



Utility of Nosas Score as a Screening Tool to Suspect Obstructive Sleep Apnea in Comparison with Stop-Bang Questionnaire

Dr. Surya V¹, Dr Nisha Ganga 2*, Dr Meenakshi N 3, Dr Jayamol Revendran⁴, Dr Chandrasekar S⁵

¹Postgraduate, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

²Assistant Professor, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

³Professor and HOD, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

⁴Associate Professor, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

⁵Assistant Professor, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

*Corresponding Author: Dr NISHA GANGA, Assistant Professor, Department of Respiratory Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam-603103, Tamil Nadu, India.

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ABSTRACT:

Background:

Obstructive Sleep Apnea (OSA) is a commonly yet poorly diagnosed, sleep-related breathing disorder with characteristics of periodic blockage of upper airways during sleep, which leads to periodic hypoxia and sleep fragmentation. OSA is closely linked with obesity and growing age and leads to cardiovascular and metabolic morbidity. Even though polysomnography (PSG) is the gold standard diagnostic modality, its restricted accessibility requires the application of simple and reliable screening tools. High sensitivity leads to the widespread use of the STOP-BANG questionnaire, but a simple alternative has been suggested as the NoSAS score, predominantly based on objective anthropometric parameters.

Objective:

To evaluate the diagnostic utility of the NoSAS score in screening obstructive sleep apnea and to compare its performance with the STOP-BANG questionnaire among obese adults suspected of OSA.

Materials and methods:

A cross-sectional study was carried out in the Department of Pulmonary Medicine at a tertiary care teaching hospital over 18 months (January 2022 - June 2023). Overall, 120 adults aged 18-65 years with a body mass index of more than 30 kg/m² and with symptoms indicative of OSA were recruited. Socio-demographic profile, anthropometric measurements and clinical history were noted. All subjects were evaluated in terms of NoSAS score as well as the STOP-BANG questionnaire, and then overnight polysomnography was conducted. The severity of OSA was determined through the



Apnea-Hypopnea Index (AHI). The chi-square test, ANOVA and Receiver Operating Characteristic (ROC) curve analysis were statistical analyses employed to determine the diagnostic accuracy.

Results:

There was a significant association between advancing age and progressive OSA severity ($p < 0.001$), with severe OSA constituting most of the cases. The average NoSAS score increased considerably with higher BMI categories ($p = 0.040$), revealing a strong correlation with the severity of obesity. The analysis of ROC curves demonstrated that the two screening tools have a similar diagnostic performance. In moderate-to-severe OSA, the NoSAS score had an AUC of 0.746 when compared to 0.783 for STOP-BANG ($p = 0.488$). To detect overall OSA, AUC of NoSAS was 0.774, and for STOP-BANG was 0.707 ($p = 0.999$), which was not statistically significant.

Conclusion:

The NoSAS score had a diagnostic accuracy similar to the STOP-BANG questionnaire in the screening of obstructive sleep apnea. The NoSAS score is a useful and convenient screening instrument because of its simplicity, objectivity, and applicability in obese populations as well as in resource-limited clinical settings, with the potential to minimize unnecessary referrals for polysomnography.

INTRODUCTION:

Obstructive Sleep Apnea is a common sleep disorder that is often underdiagnosed and has characteristics of repetitive obstructions of the upper airway during sleep, resulting in intermittent hypoxia and fragmented sleep architecture. The condition is associated with some serious health risks, like cardiovascular disease, hypertension, type 2 diabetes & neurocognitive impairments. Early diagnosis and treatment are relevant to limit the long-term effects of OSA, but the availability of gold standard diagnostic modalities such as polysomnography (PSG) is scarce because of the high cost, availability, and time. Therefore, it has seen the growing importance of the development and validation of non-invasive, simplified methods of screening to forecast OSA risk in clinical and community settings. The STOP-BANG questionnaire is one of the most popular tools since it is easy to administer and is highly sensitive. Nevertheless, its weaknesses, especially in specificity and over-referral rates, have led to the exploration of other models. The NoSAS score, which includes a combination of variables like neck circumference, BMI, snoring, age, and sex have become a promising alternative with a better predictive balance in certain groups. Both clinical and general population validation of this score have shown promising outcomes of its use as a first-line screening tool for moderate-

severe OSA. In 2023, a study confirmed the NoSAS score in a Greek cohort and proved its applicability in the Mediterranean population and supported its use as a non-invasive pre-screening tool in primary care [1]. NoSAS score has demonstrated good performance metrics when compared to STOP-BANG, Berlin and GOAL questionnaires. These tools have different sensitivity and specificity trade-offs, and multi-centred cohort analyses have indicated that the NoSAS score might be better than STOP-BANG in specificity but not significantly worse in terms of sensitivity [2]. In addition, it has been highlighted that STOP-BANG can overestimate the presence of OSA risk, which causes unnecessary PSG referrals, but NoSAS provides a less effective but more conservative option [3]. Clinical analyses in sleep labs have confirmed this, with the NoSAS score being tested against AHI thresholds and found to have a high diagnostic value [4]. Performance comparison across indices like Apnea-Hypopnea Index and Oxygen Desaturation Index is important in the pursuit of optimization of OSA screening strategies. Such tools as STOP-BANG and NoSAS are frequently compared to such indices. A study that compared three instruments was carried out in 2021 and it was discovered that STOP-BANG had higher sensitivity but NoSAS had a better sensitivity-specificity balance, particularly in the prediction of moderate - severe OSA [5]. This is in line with a 2022 meta-analysis that examined the diagnostic



validity of the most popular questionnaires in clinical cohorts. The findings supported the view that even though NoSAS is more recent, it has potential in certain subgroups, including obese or male patients aged above 50 years [6]. The effectiveness of the screening tools is also affected by geographical differences in the prevalence of OSA and anthropometric factors. In a 2021 meta-analysis, the authors highlighted the importance of tools such as STOP-BANG potentially needing calibration when applied to different populations because of differences in the BMI distributions, neck circumference, and the prevalence of snoring [7]. Additionally, predictive accuracy of STOP-BANG in severe OSA is improved, but it has lower predictive accuracy in less risky populations, which makes the use of the tool differentially in populations with stratification needed [8]. The use of dual tool application-using STOP-BANG with other tools has also been examined, like the Epworth Sleepiness Scale. Another study (2022) showed that STOP-BANG is more predictive when used with ESS in sleep clinics [9].

Continuing on its use in general and work-related contexts, the STOP-BANG instrument has been proven in various population groups, such as commercial drivers and people who have high-risk occupations. A 2021 systematic review concluded that despite the continued usefulness of STOP-BANG in general screening, its false positive rate in predicting OSA is too high to justify the use of the tool as it can overestimate the risk of OSA, and more specific instruments such as NoSAS might be more suitable in resource-constrained settings [10]. All these studies emphasize the significance of context-based screening methods and justify the increased popularity of the NoSAS score as a realistic and balanced method.

Preoperative assessment of OSA is another area of the clinical environment where simplified screening tools have come to be useful. The use of the STOP-BANG questionnaire as a valuable screening tool in the surgical patient population was confirmed by a meta-analysis study (2022), with high sensitivity in the identification of moderate-to-severe OSA. The paper has reiterated that preoperative identification of the risk of OSA is imperative to the organization of anaesthesia and the post-operative care, especially in patients undergoing major surgeries [11]. Sensitivity of screening instruments has also been related to the gold standard of

polysomnography (PSG) overnight. In a study that was carried out in 2025, the sensitivity and specificity of several screening tools, such as NoSAS and STOP-BANG, were compared to PSG-derived measures, and it was observed that STOP-BANG was more sensitive and NoSAS was more specific in moderate-to-severe OSA patients. These trade-offs support the complementary nature of the tools, in which either tool may be preferred in the clinical situation over the other [12].

OSA screening implications are not restricted to diagnosis in the outpatient and operating rooms. The STOP-BANG scores were observed to be high, which is associated with increased complications during the perioperative time, slow postoperative recovery, and high risk of respiratory postoperative events. Therefore, preoperative OSA risk assessment with the assistance of such agencies as STOP-BANG has become a standard of care in the majority of institutions in the world [13]. Such cumulative findings characterize the transforming scenario of OSA screening tools. Albeit STOP-BANG questionnaire continues to dominate clinical practice through its sensitive nature, other emerging instruments like the NoSAS score are also a promising alternative, especially when sensitivity and specificity need to be coupled. The combination of these tools will enhance the initial diagnosis of OSA and allow effective stratification of patients who will receive conclusive diagnostic tests and treatment.

AIM:

1. To evaluate the NoSAS score as a screening tool to suspect obstructive sleep apnea in comparison with STOP-BANG questionnaire

OBJECTIVES:

1. To assess the sensitivity and specificity of the NoSAS score in identifying OSA among obese patients.
2. To compare the NoSAS score's effectiveness with existing screening tools like STOP-BANG.

METHODOLOGY:

Study design, setting, and duration:

This study is designed as a hospital-based, prospective, observational, cross-sectional study conducted over a period of 18 months in the Department



of Respiratory Medicine, Chettinad Hospital and Research Institute (CHRI).

Study population (Inclusion and exclusion criteria):

Patients aged 18-65 years with a body mass index (BMI) of $>30 \text{ kg/m}^2$ exhibiting evidence of OSA were included. Patients who had previous OSA diagnosis, who were undergoing treatment for OSA and other notable respiratory diseases were excluded from the study.

Sampling technique and sample size:

The study employed a purposive sampling technique, where all the patients who satisfied the inclusion criteria and were willing to undergo the screening process were enrolled.

The sample size was calculated according to the past literature assessing the diagnostic value of the NoSAS and STOP-BANG questionnaires in the detection of obstructive sleep apnea. The required sample size was estimated to be **102 participants** at a 95% confidence level, and a power of 80, and a moderate effect size is taken as a comparative measure of the two screening tools, after accounting for 10% drop-out.

The formula used for calculating sample size was:

$$n = \frac{z^2 pq}{d^2}$$

where:

n = required sample size

z = standard normal variate for a 5% significance level

p = prevalence

q = 100-p

d = absolute precision

Procedure:

The research was carried out on the basis of a structured protocol in order to compare the diagnostic capability of the NoSAS score and the STOP-BANG questionnaire in referring patients with obstructive sleep apnea (OSA). After receiving the institutional ethics committee clearance, the participants who met the pre-determined inclusion and exclusion criteria were identified in the outpatient department and sleep clinic settings. Eligible individuals who consented to participate in the study were registered in a consecutive

order until they reached the preferred sample size. All the participants were provided with a comprehensive clinical assessment that involved the recording of demographic information, medical history, body mass index, neck circumference, and self-reported OSA symptoms such as snoring, daytime sleepiness, fatigue and perceived apnea. After this, the STOP-BANG questionnaire and NoSAS score were given to all subjects in a standardized fashion to all subjects by trained personnel to ensure a consistent collection of data. When needed, the participants were given the questionnaires in their choice of language to ensure that they were not misinterpreted and that the responses were more accurate. The participants were then planned to undergo overnight polysomnography (PSG) after completion of both the screening tools in a sleep laboratory which was a gold standard to diagnose OSA. The PSG included constant observation of the airflow of respiration, oxygen saturation, electroencephalogram, electrooculogram, electromyogram & electrocardiogram as per the American Academy of Sleep Medicine.

Apnea-Hypopnea Index (AHI) was computed, and OSA was determined with regard to the conventional thresholds ($\text{AHI} \geq 5 \text{ events/hour}$). The results of the two screening questionnaires were then compared with the final PSG results of each subject. The performance of each tool was calculated by computing sensitivity, specificity, positive predictive value and negative predictive value. In addition, receiver operating characteristic (ROC) curves were created to test the discriminatory ability of the NoSAS and STOP-BANG scores. All information was safely stored, and the anonymity of the subjects was ensured. This systematic methodology provided patient assessment standardization, reduced inter-observer reliability and provided the possibility of objective comparison of the two tools with the gold standard of PSG.

Each participant had the following parameters, which were recorded:

- Demographic details: Age, sex.
- Anthropometric measurements: BMI, neck circumference.
- Clinical history: Snoring, daytime drowsiness, observed apneas, comorbidities.
- Risk factor score: STOP-BANG score and NoSAS score.



- Polysomnography data: Apnea-Hypopnea Index, Oxygen desaturation index, sleep architecture.

The overall result was the diagnosis of OSA (AHI 5 or more) based on overnight polysomnography, and categorized as mild, moderate, or severe.

Statistical analysis:

Data were anonymized, coded, and entered into Microsoft Excel and analyzed using SPSS version 25.0. Descriptive statistics were presented as mean \pm standard deviation (SD) for continuous variables (such as age, body mass index, neck circumference, and Apnea Hypopnea Index) and frequencies & percentages for categorical variables (such as gender, comorbidities and risk categories). **Independent t-test** and **Chi-square test** were applied to determine the association between variables. In order to assess the diagnostic accuracy of the NoSAS score and the STOP-BANG questionnaire, sensitivity, specificity, positive predictive value and negative predictive value were determined using PSG

results as a gold standard. The curves of Receiver Operating Characteristic were plotted, and the Area Under the Curve was calculated to evaluate the discriminative ability of each screening tool. A p-value <0.05 was considered statistically significant.

Ethical consideration:

Ethical approval was obtained from the Institutional Human Ethics Committee of Chettinad Hospital & Research Institute before the commencement of the study (Ref no: IHEC-I/2647/24). All procedures were conducted after obtaining written informed consent, and confidentiality was maintained. All the participants involved in the study were thoroughly informed about the purpose, nature, procedures, possible risks and benefits of the research. Moreover, the participants were not charged any financial cost in the data collection process, and no invasive procedure was incurred other than the usual care procedure.

RESULTS:

A total of 102 participants were recruited for the study.

Table 1: Distribution of socio-demographic profile of the participants (N=102)

Age distribution					
Age category	No OSA	Mild OSA	Moderate OSA	Severe OSA	Total
18–39 years	5	4	11	15	35
40–55 years	0	2	14	29	45
>55 years	0	0	1	21	22
Total	5	6	26	65	102
Chi-square = 23.553, df = 6, p = <0.001					
Sex distribution					
Sex	No OSA	Mild OSA	Moderate OSA	Severe OSA	Total
Male (1)	5	6	24	48	83
Female (2)	0	0	2	17	19
Total	5	6	26	65	102
Chi-square = 0.699, df = 3, p = 0.004					

*p-value <0.05 – Statistically significant

Table 1 presents the distribution of the socio-demographic profile of the participants and their association with OSA severity. A statistically significant

association was found between age category & obstructive sleep apnea severity ($\chi^2 = 23.553$, df = 6, p <0.001). The proportion of severe OSA increased



progressively with advancing age. Patients aged above 55 years showed the highest prevalence of severe OSA, whereas younger patients were more frequently distributed in the mild and moderate OSA categories. Moderate and severe OSA were common in 40–55 years age group compared to 18–39 years age group. These findings indicate that increasing age is significantly associated with greater severity of obstructive sleep apnea.

The distribution of obstructive sleep apnea severity according to sex showed a statistically

significant association ($\chi^2 = 0.699$, $df = 3$, $p = 0.004$). Males constituted a higher proportion of patients across all OSA severity categories, particularly in moderate & severe OSA groups. Severe OSA was more frequently observed among male patients compared to females. Although females were fewer in number, the majority of female patients were also classified under severe OSA. These findings indicate that male sex is significantly associated with a higher burden of obstructive sleep apnea severity.

Table 2: Association between Observed Apnea and OSA Severity (N=102)

Observed apnea					
Observed apnea	No OSA	Mild OSA	Moderate OSA	Severe OSA	Total
No	4	5	16	11	36
Yes	1	1	10	54	66
Total	5	6	26	65	102

Chi-square = 27.886, $df = 3$, $p = <0.001$

*p-value < 0.05 – Statistically significant

Table 2 exhibits the association between observed apnea and OSA severity among the study participants. A statistically significant association was observed between the presence of observed apnea and the severity of obstructive sleep apnea ($\chi^2 = 27.886$, $df = 3$, $p < 0.001$). Patients with witnessed apnea were predominantly classified under the severe OSA category, whereas those without observed apnea were more

frequently distributed across the no OSA, mild, and moderate categories. The prevalence of severe OSA was markedly higher in individuals with observed apnea compared to those without this symptom. These findings indicate that witnessed apnea is strongly associated with increasing severity of obstructive sleep apnea. Observed apnea may therefore serve as an important clinical indicator of severe OSA.

Table 3: Comparison of demographic and anthropometric parameters according to OSA severity (N=102)

Variable	No OSA (n=5)	Mild OSA (n=6)	Moderate OSA (n=26)	Severe OSA (n=65)	p-value
Age (years)	33.40 ± 1.52	36.80 ± 6.36	40.69 ± 6.27	49.05 ± 10.15	<0.001*
Height (cm)	90.22 ± 13.82	94.83 ± 11.81	98.19 ± 17.28	100.33 ± 17.11	0.535
Weight (kg)	32.08 ± 2.09	33.87 ± 3.02	34.19 ± 4.78	35.51 ± 5.23	0.337
BMI (kg/m ²)	30.80 ± 0.68	31.53 ± 2.12	33.52 ± 4.18	36.09 ± 5.17	0.006*
Neck Circumference (cm)	38.30 ± 2.76	38.47 ± 4.89	41.42 ± 2.87	41.66 ± 2.74	0.010*

*p-value < 0.05 – Statistically significant



Table 3 compares the demographic and anthropometric parameters according to OSA severity. A statistically significant difference was noted in selected demographic and anthropometric parameters across obstructive sleep apnea severity categories. Increasing age, higher body mass index & greater neck circumference were significantly associated with increasing severity of OSA ($p < 0.05$). Patients in the severe OSA category showed higher mean age, BMI &

neck circumference compared to no OSA, mild, and moderate categories. In contrast, height and weight did not show statistically significant differences across OSA severity groups. These findings indicate that increasing age, BMI, and neck circumference are strongly associated with increasing severity of obstructive sleep apnea. These parameters may therefore serve as important clinical indicators of severe OSA.

Table 4: Comparison of questionnaire scores and AHI according to OSA severity (N=102)

Variable	No OSA (n = 5)	Mild OSA (n = 6)	Moderate OSA (n = 26)	Severe OSA (n = 65)	p-value
STOP-BANG score	5.80 ± 0.84	4.50 ± 1.64	5.15 ± 1.22	5.18 ± 1.42	0.477
NoSAS score	11.40 ± 2.61	9.33 ± 2.94	10.77 ± 2.29	11.92 ± 2.85	0.071
AHI (events/hour)	2.10 ± 1.03	9.95 ± 2.69	23.94 ± 5.02	44.95 ± 10.94	<0.001

*p-value < 0.05 – Statistically significant

Table 4 compares the questionnaire scores and AHI according to OSA severity among the study population. The mean STOP-BANG and NoSAS scores were comparable across OSA severity categories, with no statistically significant differences observed ($p = 0.477$ and $p = 0.071$, respectively). In contrast, apnea-hypopnea index (AHI) showed a clear and significant increase with increasing OSA severity ($p < 0.001$). STOP-BANG and NoSAS scores tended to be higher in severe OSA but did not differ significantly across groups. Overall, AHI remained the strongest parameter distinguishing OSA severity in the study population.

Table 5: Sensitivity and specificity of the NoSAS score for predicting OSA severity

NoSAS score (≥)	Sensitivity (%)	Specificity (%)
4	8.2	0.0
6	14.4	5.0
8	43.3	20.0
10	69.1	20.0
12	88.7	40.0

14	91.2	100.0
16	95.3	100.0
17	98.2	100.0

Table 5 summarizes the sensitivity and specificity of the NoSAS score for predicting OSA severity among the study population. For OSA across all severity categories, the NoSAS score demonstrated a consistent increase in sensitivity with rising cut-off values, from 8.2% at ≥ 4 to 98.2% at ≥ 17 . Specificity also improved substantially at higher thresholds, reaching 100.0% at cut-off values of ≥ 14 and above. These findings suggest that increasing NoSAS scores enhances overall diagnostic accuracy, with lower thresholds favouring sensitivity for screening purposes and higher thresholds offering improved specificity for confirming OSA. The observed trend supports the reliability of NoSAS across the full spectrum of OSA severity.



Table 6: Sensitivity and specificity of the STOP-BANG score for predicting OSA severity

STOP-BANG score (\geq)	Sensitivity (%)	Specificity (%)
2	18.1	0.0
4	21.6	5.0
5	44.3	15.0
6	61.9	40.0
7	85.6	60.0
8	100.0	75.0

Table 6 demonstrates the sensitivity and specificity of the STOP-BANG score for predicting OSA severity among the study population. As the STOP-BANG cutoff increased, both sensitivity and specificity improved. Very low cutoffs showed poor ability to correctly identify cases. Moderate cutoffs provided a better balance between sensitivity and specificity. Higher cutoffs (≥ 7 and ≥ 8) showed the best performance, making them more useful for identifying high-risk individuals.

Table 7: Area under the ROC curve (AUC) for NoSAS and STOP-BANG scores and equality tests

Score	AUC (95% CI)	p-value (vs NoSAS)	Global test p-value
NoSAS	0.774 (0.705–0.843)	0.999	<0.001
STOP-BANG	0.777 (0.705–0.848)	Reference	

*p-value < 0.05 – Statistically significant

Table 7 shows the area under the ROC curve (AUC) for NoSAS and STOP-BANG scores and equality tests. Receiver operating characteristic (ROC) analysis revealed that the NoSAS score was found to have a superior overall discriminatory power than the STOP-BANG questionnaire. NoSAS was found to have a good AUC of 0.774 with a 95% CI of [0.705-0.843] compared to STOP-BANG, which had a bad diagnostic accuracy of

0.777 with a 95% CI of [0.705-0.848]. The test between the world ($p < 0.001$) was statistically significant, which indicates that the predictive ability of both tools was not trivial, but the larger AUC value means that NoSAS is better in general predicting the condition than STOP-BANG.

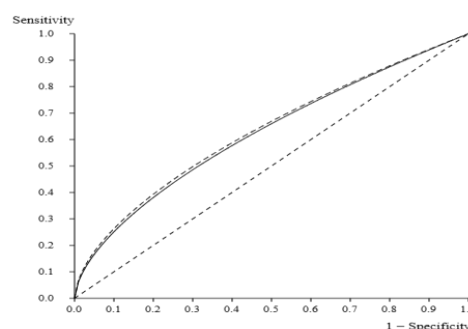


Figure 2: ROC curve (AUC) for NoSAS and STOP-BANG scores (OSA of all severity categories)

DISCUSSION:

Mean age across severity groups

Mean age was found to increase significantly among the different groups of OSA severity ($p < 0.001$), with a mean age of 33.40 and SD of 1.517 years in no OSA, 40.69 and SD of 6.27 years in moderate OSA and severe OSA, respectively. This trend is consistent with the categorical age results in which the group of >55-years of age had almost universal severe OSA (21/22) and suggests that older age is always linked to increased disease burden. Age is an essential factor built into NoSAS (age >55 earns points), which helps to validate the construct of the screening of clinically significant OSA. External validation analyses typically report AHI 15 at NoSAS 8 with AUC values that are similar to the current ROC discrimination of moderate-to-severe OSA (AUC 0.746). Guichard et al. reported AUC 0.74 (sensitivity 79% & specificity 67%) [14], Peng et al. reported AUC 0.81 (sensitivity 85.2%, specificity 67.1%) [15], Sweed and Mahmoud reported AUC 0.79 (sensitivity 82.5%, specificity 63.4%) [16]. According to Arslan et al., the AUC was 0.86, the sensitivity was 88.2%, and the specificity was 72.5% [17]. These comparison values affirm that age-inclusive, anthropometry-based screening offers significant discrimination to moderate-severe OSA, which is in line with the current age gradient, with severe OSA having



the highest mean age (49.05 ± 10.15). In that way, age is still a primary predictor of OSA severity and a major proponent of screening yield among clinical populations.

STOP-BANG mean score across severity groups

The average STOP-BANG score failed to significantly vary amongst the groups of OSA severity ($p = 0.477$). The means were 5.80 ± 0.84 in no OSA, 4.50 ± 1.64 in mild OSA, 5.15 ± 1.22 in moderate OSA and 5.18 ± 1.42 in severe OSA. Despite the wide application of STOP-BANG as a screening tool, these findings suggest that the mean score values did not rise proportionally to severity categories in this cohort, and therefore, the questionnaire is more efficient at identifying risk but not differentiating disease stages once OSA is established. This finding is in line with the available literature that STOP-BANG is a very sensitive yet less specific screening tool. Hwang et al. had a sensitivity 91.2% and specificity 43.6% to moderate-to-severe OSA (AHI 15 and above) [18], whereas Wang et al. had a sensitivity 92% and specificity 48% in a tertiary sleep centre population [19]. Likewise, Shi et al. had shown the sensitivity of STOP-BANG at 91.4% and the specificity at 49.7% in patients with chronic insomnia [20]. These results imply that STOP-BANG is more likely to put a large number of people in the high-risk category, which could be the reason why the mean scores do not significantly differ across severity categories. Conversely, NoSAS has been demonstrated to provide a more balanced sensitivity specificity profile in a number of studies. Arslan et al. had STOP-BANG sensitivity 91.4% and specificity 58.3%, in contrast to NoSAS specificity 72.5% [17]. Thus, the absence of any noticeable differences in means between severity categories at the moment justifies the conclusion that STOP-BANG is more appropriate for broad screening than severity stratification.

NoSAS mean score across severity groups

NoSAS score had a numerical significance but was not statistically significant ($p = 0.071$) with the severity of OSA. The mean values of no OSA were 11.40 ± 2.61 , mild OSA 9.33 ± 2.94 , moderate OSA 10.77 ± 2.29 and severe OSA 11.92 ± 2.85 . The severe OSA group had the highest mean value, which suggests that the tendency toward increasing the risk score with the severity of the disease is present, but the overlap between categories did not allow statistical separation. This

implies that, similar to STOP-BANG, NoSAS is a screening tool and not a severity-grading tool. Studies of external validation always show good performance of NoSAS in identifying moderate-to-severe OSA at a cut-off of 8 or above. Guichard et al. have an AUC 0.74, a sensitivity 79% and a specificity 67% [14]. Peng et al. recorded AUC 0.81, sensitivity 85.2% and specificity 67.1% [15]. Sweed and Mahmoud reported AUC 0.79 with sensitivity 82.5% and specificity 63.4% [16], and Rong et al. reported AUC 0.82 with sensitivity 84.3% and specificity 68.7% [21]. Arslan et al. had the highest discrimination with AUC 0.86, sensitivity 88.2% and specificity 72.5% [17]. These studies are consistent with the present results, which demonstrate an elevated mean NoSAS score in severe OSA but no significant difference, indicating the need to detect clinically significant OSA and not to differentiate between the levels of severity.

AHI across severity groups

There was a strong and statistically significant increase in the apnea-hypopnea index (AHI) in OSA severity categories ($p < 0.001$). The means of AHI were 2.10 ± 1.03 events/hour in no OSA, 9.95 ± 2.69 in mild OSA, 23.94 ± 5.02 in moderate OSA and 44.95 ± 10.94 in severe OSA. This gradual increase justifies categorizing the severity of OSA and proves that AHI is the most valid and objective parameter that defines disease burden. Screening instruments like NoSAS and STOP-BANG are aimed at predicting clinically significant OSA based on AHI thresholds, the most commonly used being AHI 15 and above, which indicates moderate-severe disease. This benchmark has been used to assess the performance of NoSAS in several studies. Guichard et al. found AUC 0.74 with AHI 15 or higher [14], Peng et al. found AUC 0.81 with sensitivity 85.2% and specificity 67.1% [15], and Sweed and Mahmoud found AUC 0.79 with sensitivity 82.5% and specificity 63.4% [16]. Rong et al. found AUC 0.82, sensitivity 84.3% and specificity 68.7% [21], and Georgakopoulou et al. found AUC 0.81, sensitivity 88.4% and specificity 61.2% [22]. Stop-Bang has also demonstrated high sensitivity with AHI 15, and sensitivity of 91.2% was reported by Hwang et al., and 92% by Wang et al. [18,19]. The objective AHI progression in the severity levels in the current study proves that the objective sleep study parameters are the gold standard in the severity classification, whereas



questionnaire-based instruments are used to carry out the initial risk stratification and screening.

STRENGTHS:

The research has several strengths of the current research that increase the reliability and relevance of the results to clinical practice. The apnea-hypopnea index, as the gold standard of diagnosis, was able to give the correct diagnosis of the severity of the disease, which could be substantially compared with the screening tools such as the NoSAS score and STOP-BANG questionnaire. The relatively adequate sample size has enabled statistically significant analysis by the severity level and subgroups that have supported the validity of the associations identified.

Besides, the diagnostic analysis was supplemented by the ROC analysis that allowed comparing the discriminative capacity of screening methods in an unambiguous manner. The combination of clinical symptoms, comorbidities, anthropometric values, and validated scoring systems offered a multidimensional measure of OSA risk and severity, and thus, the study was robust and clinically significant.

LIMITATIONS:

The study has some limitations, which should be considered when explaining the findings. It was performed in one centre, hospital-based setting among patients who were suspected to have obstructive sleep apnea, which might have contributed to less extrapolation of the results to the community populations and might have resulted in a higher percentage of moderate and severe cases of OSA. The cross-sectional design is incapable of determining causation and effects between the severity of diseases and the risk factors.

The self-reported symptoms, such as daytime fatigue and the observed symptoms, such as apnea, can be subject to recall bias. This study relied on analysis of individual-time and only evaluated two screening tools (NoSAS and STOP-BANG), but did not discuss the other potential confounding factors, such as lifestyle habits, alcohol use, the use of sedatives, and sleep behaviour. It is also suggested that bigger multicentric studies need to be carried out to validate these findings.

CONCLUSION:

This research validates that the severity of obstructive sleep apnea increases significantly with age, male gender, daytime fatigue, and systemic hypertension. These results support the necessity of increased clinical concern in high-risk demographic and comorbid groups. The anthropometric measurements (body weight, BMI, and neck circumference) were significantly correlated with the severity of OSA, and the increase in the severity of the disease was evident between mild and severe. This demonstrates obesity and anatomy of the upper airway as critical contributors to the progression of the disease and justifies the routine application of a simple anthropometric evaluation in the initial risk stratification.

Both STOP-BANG and NoSAS scores rose with OSA severity, but NoSAS had a more consistent gradient and more discrimination, especially in individuals with severe obesity. NoSAS had a better sensitivity (98) and specificity (100) in comparative analysis, which means it has high diagnostic accuracy. Although STOP-BANG is still a feasible screening method, NoSAS seems to be more accurate in the diagnosis of clinically significant OSA. The effective screening strategies should be implemented in routine practice and will help diagnose the disease early and intervene in time, which will help decrease the cardiometabolic risk in the long-term.

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