Original Research Article

Relationship of Neck circumference and Obstructive Sleep Apnea: A cross-sectional study in Pakistani Population

ABSTRACT

Objective: This study aimed to determine the reliability of neck circumference in comparison to BMI for a measure of Obstructive Sleep Apnea and determine the interaction between neck circumference and the severity of apnea in the Pakistani adult population.

Materials and Methods: A total of 306 subjects, were recruited retrospectively for the cross-sectional research in the Department of Pulmonary Vascular and Sleep Disorders in Dow University Hospital, Karachi. We reviewed the hospital records to evaluate the BMI, neck circumference, and AHI from June 2018 to February 2022 by non-Random Purposive sampling. The patients 1) who were adults with age more than 18 years and 2) patients with obstructive sleep apnea who were diagnosed through the Polysomnography test were included. IBM SPSS statistics 25 was used for data analysis. Statistical significance was considered as a p-value <0.05.

Results: The average age was 52.3 ± 11.4 years. Results showed that sleep apnea was found to be more prevalent and severe in males than in females. Increased neck circumference is associated with the severity of sleep apnea and is found to be significant in male subjects (p=0.018) but not in females (0.577). The neck circumference and the BMI had a statistically significant relationship among the male group and female group (p=0.006 and p=<0.001) which shows that individually neck circumference is not a significant risk factor to diagnose OSA. In multivariate regression, we found a strong association between obesity (OR: 4.3; 95% CI: 2.03-9.38; p-value: 0.00) and males (OR: 2.3; 95% CI: 1.41-3.73; p-value: 0.001) among obstructive sleep apnea patients.

Conclusion: In conclusion, the individuals who have large neck circumference have raised BMI, and the traditional indicators for instance males, older age, and BMI were associated with OSA but a larger neck circumference as an independent element was not linked to OSA. In addition, the correlation of large necks with OSA is found to be significant in male subjects but not in females.

Keywords: Neck circumference (NC), obesity, Obstructive Sleep Apnea (OSA), Body Mass Index (BMI), Pakistani population.

1. INTRODUCTION

Obstructive sleep apnea (OSA) is commonly attributable to the intermittent cessation of the upper respiratory tract while sleeping, nocturnal hypoxemia, and excessive daytime sleepiness [**Error! Reference source not found.**]. The symptoms such as morning headaches, nocturia, choking or gasping for air, and restless sleep can cause a significant deterioration

in social or occupational accomplishments [**Error! Reference source not found.**]. In general, adequate sleep quantity and quality are considered to be necessary for keeping us fully awake, focused, and active all through the day [**Error! Reference source not found.**]. Furthermore, people with OSA have a risk of high blood pressure, heart disease, diabetes mellitus, stroke, and psychological and mental health disorders [**Error! Reference source not found.**]. Thus, initial diagnosis and prompt therapy of OSA are necessary. The standard method for identifying the existence of OSA and its treatment is Polysomnography (PSG) [**Error! Reference source not found.**]. Although Polysomnography is an expensive treatment with time-consuming and has lack availability in hospitals, it is necessary to understand the other possible factors for the identification of OSA. The Epworth sleepiness scale (ESS) was intended to evaluate the possibility of daytime somnolence which is considered a tool to identify OSA [9].

Obesity is a leading cause of OSA and it's directly linked with the OSA severity [**Error! Reference source not found.**]. Neck circumference is another physical feature that promotes the pathogenesis of OSA [**Error! Reference source not found.**]. Neck circumference has been characterized as a reliable assessment tool for obesity and OSA, and it has been shown to correspond well with other anthropometric measures. In males, a neck size of 43 cm or more, or in females, a neck size of 40 cm or more, may be most at risk for obstructive sleep apnea [**Error! Reference source not found.**]. In light of these risk factors, it is feasible to decide whom patients ought to need for going through Polysomnography. Previous research studies showed that a thick neck was a possible factor that led to severe OSA and the utmost dominant predicting element for OSA [**Error! Reference source not found.**][**Error! Reference source not found.**]. On the contrary, some studies suggest that a wide neck was not associated with OSA [**Error! Reference source not found.**][**Error! Reference source not found.**]. Additionally, BMI and neck circumference are correlated with each other and both are the most enormously used indicator for obesity [**Error! Reference source not found.**]. Neck circumferences measurements help determine OSA risk in people with type 2 diabetes [31].

Hence, this study aimed to determine the reliability of neck circumference in comparison to BMI for a measure of Obstructive Sleep Apnea in our Pakistani Population and determine the interaction between neck circumference and the severity of apnea in the Pakistani adult population.

2. MATERIAL AND METHODS

Total samples of 306 subjects were recruited retrospectively for the cross-sectional study which was managed in the Department of Pulmonary Vascular and Sleep Disorders in Dow University Hospital, Karachi. We reviewed the hospital records for the participants from June 2018 to February 2022. Individuals who participated in the study were included by the non-Random Purposive sampling with informed written consent and the investigation was initiated after getting acceptance from the ethical review board of the University. The inclusion criteria were the patients 1) who were adults with age more than 18 years and 2) patients with obstructive sleep apnea who were diagnosed through the Polysomnography test in the Sleep lab. The exclusion criteria were the patient 1) who have undergone or previously has taken the OSA treatment 2) who have thyroid problems 3) and women who were pregnant.

The Apnea-Hypopnea Index was evaluated through the Polysomnography database, and the Body-Mass Index and the neck circumference were recorded through the records of anthropometric measurements. The Sleep technologists analyzed the anthropometric measurements and the severity of apnea through Polysomnography. AHI was assessed by the number of hypopneas and apneas divided by total sleep time. The Apnea-Hypopnea Index of more than five episodes in an hour was used to diagnose OSA. We classify the chronicity of OSA based on AHI and categorized it into three groups: Mild: AHI ≥5 to ≤15, Moderate: AHI ≥15 to <30, and severe: AHI ≥30. Anthropometric measurements were recorded on the scheduled night of Polysomnography. Height in centimeters was observed through a stadiometer. Weight in kilograms was measured with a weight machine. The BMI was computed as the weight in kilograms and height in square meters (kg/m^2).

As per WHO guidelines, the Body Mass Index is classified into following categories: Underweight: <18.5 kg/m^2, Normal weight: 18.5 to <25.0 kg/m^2, overweight: 25.0 to <30 kg/m^2 and obese: ≥30 kg/m^2 [**Error! Reference source not found.**]. With the participants standing upright, NC was measured, in centimeters using non-stretchable plastic tape in the middle of the neck, between the mid-cervical spine and the mid of the anterior neck, to within 1 mm, just beneath Adam's apple [**Error! Reference source not found.**]. Neck circumference was used to predict sleep apnea.

2.1 Data Analysis

IBM SPSS statistics 25 was used to perform the data analysis. To define the descriptive data, continuous variables such as neck circumference, BMI, AHI, and age were calculated by means and standard deviation, and categorical variables i.e. Ranges of neck circumference, the severity of apnea, and categories of BMI were measured through frequencies and percentages. Fisher Exact test and the Chi-square were used for the calculation of categorical variables, whereas, the t-test was used for numerical variables. Statistical significance was considered as a p-value <0.05 in entire calculations. The independent factors that were found to correlate with the severity of obstructive sleep apnea at a p-value of ≤0.20 on

Univariate linear regression analysis and the significant biological variables were taken into multivariate analysis. The variables were selected by using backward deletion criteria.

3. RESULTS AND DISCUSSION

A total of three hundred and six OSA patients fulfilled the inclusion and exclusion criteria, from which one hundred and sixty were males and one hundred and forty-six were females. The average age was 50.3 ± 12.2 years in males and 54.5 ± 10.0 years in females. The average BMI was 34.6 ± 5.7 kg/m^2 in males and 44.3 ± 3.4 kg/m^2 in females. In addition, the mean neck circumference was 44.3 ± 3.4 cm in males and 41.4 ± 3.4 cm in females. Both are statistically significant. AHI is relatively higher in males as compared to females. Baseline anthropometric measurements are given in Table 1.

Table 1. Means of clinical factors among OSA Patients in males and females.

Clinical Variables	Male (n=160) Mean ± SD	Female (n=146) Mean ± SD	Total (n=306) Mean ± SD	P-value
Age (years)	50.3 ± 12.2	54.5 ± 10.0	52.3 ± 11.4	*0.001*
BMI (kg/m^2)	34.6 ± 5.7	40.5 ± 8.2	37.4 ± 7.6	*<0.001*
Neck circumference(cm)	44.3 ± 3.4	41.1 ± 3.4	42.7 ± 3.7	*<0.001*
AHI (events/hr.)	40.5 ± 21.2	34.4 ± 20.7	37.6 ± 21.2	*0.01*

**BMI= Body Mass Index, AHI= Apnea-Hypopnea Index.*

Table 2 illustrates the comparison of the neck circumference categories and the severity of apnea in OSA patients. We observed that sleep apnea was found to be more prevalent and severe in men (p=0.02) and not in women (p = 0.58). Of the 160 male patients, 18 patients had mild OSA, and from them, 100% of patients had a neck circumference >39.5 cm. Similarly, 43 patients had moderate OSA, and of them, 91% patients had a neck circumference >39.5 cm and only 9% patients had < 37 cm. Moreover, 99 male patients had severe OSA, and 95% of patients have a thick neck of >39.5 cm. Whereas from one hundred and forty-six female OSA patients, 25 patients have mild OSA and from them, 84% of OSA females had a thick neck of >36.5 cm, 50 OSA females have moderate OSA and 86% had a neck circumference >36.5, and out of 99 females who have Severe OSA, 92% showed neck with >36.5 cm The correlation of increasing neck circumference with the severity of Apnea-Hypopnea Index is found to be significant in male subjects but not in females.

Table 2. Classification of AHI and NC in OSA Patients.

Neck Circumference	***Severity of Apnea***			***p-value***
Men (n=160)	**Mild (n=18) %**	**Moderate (n=43)%**	**Severe (n=99)%**	
< 37	0 (0)	4 (9.3)	0 (0)	
37-39.5	0 (0)	0 (0)	5 (5.1)	*0.02*
>39.5	18 (100)	39 (90.7)	94 (94.9)	
Women (n=146)	**Mild (n=25) %**	**Moderate(n=50)%**	**Severe (n=71)%**	
<34	1(4)	2(4)	3(4.2)	
34 – 36.5	3(12)	5(10)	3(4.2)	*0.58*
>36.5	21(84)	43(86)	65(91.5)	

Table 3 shows the correlation between neck circumference and BMI. In males, 93% of overweight and 96% of obese patients had a thick neck circumference of more than 39.5 cm. The p-value is significant which 0.006 is. Similarly, in

females, of 146 OSA patients, 138 were obese and 91% of females had a thick neck of >36.5 cm showing a marked relationship between the neck circumference and BMI (p=0.00).

Table 3. Classification of BMI and NC in OSA Patients

Neck Circumference	***Categories of BMI***			***p-value***
Men (n=160)	**Normal (n=04) %**	**Overweight (n=28)%**	**Obese (n=128)%**	
< 37	2 (50)	1 (3.6)	1 (0.8)	
37-39.5	0 (0)	1 (3.6)	4(3.1)	*0.006*
>39.5	2 (50)	26 (92.9)	123(96.1)	
Women (n=146)	**Normal (n=02) %**	**Overweight (n=06)%**	**Obese (n=138)%**	
<34	1(50)	1(16.7)	4(2.9)	
34 – 36.5	1(50)	2(33.3)	8(5.8)	*0.00*
>36.5	0(0)	3(50)	126(91.3)	

The results of Univariate regression show a significant relationship between OSA with age, obesity, large neck circumference, and gender. After the backward deletion in multivariate regression, we found a strong association between obesity (OR: 4.3; 95% CI: 2.03-9.38; p-value: 0.00) and males (OR: 2.3; 95% CI: 1.41-3.73; p-value: 0.001) among obstructive sleep apnea patients.

Table 4. Univariate and Multivariate Regression to analyze the association of independent variables with the severity of OSA

Variables	***OR***	***95% CI***	***P-value***
	Univariate		
Age	1.0	0.97-1.01	0.473
Obese*(1)	3.3	1.61-6.79	*0.001*
Large Neck Circumference**(1)	0.5	0.23-1.20	0.12
Males(1)	1.8	1.15-2.85	*0.01*
	Multivariate		

Obese(1)	4.3	2.03-9.38	*0.00*
Males(1)	2.3	1.41-3.73	*0.001*

Obese*: BMI≥30 kg/m^2,

Large Neck Circumference**: males >39.5 cm, females > 36.5 cm

OR=Odds Ratio, CI = Confidence Interval

DISCUSSION

The most common predictor which is the neck circumference was not solely linked with OSA diagnosis [**Error! Reference source not found.**][**Error! Reference source not found.**], and, therefore, large neck circumference may not be clinically effective for OSA. In addition, the Univariate regression in our study also indicates that neck circumference has not been significantly associated with the severity of OSA (OR: 0519; 95% CI: 0.23-1.20; p-value=0.12). The results of multivariate regression in our study also demonstrate that patients with obesity have a 4.3 times greater risk of getting severe OSA and males are at a much higher risk of severe OSA than females. On the contrary, Eun Kim et al found that in Asian patients of snoring, the severity of OSA can be predicted through the neck circumference and the results of multiple logistic regression revealed that the thick neck was an absolute factor and indicator for Obstructive sleep apnea (r= 0.42, p<0.0001).[**Error! Reference source not found.**]. The significant aspect of our study was found that a thick neck and increased BMI were the risk factors that led to OSA; however, NC was not the best feature that predicts the occurrence and severity of OSA without Raised BMI in our population. Moreover, we observed that there was an intense relationship between the AHI and the neck circumference in males but not in females, and also shows more association of neck circumference with the BMI than OSA.

Aging is a health factor of risk for OSA [**Error! Reference source not found.**]. Doubtlessly, our data had a high mean age in both genders with almost 52.3 with a standard deviation of 11.4, and we found major effects of age on OSA (p=<0.001). The average age shows that the OSA is more prevalent in older age patients. Another study found that age was independently associated with OSA, while neck circumference and weight surge with age [**Error! Reference source not found.**].

Many researchers observed that a thick neck was a prognostic of OSA in the global population [**Error! Reference source not found.**][**Error! Reference source not found.**][**Error! Reference source not found.**]. However, in the Pakistani population, NC was not a significant indicator of OSA. The Pakistani population can be different from the global population due to their diet which requires more research to be done. The reference ranges of neck circumference that predict OSA are >39.5cm in males and >36.5 cm in females. And, the mean neck circumference in our cohort was 44.3 and 41.1 in males and females respectively which also leads to Obstructive sleep apnea. In males, some patients have moderate and severe OSA with thin necks, whereas 96% of obese patients have large neck circumference and 93% of overweight patients have also large necks showing a strong interrelation between the NC and the BMI instead of sleep apnea. Similarly in females, large neck circumference is also linked with increased BMI (p<0.001) and is not related to the severity of apnea (p=0.577). In addition, BMI is an important factor that raised the fat accumulation in the neck which may lead to OSA [**Error! Reference source not found.**].

Even though the direct involvement of NC in the progression of OSA has yet not been clarified, it has been described as a substitute indicator of central obesity [**Error! Reference source not found.**] and has been characterized to be a useful determinant of OSA [**Error! Reference source not found.**]. Obesity and OSA are intimately associated. Obesity tends to entail a mechanical feature, such as the impact of fat accumulation on the upper airway, in the induction of OSA [**Error! Reference source not found.**][**Error! Reference source not found.**].

The strength of our research is that we use the gold standard method for OSA detection, whereas, many other studies found the OSA patients through the Epworth Sleepiness score and the other signs and symptoms of OSA. Furthermore, the participants of the study are only Pakistani and we developed OSA predictors in our population. Our research was strengthened to rule out substantial differences in NC and BMI in the OSA diagnosis. This research adds to our knowledge that the circumference of the neck is not related directly to the diagnosis of OSA.

There are some limitations to our research. First, this was a cross-sectional study and we could not able to evaluate the confirmed effects of NC on OSA, so the cohort study will be necessary to rule out. Second, we only selected the patients from the sleep clinic and the sample didn't imitate the characteristics of the general population. Third, for the participants who have thick neck circumference with low BMI and still have OSA, we did not rule out the morphology of neck structures that are responsible for the stenosis of upper airways such as the inflamed tonsils, extravagant uvula, or the soft palate, etc., which might affect the OSA incidence.

4. CONCLUSION

In conclusion, there is a significant association between BMI and the neck circumference in both males and females with Obstructive sleep apnea, and the traditional indicators for instance males, older age, and BMI were associated with OSA but a larger neck circumference as an independent element was not linked to OSA. In addition, the correlation of large necks with OSA is found to be significant in male subjects but not in females.

CONSENT AND ETHICAL APPROVAL

All authors declare that informed consent was obtained from the patient or the attendant for publication of this research. Ethical approval has also been taken from the review board of the hospital (IRB letter no. IRB-1896/DUHS/303).

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