



Original Research Article

THE INTERPLAY BETWEEN OBSTRUCTIVE SLEEP APNEA, DEPRESSION, AND ANXIETY: EXPLORING BIDIRECTIONAL ASSOCIATIONS AND TREATMENT IMPACTS

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ABSTRACT

Background: Obstructive Sleep Apnea (OSA) is a prevalent sleep disorder characterized by recurrent episodes of upper airway obstruction, leading to intermittent hypoxia and sleep fragmentation. Beyond its well-documented impact on cardiovascular and metabolic health, growing evidence suggests a strong bidirectional relationship between OSA and psychiatric conditions such as depression and anxiety. Individuals with OSA frequently exhibit depressive symptoms, cognitive impairments, and heightened anxiety levels, while those with pre-existing depression or anxiety disorders have a higher likelihood of developing or exacerbating OSA. Despite the clear clinical overlap, the underlying mechanisms linking these conditions remain poorly understood. Furthermore, treatment outcomes with continuous positive airway pressure (CPAP) therapy and alternative interventions have shown variable effectiveness in alleviating psychiatric symptoms, necessitating further investigation into optimal therapeutic strategies.

Objectives: This study aims to evaluate the bidirectional association between OSA, depression, and anxiety by assessing: 1. The prevalence and severity of depressive and anxiety symptoms in OSA patients. 2. The impact of untreated OSA on the progression or exacerbation of depressive and anxiety disorders. 3. The effects of CPAP therapy and other OSA treatments on depressive and anxiety symptoms. 4. Potential neurobiological and physiological mechanisms linking OSA with mood disorders. 5. Predictors of psychiatric symptom improvement following OSA treatment.

Materials and Methods: This prospective observational study was conducted at a tertiary care sleep medicine and psychiatric clinic over 12 months, enrolling 120 patients diagnosed with OSA based on polysomnography-confirmed apnea-hypopnea index (AHI >5 events/hour). Exclusion criteria included patients with severe psychiatric disorders requiring hospitalization, untreated primary psychiatric illnesses, or significant neurological conditions. Baseline assessments included Epworth Sleepiness Scale (ESS), Pittsburgh Sleep Quality Index (PSQI), Hamilton Depression Rating Scale (HAM-D), and Generalized Anxiety Disorder Scale (GAD-7). Patients were divided into groups based on OSA severity (mild, moderate, severe) and the presence of coexisting depression and/or anxiety. Participants underwent CPAP therapy for six months, with adherence monitored via compliance tracking data. A subset of patients who declined CPAP received alternative interventions such as mandibular advancement devices or lifestyle modifications. Follow-up assessments at 3 and 6 months evaluated changes in depressive and anxiety symptoms, sleep parameters, and overall quality of life. Statistical analyses

included paired t-tests, ANOVA, and regression models to assess the impact of OSA treatment on psychiatric outcomes.

Results: At baseline, 61% of OSA patients exhibited depressive symptoms (HAM-D ≥ 10), while 48% reported moderate-to-severe anxiety (GAD-7 ≥ 10). OSA severity correlated positively with depression and anxiety scores ($p < 0.01$), with severe OSA patients showing the highest psychiatric symptom burden. CPAP therapy led to significant improvements in sleep quality (PSQI score reduction by 37%) and daytime sleepiness (ESS score reduction by 42%). Additionally, CPAP users experienced a mean HAM-D score reduction of 5.2 points ($p < 0.001$) and a mean GAD-7 score reduction of 4.6 points ($p < 0.001$), indicating substantial improvement in psychiatric symptoms. Patients with higher CPAP adherence (>4 hours/night) demonstrated superior reductions in depression and anxiety symptoms, while those receiving alternative therapies showed moderate symptom relief but inferior outcomes compared to CPAP users ($p < 0.05$). Regression analysis identified baseline OSA severity, CPAP adherence, and sleep quality improvements as key predictors of psychiatric symptom resolution ($R^2 = 0.68$, $p < 0.001$).

Conclusion: This study reinforces the bidirectional relationship between OSA, depression, and anxiety, with greater OSA severity linked to increased psychiatric symptom burden. Treatment with CPAP significantly improved both sleep parameters and mental health outcomes, with higher adherence correlating with superior symptom relief. Given the high prevalence of psychiatric comorbidities in OSA, routine screening for depression and anxiety should be integrated into sleep medicine practice. Further research should explore long-term psychiatric benefits of CPAP therapy, adjunctive psychological interventions, and underlying neurobiological mechanisms linking these disorders.

Keywords: Keywords: Obstructive Sleep Apnea, Depression, Anxiety, CPAP Therapy, Sleep Quality, Mental Health, Polysomnography, Cognitive Dysfunction, Sleep Fragmentation, Neuroinflammation.

INTRODUCTION

Obstructive Sleep Apnea (OSA) is a highly prevalent but often underdiagnosed sleep disorder characterized by recurrent episodes of upper airway obstruction, intermittent hypoxia, and sleep fragmentation. These disruptions in normal sleep architecture contribute to daytime sleepiness, cognitive dysfunction, and an increased risk of cardiovascular and metabolic diseases.^[1] Individuals with OSA frequently exhibit mood disturbances, emotional instability, and cognitive impairments, raising concerns about the impact of untreated OSA on mental health. Conversely, individuals with pre-existing depressive or anxiety disorders have a higher likelihood of developing sleep disturbances, including OSA, suggesting a bidirectional relationship between these conditions.^[2]

The mechanisms underlying the relationship between OSA, depression, and anxiety remain poorly understood, though several physiological and neurobiological pathways have been proposed. Intermittent hypoxia and sleep fragmentation in OSA lead to chronic inflammation, oxidative stress, and dysregulation of neurotransmitters, particularly serotonin, dopamine, and norepinephrine, which play critical roles in mood regulation.^[3] Additionally, OSA-induced dysfunction of the hypothalamic-pituitary-adrenal (HPA) axis has been implicated in the exacerbation of anxiety and

depressive symptoms. Structural and functional alterations in brain regions such as the prefrontal cortex, hippocampus, and amygdala have been observed in OSA patients, further supporting the hypothesis that OSA contributes to psychiatric symptomatology. Moreover, the social and psychological consequences of living with an untreated sleep disorder, including fatigue, social withdrawal, impaired productivity, and decreased quality of life, may independently worsen psychiatric outcomes.^[4]

The impact of continuous positive airway pressure (CPAP) therapy, the gold standard treatment for OSA, on psychiatric outcomes has been widely debated. Several studies have shown that adherent CPAP users experience significant improvements in sleep quality, daytime functioning, and mood stabilization, whereas poor adherence or lack of treatment may exacerbate depressive and anxiety symptoms.^[5] However, the extent to which CPAP therapy directly alleviates psychiatric symptoms versus improving sleep-related functional impairment remains unclear. Some studies suggest that CPAP primarily benefits patients with severe OSA and high baseline depressive symptoms, while others indicate that alternative interventions such as mandibular advancement devices, cognitive-behavioral therapy (CBT), and pharmacological treatments may provide additional psychiatric benefits. Understanding the predictors of psychiatric symptom improvement following OSA treatment is

critical for optimizing patient management and identifying individuals who may require adjunctive mental health interventions.^[6]

Given the strong clinical overlap and potential bidirectional influences between OSA, depression, and anxiety, this study aims to evaluate their interrelationship and treatment outcomes. Specifically, this study will investigate the prevalence and severity of depression and anxiety in OSA patients, the impact of untreated OSA on psychiatric disorders, and the effectiveness of CPAP therapy in alleviating psychiatric symptoms. Additionally, we will explore potential physiological mechanisms linking OSA with mood disorders and identify predictors of symptom improvement following treatment. By addressing these gaps, this study seeks to provide a comprehensive understanding of the interplay between OSA and mental health, ultimately guiding more effective diagnostic and therapeutic approaches in clinical practice.

MATERIALS AND METHODS

This prospective observational study was conducted at a tertiary care sleep medicine and psychiatric clinic over a 12-month period, enrolling 120 adult patients diagnosed with Obstructive Sleep Apnea (OSA). The diagnosis of OSA was confirmed using overnight polysomnography (PSG), with an apnea-hypopnea index (AHI) threshold of >5 events per hour. Patients were categorized into mild (AHI 5–15), moderate (AHI 15–30), and severe OSA (AHI >30) groups. The study aimed to evaluate the bidirectional relationship between OSA, depression, and anxiety, assessing psychiatric symptom severity, impact of untreated OSA, and effectiveness of CPAP therapy and alternative treatments on mood outcomes.

Participants were recruited from sleep medicine and psychiatric outpatient departments, with eligibility criteria including adults aged 18–65 years, newly diagnosed with OSA, and free of any prior CPAP treatment. Exclusion criteria included patients with severe psychiatric disorders requiring hospitalization, primary psychiatric illnesses unrelated to OSA, significant neurological conditions, or use of psychotropic medications known to affect sleep physiology. Written informed consent was obtained from all participants before study enrollment.

At baseline, a comprehensive clinical assessment was conducted, including medical history, sleep pattern evaluation, and psychiatric screening. Sleep-related parameters such as Epworth Sleepiness Scale (ESS) and Pittsburgh Sleep Quality Index (PSQI) were recorded, along with psychiatric assessments using the Hamilton Depression Rating Scale (HAM-D) and Generalized Anxiety Disorder Scale (GAD-7). Participants were also assessed for daytime

functioning, fatigue levels, and quality of life using the SF-36 questionnaire.

Following diagnosis, participants were categorized into two groups based on treatment adherence

CPAP Group: Patients who initiated CPAP therapy and used it for at least 4 hours per night.

Non-CPAP Group: Patients who declined CPAP therapy and instead opted for alternative interventions such as mandibular advancement devices, lifestyle modifications, or positional therapy.

Treatment adherence in the CPAP group was monitored using built-in compliance tracking data from CPAP machines, while the non-CPAP group was followed up for adherence to prescribed alternative interventions. Patients underwent follow-up assessments at 3 and 6 months, where changes in sleep parameters, depressive and anxiety symptoms, daytime functioning, and quality of life were recorded.

The primary outcome measures were changes in HAM-D and GAD-7 scores at 6 months, assessing the impact of OSA treatment on psychiatric symptoms. Secondary outcomes included improvements in sleep quality, daytime functioning, and quality of life. Statistical analyses were performed using paired t-tests, ANOVA, and regression models to compare baseline and post-treatment psychiatric symptom severity across different OSA severity levels and treatment groups. A p-value < 0.05 was considered statistically significant, and all analyses were conducted using SPSS version 25.0.

By systematically evaluating the bidirectional associations between OSA, depression, and anxiety, this study aims to provide insights into the impact of sleep-disordered breathing on mental health and the effectiveness of CPAP and alternative interventions in alleviating psychiatric symptoms.

RESULTS

The study revealed a high prevalence of psychiatric comorbidities in OSA patients, with 61% experiencing depression and 48% reporting moderate-to-severe anxiety. OSA severity correlated significantly with psychiatric symptom burden ($p < 0.001$), with severe OSA patients exhibiting the highest rates of depression and anxiety. CPAP therapy led to significant improvements in sleep quality (PSQI reduction by 37%) and daytime functioning (ESS reduction by 42%), alongside substantial reductions in depressive (HAM-D: -5.2, $p < 0.001$) and anxiety (GAD-7: -4.6, $p < 0.001$) symptoms. Higher CPAP adherence (>4 hours/night) was associated with greater psychiatric symptom resolution, whereas alternative interventions (mandibular advancement devices, lifestyle modifications) showed moderate but inferior improvements compared to CPAP ($p <$

0.05). Regression analysis identified baseline AHI, CPAP adherence, and sleep quality improvements as significant predictors of psychiatric symptom improvement ($p < 0.01$), reinforcing the bidirectional relationship between OSA, depression, and anxiety.

Baseline Demographic and Clinical Characteristics

The demographic and clinical characteristics of the study population are summarized in Table 1. The mean age of participants was 48.6 ± 6.3 years, with a male-to-female ratio of 72:48. Obesity (65%) was the most common risk factor, followed by hypertension (48%) and smoking (33%). The average apnea-hypopnea index (AHI) was 26.4 events/hour, indicating a high proportion of moderate-to-severe OSA cases.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristics	OSA Patients (n=120)
Mean Age (years)	48.6 ± 6.3
Gender (Male/Female)	72/48
BMI (kg/m ²)	31.2
Hypertension (%)	58 (48%)
Diabetes Mellitus (%)	36 (30%)
Smoking (%)	40 (33%)
Obesity (%)	78 (65%)
Mean AHI (events/hour)	26.4

Prevalence of Depression and Anxiety in OSA Patients

At baseline, depressive symptoms (HAM-D ≥ 10) were present in 61% of patients, while moderate-to-severe anxiety (GAD-7 ≥ 10) was observed in 48%. Coexisting depression and anxiety were detected in 37% of cases.

Table 2: Prevalence of Depression and Anxiety in OSA Patients

Psychiatric Condition	Patients Affected (n=120)	Percentage (%)
Depression (HAM-D ≥ 10)	73	61.0%
Moderate-Severe Anxiety (GAD-7 ≥ 10)	58	48.0%
Coexisting Depression and Anxiety	44	37.0%

OSA Severity and Psychiatric Symptoms

A positive correlation was observed between OSA severity and psychiatric symptom burden. Patients with severe OSA had significantly higher rates of depression and anxiety.

Table 3: OSA Severity and Psychiatric Symptoms

OSA Severity	Depression (HAM-D ≥ 10) (%)	Anxiety (GAD-7 ≥ 10) (%)	p-value
Mild (AHI 5-15)	45%	32%	<0.05
Moderate (AHI 15-30)	60%	51%	<0.01
Severe (AHI >30)	78%	67%	<0.001

Baseline Sleep and Psychiatric Scores

At baseline, patients exhibited high levels of daytime sleepiness, poor sleep quality, and elevated depression and anxiety scores.

Table 4: Baseline Sleep and Psychiatric Scores

Parameter	Mean Score (n=120)
Epworth Sleepiness Scale (ESS)	12.5
Pittsburgh Sleep Quality Index (PSQI)	9.2
Hamilton Depression Rating Scale (HAM-D)	14.6
Generalized Anxiety Disorder Scale (GAD-7)	11.8

Effect of CPAP Therapy on Sleep Quality and Daytime Functioning

Patients who adhered to CPAP therapy showed significant improvements in sleep quality and daytime function.

Table 5: Effect of CPAP Therapy on Sleep Quality and Daytime Functioning

Parameter	CPAP Users (n=80)	Non-CPAP Users (n=40)	p-value
ESS Score Reduction	42% improvement	18% improvement	<0.001
PSQI Score Reduction	37% improvement	21% improvement	<0.001
SF-36 Quality of Life Improvement (%)	56%	34%	<0.01

Effect of CPAP Therapy on Depression and Anxiety Scores

CPAP therapy resulted in significant reductions in depression and anxiety scores, with greater symptom improvement in high-adherence users.

Table 6: Effect of CPAP Therapy on Depression and Anxiety Scores

Parameter	CPAP Users (n=80)	Non-CPAP Users (n=40)	p-value
HAM-D Score Reduction	5.2 points	2.3 points	<0.001
GAD-7 Score Reduction	4.6 points	2.0 points	<0.001

CPAP Adherence and Psychiatric Symptom Improvement

Greater CPAP adherence was associated with superior depression and anxiety symptom resolution.

Table 7: CPAP Adherence and Psychiatric Symptom Improvement

CPAP Adherence	Depression Improvement (HAM-D Reduction)	Anxiety Improvement (GAD-7 Reduction)	p-value
High (>4 hours/night)	6.8 points	5.9 points	<0.001
Moderate (2-4 hours/night)	4.3 points	3.5 points	<0.01
Low (<2 hours/night)	1.7 points	1.2 points	<0.05

Predictors of Psychiatric Symptom Improvement (Regression Model)

Regression analysis identified baseline AHI, CPAP adherence, and sleep quality improvements as significant predictors of psychiatric symptom improvement.

Table 8: Predictors of Psychiatric Symptom Improvement

Predictor	Beta Coefficient	p-value
Baseline AHI	-0.42	<0.01
CPAP Adherence	-0.58	<0.001
Baseline HAM-D Score	0.51	<0.01
Baseline GAD-7 Score	0.47	<0.01

Comparison of CPAP and Alternative Treatments on Psychiatric Symptoms

CPAP therapy showed superior symptom reduction compared to mandibular advancement devices (MADs) and lifestyle modifications.

Table 9: Comparison of CPAP and Alternative Treatments

Treatment Type	Depression Improvement (%)	Anxiety Improvement (%)	p-value
CPAP Therapy	78%	71%	<0.001
Mandibular Advancement Device (MAD)	52%	48%	<0.05
Lifestyle Modification	40%	36%	0.08

Longitudinal Follow-Up of Depression and Anxiety Scores Over 6 Months

CPAP therapy led to progressive reductions in depression and anxiety symptoms, with the greatest improvement at 6 months.

Table 10: Longitudinal Follow-Up of Depression and Anxiety Scores

Time Point	Mean HAM-D Score	Mean GAD-7 Score	p-value (vs. Baseline)
Baseline	14.6	11.8	-
3 Months	10.8	9.1	<0.01
6 Months	8.2	6.7	<0.001

DISCUSSIONS

The findings of this study reinforce the bidirectional relationship between Obstructive Sleep Apnea (OSA), depression, and anxiety, highlighting the significant psychiatric burden among OSA patients and the therapeutic impact of CPAP therapy. At baseline, 61% of patients exhibited depressive symptoms, while 48% reported moderate-to-severe anxiety, with severe OSA patients showing the highest psychiatric symptom burden ($p < 0.001$).^[7] This aligns with previous research demonstrating that OSA-related intermittent hypoxia, sleep fragmentation, and autonomic dysfunction contribute to mood disturbances by disrupting neurotransmitter regulation, increasing systemic inflammation, and altering the hypothalamic-pituitary-adrenal (HPA) axis. Conversely, patients

with pre-existing depression and anxiety are more likely to develop sleep disturbances and worsen OSA-related outcomes, emphasizing the complex interplay between these conditions.^[8]

The study also demonstrated that CPAP therapy significantly improved both sleep parameters and psychiatric symptoms, with CPAP users experiencing a mean reduction of 5.2 points in HAM-D ($p < 0.001$) and 4.6 points in GAD-7 scores ($p < 0.001$) over six months. Improvements in sleep quality (PSQI reduction by 37%) and daytime functioning (ESS reduction by 42%) were observed, further supporting the hypothesis that better sleep regulation positively impacts mental health outcomes.^[9] Additionally, higher CPAP adherence (>4 hours/night) correlated with greater psychiatric symptom improvement, whereas non-adherent patients and those using alternative treatments

(mandibular advancement devices, lifestyle modifications) exhibited moderate but less pronounced improvements ($p < 0.05$). These findings underscore the need for enhanced adherence strategies to maximize CPAP's benefits in both sleep and mental health management.^[10]

The regression analysis identified baseline AHI, CPAP adherence, and sleep quality improvements as key predictors of psychiatric symptom resolution ($p < 0.01$). This suggests that OSA severity is directly linked to mood disturbances, but effective intervention can mitigate these psychiatric effects. Given the high prevalence of undiagnosed OSA among psychiatric patients, routine screening for sleep disorders should be integrated into mental health assessments, particularly for individuals with treatment-resistant depression or anxiety disorders.^[11]

Despite the strong findings, this study has limitations. First, it was conducted in a single tertiary care center, which may limit the generalizability of results to broader populations. Second, while CPAP therapy was the primary intervention, other factors such as cognitive-behavioral therapy (CBT), medication adjustments, and lifestyle changes were not fully accounted for in psychiatric symptom resolution. Future research should explore multimodal approaches combining CPAP with psychological interventions to determine the most effective treatment strategy for OSA patients with comorbid depression and anxiety.

Overall, these results reinforce the critical role of OSA treatment in improving mental health outcomes, suggesting that early diagnosis and intervention in OSA patients may prevent or alleviate depressive and anxiety symptoms. Given the strong bidirectional influence, sleep medicine and psychiatry must adopt a collaborative approach to managing these interconnected conditions.

CONCLUSION

This study highlights the strong association between OSA, depression, and anxiety, demonstrating that higher OSA severity correlates with greater psychiatric symptom burden. CPAP therapy significantly improved sleep quality, daytime functioning, and psychiatric symptoms, with higher adherence leading to superior outcomes. Alternative treatments provided moderate symptom relief but were less effective than CPAP ($p < 0.05$), reinforcing the importance of CPAP as the primary intervention for OSA-related psychiatric comorbidities.

Given the high prevalence of depression and anxiety in OSA patients, routine psychiatric screening should be integrated into sleep medicine practice, and vice versa, sleep assessments should be part of psychiatric evaluations, particularly for individuals with treatment-resistant mood disorders. Future research should explore long-term psychiatric

benefits of CPAP therapy, adjunctive psychological interventions, and neurobiological mechanisms linking these disorders. In conclusion, effective OSA treatment not only improves sleep parameters but also has a profound impact on mental health, reducing depression and anxiety symptoms. These findings support the integration of sleep disorder management into mental health care protocols to optimize overall patient well-being.

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