Original Article

Diagnosis of Obstructive Sleep Apnea

# Validation of Screening Tools and Comparison of Anthropometric Characteristics in Diagnosis of Obstructive Sleep Apnea

**Saima Akhter, Nausheen Saifullah, Fatima Zaina, Noureen Durrani and Mirza Saifullah Baig**

## ABSTRACT

**Objective:** To determine the validity and also compare screening questionnaires and anthropometric characteristics in diagnosis of obstructive sleep apnea in Pakistani population.

**Study Design:** Cross-sectional study

**Place and Duration of Study:** This study was conducted at the Department of Pulmonology, Jinnah Postgraduate Medical Center Karachi from January 2019 to December 2019.

**Materials and Methods:** Sixty-nine patients came for sleep study and underwent Polysomnography. Apnea Hypopnea Index ≥5 was considered as positive for OSA.

**Results:** Forty-one (59.42%) were males and 28 (40.58%) were females with average age of 49.71±10.67 years. All patients underwent PSG and 60 (86.96%) were diagnosed positive for OSA. Patients' anthropometric characteristics and all four questionnaires were not significantly different among OSA positive and negative except neck circumference (p=0.009). ROC curve showed that the highest AUC was observed for NC which was 0.741 (95% CI: 0.541–0.940, p=0.018) and the optimal cut-off value was ≥40cm. The lowest AUC was 0.522 (95% CI: 0.408–0.635, p=0.701) for Berlin questionnaire. AUC determined for all screening tools excluding NC depicted poor predictive ability of these tests and these tests were not good in discriminating the OSA positive and OSA negative patients.

**Conclusion:** Neck circumference was independent screening tool to predict OSA. Interestingly screening questionnaires BQ, ESS, SBQ and Mod-ESS are not accurate tool for prediction of OSA in our population.

**Key Words:** Berlin questionnaire, Epworth Sleepiness Scale, Modified Epworth Sleepiness Scale, Neck Circumference, Obstructive sleep apnea.

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## INTRODUCTION

Obstructive sleep apnea (OSA) is a frequent medical condition and sleep disorder characterized by recurrent events of either complete or partial and both collapse of upper airways (particularly in oropharyngeal tract) resulting in reduction/cessation of the airflow.

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Approximately 2–4% adult population is affected by OSA and middle-aged men are more frequently affected.[1] The reported OSA prevalence in India is around 13.74%.[2] In Bangladesh, the OSA prevalence in men and women was 17.3% and 6.25% respectively.[3] Hypopnea and apnea appear during sleep, as a result most of the patients are unaware of the condition and about 80% of the patients with OSA of moderate to severe degree remain undiagnosed and hence untreated.[4]

Literature demonstrates obesity as one of the major predictive risk factors of OSA. Several anthropometric measures are used to grade obesity including body mass index, hip circumference, abdominal circumference, neck circumference and modified Mallampati Index. The point of interest is to determine which of these parameters are better in detecting obesity. OSA patients may be mostly asymptomatic[5,6] but are associated with major health related problems which include cardiovascular diseases, glucose intolerance, premature death, cerebrovascular and motor vehicle accidents, decreased functional ability, type 2 diabetes, impotence and nocturnal arrhythmias.[7,8] Thus as a matter of fact, timely screening of OSA patients has utmost

importance in avoiding the associated public health issues.

The gold standard to diagnose OSA is polysomnography (PSG) which is non-invasive technique and monitor multiple physiological variables such as eye movement, electroencephalography, muscle tone, airflow, oxygen saturation and respiratory effort.[9] However, PSG is non-affordable, complex and time consuming procedure which requires highly skilled personnel. Since the gold standard to diagnose PSG is unaffordable and inaccessible for all patients, thus many screening questionnaires such as Epworth sleepiness scale (ESS)[10], Stop-Bang questionnaire (SBQ)[11], Berlin questionnaire (BQ)[12] have been developed as a part of pre-selection process.

In our local settings, it is practically difficult to recommend to PSG due to affordability issue to every patient which yields the need of some scoring tool to triage the patient. To the best of our knowledge, no study has been conducted in Pakistan yet to validate SBQ and BQ in our local population. Therefore, the current study was aimed to determine the validity of screening questionnaires and compare anthropometric characteristics in classification of obstructive sleep apnea in our population.

# MATERIALS AND METHODS

This cross-sectional study was conducted at Jinnah Postgraduate Medical Center from 1st January 2019 to 31st December 2019. Sixty-nine patients referred to Pulmonology Department of JPMC who were advised to visit sleep clinic were recruited into the study. Patients of any gender and age of 18 years or above and referred for sleep studies were included into the study. Patients with previous history of chronic obstructive pulmonary disease and/or asthma, were excluded from the study. Patients with neurological and muscular disorder were also excluded.

Patients' demographic (age in years and gender) and anthropometric data including height (in meter), weight (in Kg), body mass index (in $kg/m^2$), neck circumference (in cm), were documented in pre-designed proforma. Body mass index was determined by dividing weight with square of height. Measurement for neck circumference (NC) was made at midway of the neck i.e. just below Adam's apple along a parallel line with one decimal place observation. Threshold of more than 40cm was used to label patient as high risk for OSA. Attending physician filled three screening questionnaires before performing sleep study.

All patients underwent PSG. The standard diagnostic computerized PSG was performed American Association of Sleep Medicine guidelines were followed for scoring of sleep stage.[13] Apnea Hypopnea Index (AHI) index was determined as number of apnea and/or hypopneas per hour of total sleep time. OSA was defined on basis of AHI index. AHI<5 was considered as OSA free patients whereas OSA was considered for AHI≥5.

**Berlin Questionnaire:** Berlin questionnaire was developed in 1999 and has ten items and three categories. First category is related to snoring and comprises of first 5 questions. First category is taken as positive if total score is ≥2 points. Second category is related to daytime sleepiness and fatigue and includes Q6, 7 & 8. Second category is positive if total score is ≥2 points. Third category is about hypertension and body mass index which is considered positive either patients is hypertensive or BMI is higher than $30kg/m^2$. Patients are labeled as high risk for OSA if at least 2 categories are positive otherwise low risk.[12]

**Stop-Bang Questionnaire:** Stop-bang questionnaire is an eight items tool of which four items are subjective which includes snoring, tiredness, observed apnea and high blood pressure (STOP) and four are demographic including BMI, age, neck circumference and gender (BANG). Patients were classified as high risk for score ≥3 otherwise low risk.[11]

**Epworth Sleepiness Scale:** Epworth sleepiness scale is a tool for measuring daytime sleepiness that contains total 8 items with score of 0-3 for each question. ESS score ranges from 0 to 24. Patients were labeled OSA high risk for score >10.[10]

**Modified Epworth Sleepiness Scale:** Modified Epworth sleepiness scale is modified form of ESS. BMI and NC were added in addition to ESS to determine modified ESS. Patient was considered high risk for OSA if ESS>10 and BMI>$35kg/m^2$ and NC>40cm.[14]

Qualitative variables were summarized in terms of frequency and percentage. Mean ± standard deviation or median and inter-quartile range was used to summarize quantitative variables based on assumption of normality. Shapiro-Wilk test was used to test the assumption of normality. Independent t-test or Mann-Whitney U test was used to compare continuous variables among OSA positive and OSA negative patients. Chi-square or Fisher Exact test was used to compare categorical variables among disease positive and disease free patients. Diagnostic accuracy of screening tools was determined using sensitivity, specificity, positive predictive value, negative predictive value and 95% confidence intervals for these parameters were also computed. Area under the curve was determined for screening tools using receiver operating characteristic curve to determine their classification ability. P-value <0.05 was taken as statistically significant. Stata version 14 was used to perform data analysis.

# RESULTS

Sixty (86.96%) patients were labeled positive for obstructive sleep apnea whereas 9 (13.04%) were identified as negative for OSA using gold standard. Overall average age of the study participant was 49.71

± 10.67 years. Most of the study participants were male (n=41, 59.42%). The two groups of patients didn't differ based on age (p=0.078), BMI (p=0.068), hip to waist ratio (p=0.90), and gender (p=0.144). Average NC was significantly higher in OSA positive patients as compared to OSA free patients (p=0.009). Frequency of high risk for OSA using all four tools was also not statistically different among two groups (Table 1).

BQ identified total 64(92.8%) patients as high risk to develop OSA yielding the sensitivity and specificity of 93.33% and 11.11% respectively. Using cut-off of ≥3 for OSA high risk patients, Stop-Bang questionnaire predicted 67(97.1%) patients as high risk for OSA with sensitivity and specificity of 98.33% and 11.11% respectively. 52(75.4%) patients were categorized as high risk for OSA using ESS at cut-off >10. 78.33% and 44.44% was sensitivity and specificity respectively. Only 29(42%) patients were predicted as high risk for OSA by MESS with sensitivity and specificity of 45% and 77.78% respectively. Sensitivity and specificity for NC against the threshold more than 40cm for high risk of OSA was 80% and 66.67% respectively (Table 2).

Area under the curve was also calculated to determine the predictive ability of the screening tools. The highest AUC was observed for NC which was 0.741 (95% CI: 0.541–0.940, p=0.018) which shows good discrimination ability of NC. Optimal cut-off value of NC for identifying high risk OSA patients was 40cm and above. The lowest AUC was 0.522 (95% CI: 0.408–0.635, p=0.701) for Berlin questionnaire. The AUC determined for all screening tools excluding NC depicted poor predictive ability of these tests and these tests were not good in discriminating the OSA positive and OSA negative patients (Fig. 1).

**Table No.1: Patients' characteristics with OSA**

| Patients' Characteristics | OSA Present (n = 60 ) Mean±SD OR No. (%) | OSA Absent (n = 9) Mean±SD OR No. (%) | p-value |
|---|---|---|---|
| Age (years) | 48.83±10.99 | 55.56±5.61 | 0.078 |
| Gender (male) | 38 (92.7%) | 3 (7.3) | ǂ0.144 |
| BMI (kg/m$^2$) | 38.78±7.21 | 33.82± 9.17 | 0.068 |
| Hip to waist ratio (cm)# | 0.95 (0.93-0.98) | 0.94 (0.92-1.03) | 0.893 |
| Neck circumference(cm) | 43.77± 4.19 | 39.73±4.45 | *0.009 |
| Berlin (high risk) | 56 (87.5) | 8 (12.5) | ǂ0.514 |
| Stop-Bang (high risk) | 59 (88.1) | 8 (11.9) | ǂ0.246 |
| ESS (high risk) | 47 (45.2) | 5 (6.8) | ǂ0.209 |
| MESS (high risk) | 27 (25.2) | 2 (3.8) | ǂ0.285 |

#:non-normally distributed variable expressed as median (Inter-quartile range) ǂ:Fisher-Exact test is reported *P-value <0.05

**Table No.2: Diagnostic Accuracy of Berlin Questionnaire, Stop-Bang questionnaire, ESS, MESS & Neck circumference against gold standard**

| Variable | Sensitivity (95% CI) | Specificity (95% CI) | PPV (95% CI) | NPV (95% CI) | AUC (95% CI) | p-value |
|---|---|---|---|---|---|---|
| Berlin questionnaire | 93.33 (83.80–98.15) | 11.11 (0.28–48.25) | 87.50 (76.85–94.45) | 20.00 (0.51–71.64) | 0.522 (0.408–0.635) | 0.701 |
| Stop Bang questionnaire | 98.33 (91.06–99.96) | 11.11 (0.28–48.25) | 88.06 (77.82-94.70) | 50 (1.26–98.74) | 0.554 (0.350–0.758) | 0.606 |
| MESS | 45 (32.12–58.39) | 77.78 (39.99–97.19) | 93.10 (77.23–99.15) | 17.50 (7.34–32.78) | 0.614 (0.456–0.771) | 0.156 |
| ESS | 78.33 (65.80–87.93) | 44.44 (13.70–78.80) | 90.38 (78.97–96.80) | 23.53 (6.81–49.90) | 0.619 (0.391–0.846) | 0.308 |
| Neck circumference | 80 (67.67–89.22) | 66.67 (29.93–92.51) | 94.11 (83.76–98.77) | 33.33 (13.34–59.01) | 0.741 (0.541–0.940) | 0.018 |

PPV - Positive predictive value, NPV - Negative predictive value, AUC – Area under the curve.

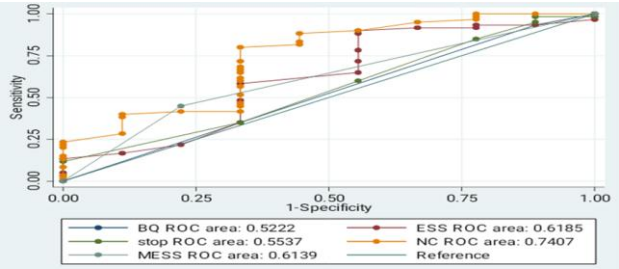


**Figure 1: Receiver Operating Characteristic Curve (ROC) for Berlin questionnaire (BQ), Stop-Bang questionnaire (STOP), Epworth Sleepiness Scale (ESS), Modified Epworth Sleepiness Scale (MESS) and Neck circumference (NC).**

# DISCUSSION

In the current study highly suspected OSA patients were recruited and 86.96% of them actually had positive OSA diagnosis as determined by PSG. Among all patients' characteristics, only neck circumference was significantly different between patients with and without OSA. However, various researcher in previous studies observed that age[8,15] gender distribution[8,16], body mass index[8,15] and neck circumference[15,16] were significantly different among patients with and without OSA.

The current study validated the use of BQ, SBQ, ESS, MESS and NC in screening of high risk OSA patients. Three screening questionnaire BQ, ESS and MESS were not identified as reliable screening tool to detect presence of OSA. Similar to the present study, previous studies conducted in Asia, also reported the unreliability of BQ in predicting OSA.[17,18] A study conducted in Singapore concluded that BQ was sensitive screening tool when applied in general population and was good in discriminating OSA patient for AHI ≥30. In the same study it was also documented that discrimination ability was moderate when BQ was used for AHI ≥15.[19] It appears that reliability of screening questionnaire dependents on both patients' characteristics and AHI diagnostic threshold values.[20,21]

We observed the high sensitivity and low specificity of SBQ while discrimination ability on ROC was not good (55.4%). Highly suspicious OSA patients were enrolled into the study that might be the reason for high sensitivity and low specificity. In contrast to the current study, multiple researchers validated the use of SBQ on OSA suspected patients and identified SBQ as good screening tool.[22,23] The discrimination ability of ESS in our study for detecting OSA patients was poor which was consistent with other studies.[23,24]

MESS used in the study is updated version of ESS in which BMI and NC were added. This screening tool had low sensitivity and specificity was high but area under the curve indicated that tool was not sufficient in detecting high risk OSA patients. Hence adding BMI and NC in ESS didn't make any significant improvement in its predictive ability. A study was conducted in Pakistan in which accuracy of ESS and MESS was compared and researcher found that MESS was better in identifying OSA patients than ESS. However, the conclusion was made based on sensitivity, specificity, PPV and NPV. The author didn't determine and compare the predictive ability in terms of area under the curve for the two screening tools which makes the study findings arguable.[14]

In the current study, only NC was identified as good predictive marker with fair area under the curve (74.1%). It is documented in literature that NC reflects upper body obesity and is considered to be a better marker than BMI for OSA.[25] A study conducted in Asia also reported that neck circumference is useful indicator for prediction of OSA presence and its severity in snoring patients.[16]

The present study aimed to identify the best screening tool to predict OSA in Pakistani population. In the current study, highly suspicious patients were recruited into the study that either visited or referred for sleep study. The study didn't reflect features of general population. The study findings could be affected by change of study population. Moreover, the study evaluated the predictive abilities of the screening tool against only AHI ≥5 which is also one of limitations of the study. Therefore, to further confirm the findings of the present study, it is recommended to the replicate the present study in Pakistan but on general population with accuracy assessment of screening tools against different threshold of AHI.

# CONCLUSION

The study shows we could not use these three screening for prediction in Pakistani Population and consideration must be given to anthropometric features for better understanding of disease.

**Author's Contribution:**

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|---|---|
| Concept & Design of Study: | Saima Akhter |
| Drafting: | Nausheen Saifullah, Fatima Zaina |
| Data Analysis: | Noureen Durrani, Mirza Saifullah Baig |
| Revisiting Critically: | Saima Akhter, Nausheen Saifullah |
| Final Approval of version: | Saima Akhter |

**Conflict of Interest:** The study has no conflict of interest to declare by any author.

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