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ASSOCIATION OF SPIROMETRIC PARAMETERS AND STOP-BANG SCORE WITH SEVERITY OF OBSTRUCTIVE SLEEP APNEA: AN AMBISPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Objective: Obstructive sleep apnea (OSA) is a common sleep-related breathing disorder associated with important cardiometabolic consequences. This study aimed to evaluate the relationship between spirometric parameters, STOP-BANG score, and OSA severity in patients evaluated for suspected sleep-disordered breathing.

Materials and Methods: This ambispective observational study included 90 adults who underwent polysomnography, spirometry, and STOP-BANG assessment. Clinical variables included age, sex, body mass index (BMI), neck circumference, Epworth Sleepiness Scale (ESS), smoking status, apnea–hypopnea index (AHI), and forced expiratory volume in 1 second (FEV_1). OSA severity was classified as mild, moderate, or severe according to AHI. Continuous variables were summarized as mean ± standard deviation. Pearson correlation, one-way ANOVA, ROC analysis, and multivariable logistic regression were performed. Sample size was estimated assuming a moderate correlation coefficient ($r = 0.30$), with 80% power and 5% alpha.

Results: The study population had a mean age of 54.1 ± 10.0 years and mean BMI of 30.3 ± 3.0 kg/m². Severe OSA was present in 56.7% of patients. FEV_1 showed a significant inverse correlation with AHI ($r = -0.409$, $p < 0.001$). FEV_1 also declined progressively across OSA severity groups, from 84.9 ± 13.0% predicted in mild OSA to 73.5 ± 13.1% predicted in severe OSA ($p = 0.011$). STOP-BANG score showed modest predictive performance for severe OSA (AUC = 0.573), while FEV_1 demonstrated better discrimination (AUC = 0.665). A combined model improved discrimination slightly (AUC = 0.672).

Conclusion: Reduced FEV_1 remained independently associated with severe OSA after adjustment for age, sex, BMI, neck circumference, and STOP-BANG score. Although spirometry cannot replace polysomnography, it may provide complementary physiological information for OSA risk stratification.

KEYWORDS: Obstructive sleep apnea; Spirometry; FEV_1; STOP-BANG; Apnea–hypopnea index; Pulmonary function

INTRODUCTION

Obstructive sleep apnea (OSA) is characterized by recurrent partial or complete upper airway obstruction during sleep, leading to intermittent hypoxia, sleep fragmentation, and sympathetic activation [1,2]. The disorder is now recognized as a major contributor to cardiovascular and metabolic risk, reduced daytime function, and impaired quality of life [3,4].

Although polysomnography remains the gold standard for diagnosis, access to sleep studies is still limited in many settings because of cost, equipment requirements, and dependence on trained personnel [5]. This has encouraged interest in simple adjunctive tools that may improve clinical risk stratification.

Spirometry is inexpensive, widely available, and routinely performed in respiratory practice. From a physiological standpoint, reduced lung volumes may lessen caudal traction on the upper airway, thereby increasing collapsibility during sleep [6,7]. In that context, lower FEV_1 or FVC may act as a surrogate of impaired respiratory mechanics and potentially reflect greater susceptibility to OSA-related airway instability.

Clinical screening tools such as STOP-BANG are widely used because they are easy to apply and highly sensitive in many populations [8,9]. However, their performance varies according to the characteristics of the studied cohort, and they do not directly measure respiratory mechanics. For this reason, combining questionnaire-based screening with objective lung function assessment may provide additional information.

The present study was undertaken to evaluate the association between spirometric parameters and OSA severity, and to assess the comparative screening value of STOP-BANG in a real-world cohort of patients evaluated for suspected sleep-disordered breathing.

MATERIALS AND METHODS

Study design and setting

This ambispective observational study was conducted in the Department of Respiratory Medicine, Father Muller Medical College Hospital, Mangalore, India, from January 2025 to June 2026. Adult patients evaluated for suspected OSA were enrolled retrospectively and prospectively. Ethical approval was obtained from the Father Muller Institutional Ethics Committee (Protocol No. 858/2025; Ref. No. FMIEC/CCM/2025), and the study adhered to the Declaration of Helsinki
A total of 90 adults evaluated for suspected OSA were included, with clinical data obtained retrospectively and spirometry and questionnaire data collected prospectively. Eligible participants were aged ≥18 years, had clinical suspicion of OSA, and had complete Level II sleep study and spirometry data. Patients with acute respiratory tract infection, chronic respiratory disease significantly affecting pulmonary function, or incomplete clinical or sleep study data were excluded.Data collection.
Demographic and clinical variables including age, sex, body mass index (BMI), neck circumference, smoking status, Epworth Sleepiness Scale (ESS), STOP-BANG score, apnea-hypopnea index (AHI), and forced expiratory volume in one second (FEV_1) were recorded. Smoking status was categorized as non-smoker, ex-smoker, or current smoker. Although forced vital capacity (FVC) is a more direct measure of static lung volume, FEV_1 was selected as the primary spirometric parameter because it is routinely measured in clinical practice, demonstrates excellent test–retest reproducibility, and was available for all study participants. In addition, FEV_1 has been widely used as an overall indicator of pulmonary function and was therefore chosen as the primary spirometric parameter for analysis in this study.

STOP-BANG scoring

The STOP-BANG questionnaire was administered using the standard eight-item validated instrument. Participants were categorized as low risk (0–2), intermediate risk (3–4), or high risk (≥5).

Spirometry

Spirometry was performed using the EasyOne® portable spirometer (ndd Medical Technologies, Zurich, Switzerland) in accordance with the American Thoracic Society/European Respiratory Society (ATS/ERS) 2019 Technical Standards. Each participant performed at least three acceptable and reproducible forced expiratory maneuvers. The highest acceptable values of forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were recorded and expressed as percentages of predicted values. The FEV_1/FVC ratio was also recorded. Only spirometry tests fulfilling ATS/ERS acceptability and reproducibility criteria were included in the final analysis. [10,11]

Polysomnography

Overnight Level II sleep studies were performed using the SOMNOtouch™ RESP system (SOMNOmedics GmbH, Randersacker, Germany). The system recorded electroencephalography (EEG), electrooculography (EOG), chin electromyography (EMG), electrocardiography (ECG), nasal airflow, thoracoabdominal respiratory effort, pulse oximetry, snoring, body position, and limb movements. Sleep recordings were manually scored by trained sleep technologists according to the American Academy of Sleep Medicine (AASM) Manual for the Scoring of Sleep and Associated Events. The apnea–hypopnea index (AHI) was calculated as the total number of apneas and hypopneas per hour of sleep. OSA severity was classified according to AASM criteria as mild (AHI 5.0–14.9 events/hour), moderate (AHI 15.0–29.9 events/hour), and severe (AHI ≥30 events/hour). [5]

Sample size calculation

Sample size was calculated using Fisher's Z transformation for correlation analysis, assuming an anticipated correlation coefficient (r) of 0.30, a two-sided alpha error of 0.05, and a study power of 80%. The minimum required sample size was estimated to be 85 participants. To compensate for incomplete records and improve statistical precision, 90 participants were included in the final analysis.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics Version 25.0. Continuous variables were assessed for normality using the Shapiro–Wilk test and expressed as mean ± SD, while categorical variables were presented as frequencies and percentages. Differences among mild, moderate, and severe OSA groups were assessed using one-way ANOVA with Tukey's post hoc test, and categorical variables using the Chi-square or Fisher's exact test. Pearson's correlation was used to assess the relationship between spirometric parameters and AHI. ROC curve analysis evaluated the diagnostic performance of FEV_1 (% predicted), STOP-BANG score, and their combination for severe OSA (AHI ≥30 events/hour), expressed as AUC. Multivariable logistic regression identified independent predictors of severe OSA, with adjusted ORs and 95% CIs reported.

RESULTS

Baseline Characteristics

A total of 90 patients were included in the analysis. The mean age was 54.14 ± 10.00 years, and the mean BMI was 30.34 ± 3.02 kg/m². The mean ESS score was 13.43 ± 3.12, mean neck circumference was 39.32 ± 3.07 cm, mean STOP-BANG score was 3.99 ± 1.43, and mean AHI was 33.07 ± 16.52 events/hour. The mean FEV_1 was 77.04 ± 14.17% predicted (Table 1).

Distribution of OSA Severity
Among the study population, 16 (17.8%) patients had mild OSA, 23 (25.6%) had moderate OSA, and 51 (56.7%) had severe OSA (Table 2).

Correlation Analysis
Pearson correlation analysis demonstrated a significant inverse correlation between FEV_1 (% predicted) and AHI ($r = -0.409$, $p < 0.001$), indicating that lower FEV_1 values were associated with increasing OSA severity. In contrast, Age, BMI, neck circumference, ESS score, and STOP-BANG score were not significantly correlated with AHI.(Table 3), (Figure 1).

Comparison Across OSA Severity Groups
Mean FEV_1 (% predicted) declined progressively with increasing OSA severity, measuring 84.85 ± 13.02% in patients with mild OSA, 79.50 ± 14.96% in moderate OSA, and 73.48 ± 13.15% in severe OSA (ANOVA, $p = 0.011$) (Figure 2) Post hoc analysis demonstrated that the significant difference was primarily between patients with mild and severe OSA, whereas differences between mild and moderate OSA and between moderate and severe OSA were not statistically significant.

ROC Curve Analysis
Receiver operating characteristic analysis demonstrated that FEV_1 (% predicted) had better discriminatory performance for identifying severe OSA (AUC = 0.665) than the STOP-BANG questionnaire (AUC = 0.573). Combining FEV_1 with the STOP-BANG score resulted in a slight improvement in discrimination (AUC = 0.672), suggesting that spirometry may provide complementary information when used alongside clinical screening tools (Table 5; Figure 3).

Multivariable Logistic Regression Analysis
Multivariable logistic regression analysis demonstrated that reduced FEV_1 remained independently associated with severe OSA after adjustment for age, sex, BMI, neck circumference, and STOP-BANG score (adjusted OR 0.954, 95% CI 0.923–0.986; $p = 0.006$). None of the remaining variables were independently associated with severe OSA (Table 6).

DISCUSSION
This ambispective observational study demonstrated that reduced FEV_1 was significantly associated with increasing severity of obstructive sleep apnea. Among the variables evaluated in this cohort, FEV_1 showed the strongest inverse correlation with AHI and demonstrated fair discriminatory ability for identifying severe OSA. These findings suggest that spirometry may provide useful physiological information that complements established clinical screening tools such as the STOP-BANG questionnaire.
Importantly, the association between reduced FEV_1 and severe OSA remained significant after adjustment for age, sex, BMI, neck circumference, and STOP-BANG score, suggesting that FEV_1 was independently associated with severe OSA in this cohort.
The physiological explanation is plausible. Lower lung volumes reduce caudal traction on the pharyngeal airway, which may increase upper airway collapsibility during sleep [6,7]. Although caudal traction is primarily a function of static lung volume, FEV_1 correlates closely with these volumes in the absence of severe underlying obstructive airway disease. In this context, FEV_1 acts as a practical, highly reproducible surrogate marker of global respiratory mechanics rather than merely a measure of fixed airway obstruction.
This is especially relevant in patients who do not have overt chronic lung disease but still demonstrate reduced spirometric values.
Although the STOP-BANG questionnaire is a well-established and validated screening tool for identifying patients at risk of OSA, its association with AHI was weak and not statistically significant in the present study. This finding may be related to the referral-based nature of our cohort, in which a large proportion of patients already had moderate-to-severe OSA, thereby reducing the discriminatory ability of the questionnaire. Nevertheless, STOP-BANG remains a valuable screening instrument, while spirometry may provide complementary physiological information for assessing disease severity.
The lack of significant associations for BMI, ESS, age, and neck circumference across severity strata is also noteworthy. This may reflect the relatively homogeneous clinical profile of the cohort, most of whom were already referred for suspected sleep-disordered breathing. In a referral-based sample, many patients share similar symptom burden and anthropometric risk factors, which can reduce between-group contrast. In such a setting, spirometric variation may be more informative than questionnaire scores alone.
From a clinical standpoint, the findings are useful for resource-limited settings where access to polysomnography is constrained. A patient with suspected OSA, a higher STOP-BANG score, and reduced FEV_1 may be considered for prioritization for formal sleep testing. Spirometry should not replace polysomnography, but it may help refine risk assessment when used alongside standard screening [9]. A proposed clinical workflow integrating STOP-BANG screening and spirometry is shown in Figure 4.
These findings are consistent with earlier work showing that lung volume and upper airway mechanics are interrelated in sleep apnea [6,7]. They also reinforce the importance of interpreting spirometric results in context rather than viewing them only as markers of intrinsic lung disease [10,11].

Strengths

Strengths of this study include its ambispective design, standardized Level II polysomnography, adherence to ATS/ERS spirometry standards, and the combined evaluation of physiological and questionnaire-based screening tools in patients with suspected OSA. The inclusion of multivariable logistic regression strengthened the assessment of independent associations.

Limitations

This study has several limitations. First, it was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the findings. Second, the ambispective design introduces the possibility of selection and information bias. Third, because the study population consisted of patients referred for suspected OSA, severe disease was overrepresented. Fourth, although multivariable regression analysis was performed, the relatively small sample size may have limited the statistical power to detect independent associations for other clinical variables. Residual confounding by unmeasured variables cannot be excluded.

CONCLUSION

Reduced FEV_1 was independently associated with severe OSA after adjustment for age, sex, BMI, neck circumference, and STOP-BANG score. Although spirometry cannot replace polysomnography or established screening tools such as the STOP-BANG questionnaire, it may provide complementary physiological information that enhances clinical risk stratification when used alongside these tools.

Future multicenter studies with larger sample sizes and multivariable analyses are needed to validate these findings and further define the complementary role of spirometry in OSA risk assessment.

Tables & Figures

Table 1. Baseline Characteristics of the Study Population (n = 90)

Variable	Value
Age (years), mean ± SD	54.14 ± 10.00
Male, n (%)	41 (45.6)
Female, n (%)	49 (54.4)
BMI (kg/m²), mean ± SD	30.34 ± 3.02
Neck circumference (cm), mean ± SD	39.32 ± 3.07
ESS score, mean ± SD	13.43 ± 3.12
STOP-BANG score, mean ± SD	3.99 ± 1.43
AHI (events/hour), mean ± SD	33.07 ± 16.52
FEV_1 (% predicted), mean ± SD	77.04 ± 14.17

Abbreviations: BMI, body mass index; ESS, Epworth Sleepiness Scale; AHI, apnea–hypopnea index; FEV_1, forced expiratory volume in one second.

Table 2. Distribution of OSA Severity Category

OSA Severity	N	Percentage
Mild (AHI 5–14.9)	16	17.8
Moderate (AHI 15–29.9)	23	25.6
Severe (AHI ≥30)	51	56.7
Total	90	100

Table 3. Correlation Between Clinical Variables and AHI

Variable	Pearson's r	p-value
Age	0.067	0.532
BMI	-0.074	0.486
Neck circumference	0.100	0.350
ESS	0.088	0.407
STOP-BANG	0.101	0.343
FEV1	-0.409	<0.001

Bold indicates statistically significant association ($p < 0.05$).

Table 4. Comparison of Clinical Variables Across OSA Severity Groups

Variable	Mild (n=16)	Moderate (n=23)	Severe (n=51)	p-value
Age (years)	52.8 ± 9.8	53.9 ± 10.4	54.9 ± 9.9	0.516
BMI (kg/m²)	29.8 ± 2.9	30.2 ± 3.1	30.6 ± 3.0	0.211
Neck circumference (cm)	38.9 ± 2.9	39.2 ± 3.1	39.5 ± 3.1	0.298
ESS	13.1 ± 2.9	13.5 ± 3.0	13.6 ± 3.3	0.624
STOP-BANG	3.8 ± 1.2	4.0 ± 1.4	4.1 ± 1.5	0.533
FEV_1 (% predicted)	84.85 ± 13.02	79.50 ± 14.96	73.48 ± 13.15	0.011

Post hoc analysis (Tukey HSD) demonstrated a significant difference between the mild and severe OSA groups only.

Table 5. Receiver Operating Characteristic (ROC) Analysis for Prediction of Severe OSA

Variable	AUC
STOP-BANG score	0.573
FEV_1 (% predicted)	0.665
Combined model	0.672

AUC = Area under the receiver operating characteristic curve.

Table 6: Multivariable logistic regression model for prediction of severe OSA (AHI ≥30 events/hour). OR = odds ratio; CI = confidence interval.

Variable	Adjusted OR	95% CI	p-value
FEV_1 (% predicted)	0.954	0.923–0.986	0.006
Age	1.001	0.952–1.053	0.959
BMI	0.953	0.817–1.110	0.535
STOP-BANG score	1.256	0.819–1.926	0.297
Neck circumference	1.042	0.896–1.212	0.590
Male sex	0.919	0.298–2.837	0.884

Table 7. Summary of Major Findings

Finding	Result
Strongest correlation with AHI	FEV_1 (r = -0.409, p <0.001)
Significant difference among OSA severity groups	FEV_1 (p =0.011)
Best ROC performance	Combined Model (AUC=0.672)
Better single predictor	FEV_1 (AUC=0.665)
STOP-BANG AUC	0.573

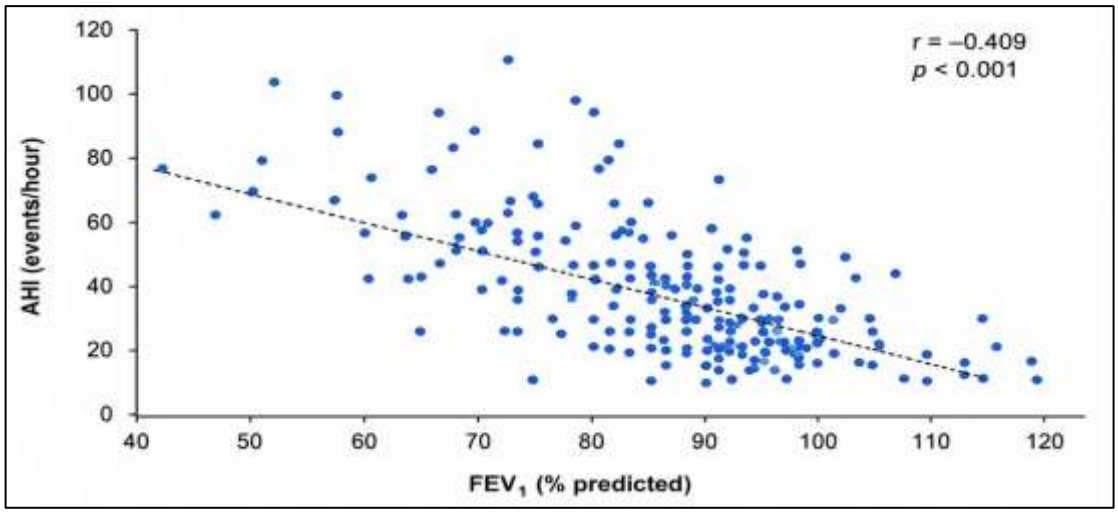

Figure 1. Scatter plot showing the inverse relationship between FEV_1 (% predicted) and AHI.

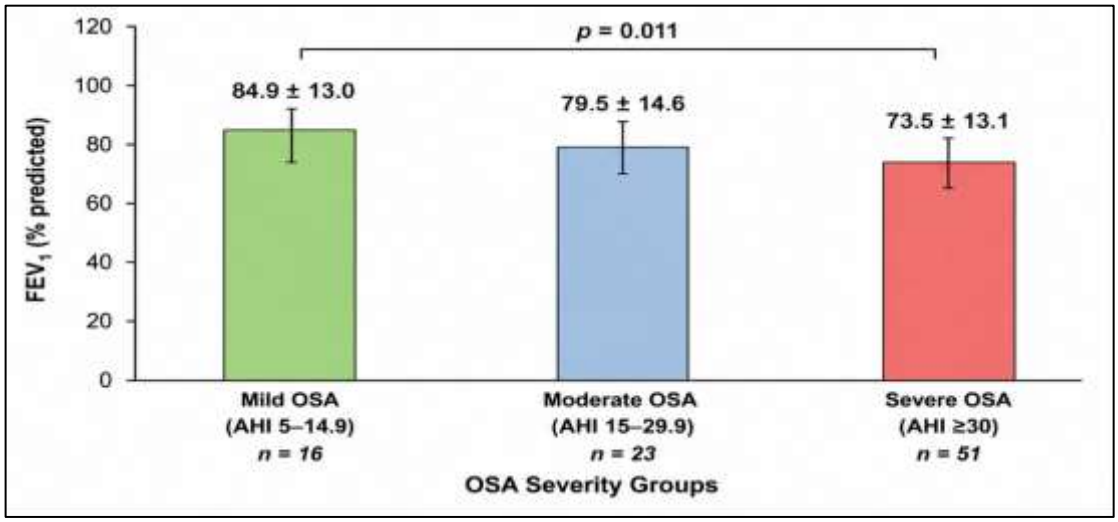

Figure 2. Mean FEV_1 (% predicted) across OSA severity groups (error bars = SD)

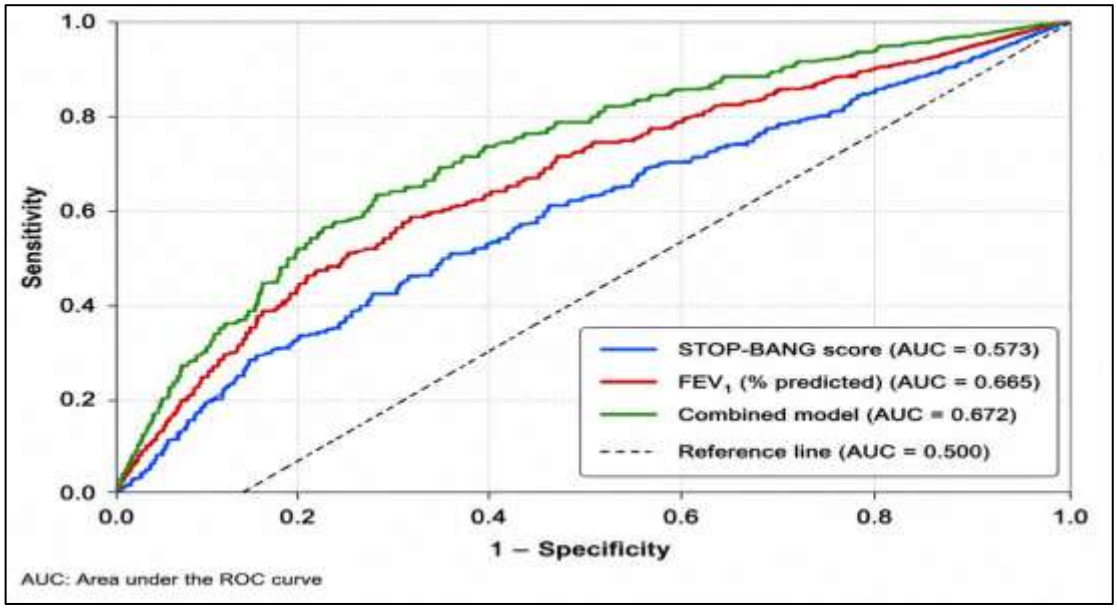

Figure 3. Receiver operating characteristic (ROC) curves for prediction of severe OSA (AHI ≥30 events/hour)

Acknowledgements

The authors thank the Department of Respiratory Medicine, Father Muller Medical College Hospital, Mangalore, for their support in conducting this study. The authors also acknowledge the sleep laboratory staff and pulmonary function laboratory personnel for their assistance in data collection.

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