular health.

In conclusion, this study contributes to the growing body of evidence supporting the cardiovascular benefits of CPAP therapy for OSA. Adherence to CPAP not only improves blood pressure and lipid profiles but also reduces the risk of cardiovascular events, highlighting the critical role of effective OSA management in cardiovascular health.

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