



Original Article



Identifying Factors Associated with High-Risk Obstructive Sleep Apnea (OSA) among Hypertensive Patients: A Case-Control Study in A Tertiary Care Hospital in Pakistan

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ABSTRACT

Obstructive sleep apnea (OSA) involves repeated upper-airway collapse and intermittent hypoxia. In hypertensive patients, particularly in developing regions, undetected OSA exist which significantly increases cardiovascular dangers. **Objective:** To identify factors associated with high-risk OSA in patients with raised blood pressure attending two tertiary hospitals in Peshawar. **Methods:** This case-control study (June 2025–September 2025) included 156 hypertensive adults (78 cases, 78 controls). Inclusion required a diagnosis of hypertension and a specific STOP-Bang score (cases ≥ 3 ; controls ≤ 2). Exclusion criteria involved prior OSA treatment, pregnancy, resistant hypertension, or severe mental health conditions. Data were collected via structured questionnaires and analyzed using multivariable logistic regression. **Results:** Mean age, BMI, and neck circumference were significantly higher in the high-risk group ($p < 0.001$). Gender, BMI category, and ischemic heart disease were significantly associated. In crude regression, age, gender, BMI, neck circumference, and ischemic heart disease were significant predictors; however, after adjustment, only older age, male gender, and larger neck circumference remained independently associated with high-risk OSA. **Conclusions:** Older age, male gender, and increased neck circumference independently predict high-risk OSA in hypertensive patients. STOP-Bang proved useful as a screening tool, and the high prevalence of anxiety highlights the broader clinical burden. Incorporating neck circumference and age into routine hypertension care may aid earlier OSA recognition.

INTRODUCTION

The most widespread sleep-related breathing condition is Obstructive Sleep Apnea (OSA), defined by cycles of breathing pauses and restarts during sleep. Unlike other forms, OSA happens when pharyngeal muscles relax excessively, resulting in transient airway blockage. Common symptoms include loud snoring, increased daytime sleepiness, and repeated nighttime episodes of upper-airway collapse. These repeated episodes of sleep fragmentation and hypoxia contribute to impaired daytime functioning and cognitive decline [1]. OSA prevalence

reaches 50% in the hypertensive population and up to 71% in resistant hypertensive cases [2, 3]. The intermittent hypoxia in OSA triggers sympathetic activation and oxidative stress, promoting cardiovascular diseases, diabetes mellitus, and increasing mortality risk if left untreated [1, 4]. Studies have shown that obesity and a larger neck circumference, typically ≥ 35.5 cm in males and ≥ 32 cm in females, are major factors linked with severe OSA risk [5-7]. The coexistence of OSA and hypertension is clinically critical, as both conditions share



pathophysiological mechanisms like inflammation and vascular remodeling, all contributing to elevated blood pressure [8]. Regional studies have demonstrated a high prevalence of OSA symptoms among hypertensive patients, with evidence consistently showing that OSA is significantly associated with elevated blood pressure and hypertension even after adjusting for demographic and lifestyle factors [9, 10]. For confirmatory diagnosis of OSA, polysomnography is the gold standard procedure, but its use remains restricted in settings like ours due to cost and availability [11]. Globally, almost 75%-80% of OSA cases remain undiagnosed [12], with particularly low awareness in regions like Karachi, where only 15% of respondents demonstrated adequate understanding of OSA [13]. Furthermore, up to 93% of moderate-to-severe OSA cases in women may go unrecognized [14]. A study conducted in a local tertiary setting showed a substantial burden of OSA, emphasizing the fact that OSA remains significantly under-recognized in the local population [15]. To address this diagnostic gap, the STOP-Bang questionnaire (SBQ) provides a validated, sensitive, and cost-effective screening instrument, offering high sensitivity for detecting moderate-to-severe OSA in low-resource environments [16, 17].

Despite the globally well-established link between OSA and cardiovascular diseases, there is still a significant lack of regional evidence regarding risk factors specific to hypertensive populations in Pakistan. While general predictors are known, local predictors such as specific neck circumference threshold remains unexplored among the high-risk group. This study addresses this literature gap. This study aims to focus on finding local determinants in a tertiary care setting in Peshawar to enable earlier clinical recognition of OSA. As identifying these determinants is crucial for developing targeted screening protocols and improving management outcomes in low-income settings.

METHODS

This case-control study was conducted from 1st June to 1st September 2025 at Rehman General Hospital and Rehman Specialist Hospital in Peshawar, Pakistan. The participants were briefed on the study objectives and then signed informed consent forms. The research protocol was approved by the Institutional Review Committee on 15th May 2025 (Approval Letter Reference No: IRC-Approval-10-15-5-25). For this case-control study, the sample size was estimated using the formula, $n = (Z\alpha/2 + Z\beta)^2 \times [p_1(1-p_1) + p_2(1-p_2)] / (p_1 - p_2)^2$. The parameters used for the formula were 95% confidence level ($Z\alpha/2=1.96$), 80% power ($Z\beta=0.84$), and based on a reported smoking prevalence difference of 28.4% in cases (p_1) versus 9.2% in controls (p_2) [18]. Cases were defined as hypertensive adults (blood

pressure $\geq 140/90$ mmHg or on antihypertensive medication) with a Snoring, Tiredness, Observed apnea, high blood pressure, Body mass index, Age, Neck circumference, and Gender (STOP-Bang) questionnaire score ≥ 3 and at least one additional high-risk feature. Controls were hypertensive adults with a STOP-Bang score ≤ 2 [19] was followed for these classification and exclusion criteria. Participants with prior OSA treatment, pregnancy, resistant hypertension, or severe mental health conditions were excluded. The STOP-Bang questionnaire is a well-recognized, reliable, and practical screening instrument; using a cutoff score of ≥ 3 , it demonstrates a sensitivity of 93% for moderate-to-severe OSA and 100% for severe OSA [16]. The tool consists of 8 questions with a possible score ranging from 0 to 8, and has a reported Cronbach's alpha of 0.72, showing good internal consistency [20]. Data were collected using interviewer-led structured questionnaires covering sociodemographic variables (age, gender, socioeconomic status, and education level) and health-related variables. Height was measured using a stadiometer, weight using a digital weighing scale, blood pressure using a sphygmomanometer, and neck circumference using a non-stretchable measuring tape. Body mass index was calculated as weight in kilograms divided by height in meters squared. Comorbidities, including diabetes mellitus, ischemic heart disease, stroke, and hypercholesterolemia, were verified based on documented diagnosis and current medication use. Psychological distress was assessed using the Hospital Anxiety and Depression Scale (HADS) with Urdu/Pashto verbal translation. HADS consists of two 7-item subscales, score of each range from 0 (minimum) to 21 (maximum); both subscales have demonstrated good internal validity with reported Cronbach's alpha ranging from 0.80 to 0.90 [21]. The scores of HADS-A and HADS-D were categorized as, a score of 0-7 was classified as Normal, a score of 8-10 was classified as Borderline, and a score of 11-21 was classified as abnormal [21].

All statistical analyses were performed using SPSS version 26.0. Quantitative variables were expressed as mean \pm standard deviation and compared using independent t-tests, while qualitative variables were analyzed using Chi-square or Fisher's exact tests. Predictors of high-risk OSA were identified using binary logistic regression, followed by multivariable logistic regression for variables with $p \leq 0.20$ to calculate adjusted odds ratios. For all logistic regression models, the 'Low-Risk OSA' group (STOP-Bang score ≤ 2) served as the reference category. For categorical predictors, 'Female' was utilized as the reference category for Gender, and the 'Absence of comorbidity' served as the reference for clinical variables. Statistical significance was defined as $p \leq 0.05$ at a 95% confidence level.

RESULTS

A total of 156 hypertensive patients were analyzed, equally separated into high-risk (n = 78) and low-risk (n = 78) OSA classes using the STOP-BANG questionnaire. The overall mean age was 54.3 ± 13.1 years, mean BMI 27.3 ± 5.4 kg/m², and mean neck circumference 15.0 ± 1.5 inches. Most participants were non-educated (65.4%) and belonged to the middle socioeconomic class (71.8%). Based on HADS scoring, anxiety symptoms were predominantly prevalent, with most participants in the abnormal anxiety range, while depressive symptoms were generally mild. In order to compare the quantitative variables among the two groups t-test was applied, which showed a significant difference between the groups. Mean age, BMI, and neck circumference were markedly elevated in the high-risk group (p<0.001 for all), as shown in Table 1.

Table 1: Comparison of Continuous Variables Between High- and Low-Risk OSA Groups

Variable	Low-Risk Mean ± SD	High-Risk Mean ± SD	t-value	p-value
Age (years)	48.2 ± 11.7	60.4 ± 11.6	-6.22	<0.001*
BMI (kg/m ²)	25.8 ± 4.5	28.9 ± 5.9	-3.56	<0.001*
Neck Circumference (inches)	14.2 ± 1.0	15.9 ± 1.5	-7.63	<0.001*

BMI: Body mass index; SD: Standard deviation. *Indicates statistical significance at p≤0.05

Chi-square was applied to assess the relationship between qualitative variables and that of OSA-risk (Table II). A significantly higher proportion of males was observed among high-risk OSA cases compared to controls (χ² = 10.74, p=0.001). Similarly, BMI category showed a significant relationship with OSA risk (χ² = 14.35, p=0.002), with obesity being more frequent in the high-risk group. Ischemic heart disease (χ² = 10.26, p=0.001) was also significantly linked with high-risk OSA. A borderline association was noted for stroke (χ² = 3.85, p=0.050; LR = 4.10, p=0.043; Fisher's exact 1-sided = 0.049). Observed counts and percentages within groups are presented in table 2.

Table 2: Association of Categorical Variables with OSA Risk (Chi-Square Test)

Variable	Category	Low-Risk, (n, %)	High-Risk, (n (%))	χ ²	p-value
Gender	Male	15 (19.2%)	34 (43.6%)	10.741	0.001*
	Female	63 (80.8%)	44 (56.4%)		
BMI Category	Underweight (<18.5)	5 (6.4%)	2 (2.6%)	14.351	0.002*
	Normal (18.5-24.9)	26 (33.3%)	20 (25.6%)		
	Overweight (25-29.9)	35 (44.9%)	23 (29.5%)		
	Obese (≥30)	12 (15.4%)	33 (42.3%)		
Ischemic Heart Disease	Yes	13 (16.7%)	31 (39.7%)	10.256	0.001*
	No	65 (83.3%)	47 (60.3%)		
Stroke (History)	Yes	3 (3.8%)	9 (11.5%)	3.847	0.050*
	No	75 (96.2%)	69 (88.5%)		

All expected counts were ≥5 except for the stroke variable (minimum expected count = 3.25). Fisher's exact test was therefore additionally applied. *Indicates statistical significance at p≤0.05

Binary logistic regression was applied for every potential predictor separately, and then multivariable regression was applied on the variables having a p-value up to 0.2, as shown in table 3.

Table 3: Crude Logistic Regression of Factors Associated with High-Risk OSA

Predictor	B	SE	Wald	OR (95% CI)	p-value
Age (years)	0.129	0.028	21.311	1.14 (1.06-1.21)	<0.001*
Gender (male)	1.177	0.367	10.291	3.25 (1.61-6.55)	0.001*
BMI (kg/m ²)	0.115	0.045	6.570	1.12 (1.03-1.22)	0.010*
Neck circumference (inches)	1.041	0.274	14.424	2.83 (1.54-5.21)	<0.001*
Smoking Status	0.330	0.141	5.459	1.39 (0.84-2.33)	0.190
Cholesterol (Abnormal)	0.247	0.192	1.660	1.28 (0.92-1.79)	0.150
Stroke (History)	0.418	0.239	3.060	1.52 (0.95-2.42)	0.080
Ischemic Heart Disease	1.193	0.382	9.763	3.30 (1.55-7.02)	0.002*

OR: Odds ratio; CI: Confidence interval; SE: Standard error; BMI: Body mass index. Note: The Low-risk OSA group (STOP-Bang scores≤2) served as the reference category for the calculation of odds ratios. For categorical predictors, 'Female' served as the reference category for Gender, and 'No' (absence of the condition) served as the reference for all clinical comorbidities. * Indicates statistical significance at p≤0.05

After adjustment, age, gender, and neck circumference remained independent predictors of high-risk OSA, whereas BMI and IHD lost statistical significance, as shown in table 4.

Table 4: Multivariable Logistic Regression of Factors Associated with High-Risk OSA

Predictor	B	SE	Wald	OR (95% CI)	p-value
Age (years)	0.122	0.031	15.44	1.13 (1.06-1.21)	<0.001*
Gender (male)	1.085	0.482	5.07	2.96 (1.22-7.18)	0.016*
Neck circumference (inches)	1.005	0.231	18.93	2.73 (1.55-4.83)	<0.001*

AOR: Adjusted odds ratio; CI: Confidence interval; SE: Standard error. Note: The Low-risk OSA group (STOP-Bang scores≤2) served as the reference category for the calculation of odds ratios. For categorical predictors, 'Female' served as the reference category for Gender, and 'No' (absence of the condition) served as the reference for all clinical comorbidities. *Indicates statistical significance at p≤0.05

Older age, male gender, and increased neck circumference showed independent association with greater odds of high-risk OSA among hypertensive patients. Although BMI and ischemic heart disease were initially significant in crude models, their effects were no longer significant after adjustment, suggesting shared variance with anthropometric predictors.

DISCUSSION

This case-control analysis assessed factors linked with high-risk OSA in hypertensive patients through the STOP-Bang tool. Older age, male sex, and greater neck circumference were confirmed as independent predictors, supporting trends described in previous regional and global studies. These findings align with the observations of Salim *et al.* who reported that men with older ages and higher BMI were found to have higher OSA risk among hypertensive patients in Kenya [11]. Similarly, the nationwide Korean analysis by Huh *et al.* confirmed age and male gender as robust predictors of OSA after full multivariable adjustment [18]. The contribution of male sex to OSA risk has also been described in broader epidemiological literature, emphasizing the influence of sex hormones and craniofacial morphology on airway collapsibility [22]. Neck circumference demonstrated a particularly strong and independent association with high-risk OSA in the present study. This finding supports evidence from the Salim *et al.* [11] and Huh *et al.* [18] cohorts, where neck circumference remained one of the most powerful predictors of OSA even after adjusting for confounders. Larger neck circumference indicates upper airway anatomical narrowing and increased soft tissue volume, factors that predispose individuals to pharyngeal collapse during sleep. In contrast, BMI, though widely recognized as an OSA risk factor, reflects general adiposity rather than regional fat distribution. Consequently, BMI's predictive strength often diminishes when neck circumference is included in multivariate models, as also noted by Salim *et al.* [11]. This suggests that regional adiposity (particularly around the upper airway) may play a more direct etiological role in OSA development than generalized obesity. These findings therefore support the study hypothesis that selected demographic and anthropometric characteristics are significantly linked to hypertensive patients who are at higher risk of OSA. The attenuation of certain variables in the adjusted model in the present study parallels patterns observed in earlier research. While BMI and ischemic heart disease (IHD) demonstrated an association that was statistically significant with high-risk OSA in unadjusted analysis, both lost statistical significance in the multivariable logistic regression. A similar attenuation was reported in the Korean population by Huh *et al.* [18], where hypercholesterolemia and chronic kidney disease (CKD) showed strong crude associations with high-risk OSA, but these associations disappeared after full adjustment. This loss of significance highlights that such comorbidities as hypercholesterolemia, CKD, IHD, and BMI may act as mediating or intermediary factors within a shared cardiometabolic pathway rather than as independent

determinants. In the current study, the multicollinearity between BMI and neck circumference likely contributed to BMI's non-significance, as both variables capture overlapping elements of obesity and airway morphology. Neck circumference thus emerged as the more specific anthropometric correlate of OSA risk in this hypertensive cohort. The high prevalence of anxiety among hypertensive participants in this study is noteworthy. Although no significant association was found between anxiety or depression and OSA risk, the frequency of abnormal anxiety scores suggests that psychological distress is prevalent among patients with chronic hypertension; studies conducted in the past have shown the prevalence of disorders like anxiety and depression among the OSA population [4, 11]. While mood disorders did not directly predict OSA status in this analysis, the coexistence of hypertension, anxiety, and sleep-related symptoms may collectively aggravate patient outcomes, underscoring the value of integrated screening and management approaches. Overall, these results indicate that the STOP-BANG is a practical and reliable instrument for screening OSA in hypertensive subjects in routine clinical practice. The identification of neck circumference, age, and male gender as strong predictors is clinically valuable, as these parameters are simple to measure and cost-effective. The observed attenuation of metabolic and cardiovascular factors (BMI, IHD, cholesterol) after adjustment reinforces the complexity of OSA's pathophysiology, emphasizing that structural and demographic determinants may hold greater predictive power in this population.

This study's strengths include a robust case-control design and standardized data collection, which ensured reliable measurements of anthropometric and clinical parameters. Potential confounders were statistically addressed through multivariable logistic regression, and the use of the validated STOP-Bang questionnaire provided a cost-effective approach for identifying OSA risk in a resource-limited setting. However, limitations include the single-center tertiary care design, which may restrict the generalizability of findings to broader populations. Furthermore, the high prevalence of diabetes among hypertensive patients complicated the recruitment of fully matched non-diabetic controls, and sociocultural factors may have influenced self-reported smoking status in females. Finally, while the STOP-Bang tool is a validated screening instrument, the absence of polysomnography—the diagnostic gold standard—may have introduced some degree of misclassification. Despite these constraints, the study provides valuable insights into clinical determinants of OSA risk, underscoring the necessity of integrated screening protocols in routine hypertensive care. Routine Screening: Integrate neck circumference measurements and the STOP-Bang questionnaire into standard

hypertension management for earlier OSA detection. Resource Optimization: Prioritize structural and demographic predictors, such as age and gender, in clinical settings where polysomnography is unavailable. Integrated Care: Screen hypertensive patients for psychological distress as part of a holistic management approach. Further Research: Conduct multicenter studies utilizing polysomnographic validation to refine these risk thresholds for the local population.

CONCLUSIONS

This study demonstrates that older age, male gender, and increased neck circumference are independent predictors of high-risk obstructive sleep apnea (OSA) among hypertensive patients in Peshawar. The STOP-Bang questionnaire serves as a practical, high-sensitivity screening tool in resource-limited settings where polysomnography is unavailable. These findings suggest that incorporating routine neck circumference measurements into hypertension management can facilitate earlier OSA detection. Such integrated screening is vital for mitigating cardiovascular risks and addressing the significant psychological burden prevalent in this population.

Authors' Contribution

Conceptualization: IUH

Methodology: IUH, HI, AB, AA, HH, TR

Formal analysis: IUH, AA

Writing and Drafting: IUH, HI, AB, AA, HH, TR

Review and Editing: IUH, HI, AB, AA, HH, TR

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

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