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Is Neck Circumference A Better Measure for Determining Obesity? A Cross-Sectional Analytical Study to Assess Its Validity in Type II Diabetes Mellitus Patient

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ABSTRACT

Introduction: Several anthropometric measurements like Body mass index (BMI), skin fold thickness, Waist circumference (WC), waist-height ratio (WHtR), and Waist hip ratio (WHR) are available for diagnosing obesity at the population level. But each of them has its disadvantage as well. Neck circumference, which has been the recent anthropometric tool of interest can be used as an alternative to these measurements. **Objective:** To determine the validity of neck circumference as an anthropometric parameter of obesity and to estimate the cut-off points for obesity in type II diabetes mellitus patients.

Material & Methods: This analytical cross-sectional study was done among 141 Type II diabetes patients attending rural and urban health training centre non-communicable disease clinic of Sri Ramachandra Institute of higher education and research, Chennai. After obtaining informed consent, their anthropometric measurements like NC, BMI, WC, HC, and WHR was measured.

Results: Neck circumference ≥36.5cm in males and ≥33.2cm in females is conceivably the perfect cut-off point for diagnosing overweight/Obesity in Type II diabetes mellitus.

Conclusion: This analytical study deduced that NC is a valid anthropometric measurement for diagnosing obesity among Type II diabetes mellitus with plausible sensitivity and specificity.

Keywords: Neck Circumference, Obesity, Body Mass Index, Anthropometry, Diabetes Mellitus

INTRODUCTION

Obesity is defined as an enormous and unusual deposition of fat in the adipose tissue leading to health impairment.[1] Obesity is arbitrarily and dynamically interrelated to Type 2 diabetes and it is a modifiable risk factor.[2] Overweight and obesity combined with diabetes have the potential to double the risk of metabolic syndrome and cardiovascular events. Therefore weight reduction will be beneficial to the patients with type II diabetes not only in terms of glucose control, but to prevent cardiovascular events, and micro and macrovascular outcomes of diabetes.[3]

Obesity can be evaluated by innumerable methods such as computed tomography, dual-energy X-ray absorptiometry, and magnetic resonance imaging by weighing body fat and fat distribution but these are costly and most advanced methods, and cannot be applied in routine primary care.[4] As an alternative, we can use several anthropometric measurements such as Body mass index (BMI), skin fold thickness, Waist circumference (WC), hip circumference (HC), waist-height ratio (WHtR), and Waist hip ratio (WHR) to measure obesity indirectly.[5] Among anthropometric parameters, BMI is the most convenient method of determining the prevalence of obesity

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at the population level, where weight in Kg is divided by Height in m^2. The advantage of BMI over other anthropometric parameters is, that it is completely age and sex independent and the disadvantage is that it does not account for variability in body fat distribution especially intra-abdominal fat mass.[6] For assessing intra-abdominal fat deposition, waist circumference and waist-hip ratio are the most definitive measure. Waist circumference proves to be a useful measure of central adiposity for a while and few studies depicted its strong correlation with cardiovascular and metabolic risks.[7,8] But the disadvantage of waist circumference is that it encompasses both visceral abdominal fat (VAT) and subcutaneous fat (SC)[9], and the disadvantage of weight – hip ratio is that it takes time and involves more than one body part. Both anthropometric parameters are problematic in terms of environmental and cultural issues.[10] Therefore neck circumference(NC), which has been the recent anthropometric tool of interest is the unique marker of upper body subcutaneous adipose tissue distribution.[11] Neck circumference is also an excellent marker of visceral abdominal tissue (VAT) and insulin resistance compared to other anthropometric measures.[11] Insulin resistance accounts for the elevation of very-low-density lipoprotein (VLDL) and triglycerides levels leading to cardiovascular events in type II diabetes mellitus.[11] Few studies also depicted that individuals with larger neck circumference have been associated with cardiometabolic risk factors compared to individuals with less neck circumference.[12,13]Despite the fact that Neck circumference is an excellent indicator of insulin resistance and metabolic syndrome[13,14], insulin resistance is usually higher in diabetics than in non-diabetics, and previous research has shown that NC cut off value varies between diabetic and Non-diabetic populations[11]. Therefore, determining the cut-off value of NC separately for Type II diabetes mellitus patient becomes more essential. This study aims to determine the validity of neck circumference as an anthropometric parameter of obesity and to estimate the cut-off points for obesity in type II diabetes mellitus patients.

MATERIAL AND METHODS

This analytical cross-sectional study was conducted among Type II diabetes patients attending rural and urban health training centre non-communicable disease clinic of Sri Ramachandra Institute of higher education and research (SRIHER), Chennai – 600116. Type II diabetes patients with a duration of illness of more than 1 year and those who granted informed consent were included. The study has no exclusion criteria. With the intense review of previous literature, the sensitivity and specificity of Neck circumference for diagnosing obesity were taken as 55% and 77% with a relative precision of 20% and 15% and a Z value of 1.96, the sample size calculated was 115.[15] About 20% of the sample size [23] was added to take care of any refusal to participate in this study and the sample size arrived for the study was 138.

Through the Universal sampling method, all the type II diabetes patients who were present during data collection days were included i.e., 141. The data on anthropometric parameters such as height and weight are measured using a stadiometer and calibrated weighing machine. Waist circumference, Hip circumference, and Neck circumference were measured to the nearest 0.1 cm using a flexible measuring tape in those wearing light clothing and standing straight.[16] To measure the neck circumference, the patients were asked to hold their heads erect and shoulders down without hunching and the flexible measuring tape was placed horizontally around the neck at the level of the mid-cervical spine and mid-anterior neck, and the readings were taken.[11,17] Waist circumference was measured with the patient in the standing position and at the end of normal expiration, the flexible measuring tape was placed horizontally at the level halfway between the inferior margin of the lowest rib and iliac crest, and the readings were taken.[10,18]

Body mass index (BMI) was calculated by dividing weight in Kilogram by Height in $metre^2$ and the patient was divided into two categories based on WHO appropriate body mass index cut-off points for Asians[19] into overweight/obese (BMI >23Kg/m^2) and Normal (BMI <23Kg/m^2). Waist Hip ratios were given by simply dividing Waist circumference by Hip circumference. Ethical clearance was procured from the institutional ethics committee of Sri Ramachandra Medical College and Research Institute (SRIHER) [CSP-MED/19/JUN/53/65] before the commencement of the study. Written informed consent from all participants was obtained before the interview.

Statistical Analysis: Data entry was done in excel and analysis was completed using the statistical package for social sciences (SPSS) 16 version software. Continuous variables such as age, height, and weight were depicted in mean and standard deviation. Independent T-test and Pearson's Correlation coefficient were used as tests of significance for analysing the data and the p-value of ≤ 0.05 was taken as statistically significant. Receiving operating characteristic curve (ROC) was generated to find out the sensitivity and specificity of Neck circumference against BMI.

RESULTS

In this study, 141 Type II diabetes patients were recruited. Among 141 participants 52 are males and 89 are females. The mean age of females was higher than the male and the difference was not statistically significant (55.44±11.15 years in males vs. 57.52±8.45 years in females, P=0.212). The mean ± SD of weight in males was higher compared to females and it was statistically significant (66.5±13.35 Kg in males vs. 60.05±10.31 Kg in females, P<0.01*).

Table 1: Independent t-test comparing age and anthropometric parameters in male and Female diabetic patients

Parameters	Males (n=52)	Females (n=89)	p-value
Age	55.44±11.15	57.52±8.45	0.212
Weight	66.5±13.35	60.05±10.31	**0.002***
Height	161.85±5.93	151.74±7.86	**<0.001***
Waist Circumference	92.38±9.50	88.18±8.06	**0.006***
Hip Circumference	97.86±9.29	102.68±9.33	**0.004***
Waist Hip Ratio	0.94±0.07	0.86±0.05	**<0.001***
BMI	25.34±4.67	26.19±4.15	0.264
Neck circumference	37.97±3.26	34.35±2.91	**<0.001***

*p<0.05 is considered significant

Table 2: Correlation of Neck circumference (NC) and other anthropometric parameters in male and female diabetic patients

Parameters	Neck Circumference (MALES)		Neck Circumference (FEMALES)	
	Pearson coefficient (r)	p-value	Pearson coefficient (r)	p-value
Weight(kg)	0.732	**<0.001***	0.567	**<0.001***
Height(cm)	0.221	0.115	0.036	0.739
BMI(Kg/m²)	0.765	**<0.001***	0.561	**<0.001***
WC (cm)	0.595	**<0.001***	0.618	**<0.001***
HC (cm)	0.704	**<0.001***	0.565	**<0.001***
WHR	0.319	**0.021***	-0.076	0.481

*p<0.05 is considered significant

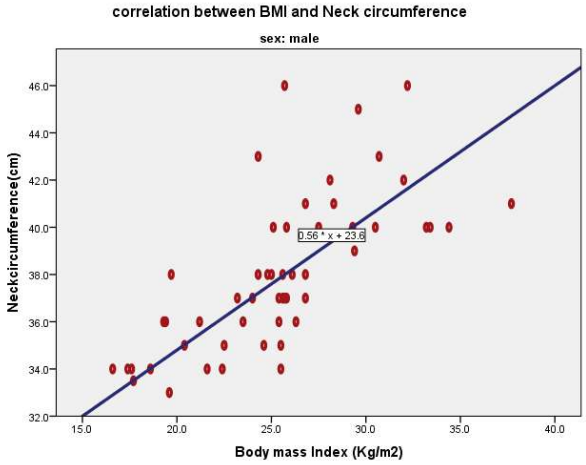

Figure 1: Scatter plot relating BMI (Kg/m²) and Neck circumference (cm) in male diabetic patients

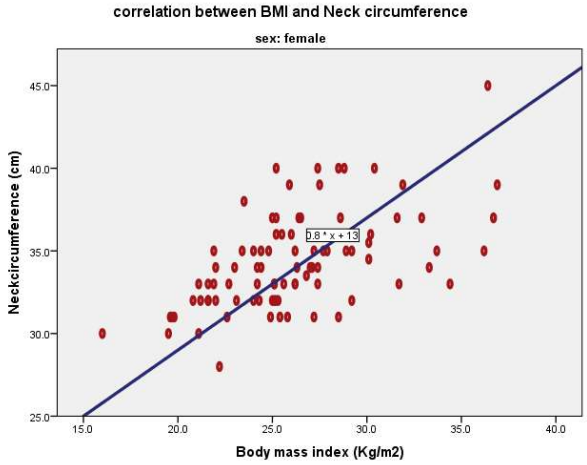

Figure 2: Scatter plot relating BMI (Kg/m²) and Neck circumference (cm) in female diabetic patients

The mean height, waist circumference, and Waist Hip ratio were more in males compared to females and the difference was found to be statistically significant (P<0.01*). The mean BMI difference between genders was not statistically significant (25.34±4.67 Kg/m² in males vs. 26.19±4.15 Kg/m² in females). The Neck circumference, which was our variable of interest was significantly more in males than in females (37.97±3.26 cm vs. 34.35±2.91 cm, P<0.01). The results are summarized in **Table 1**.

Table 2 shows a person's correlation analysis of neck circumference with other anthropometric parameters such as Body mass index, Waist circumference, Hip circumference, and WHR for both males and females.

In male diabetic patients, Neck circumference was positively correlated with weight (r = 0.732), BMI (r = 0.765), Waist circumference (r =0.595) and Hip circumference (r = 0.704) and it was statistically significant (P<0.01*). Similarly in female diabetic patients, a positive correlation was seen between Neck circumference and other anthropometric parameters such as weight (r = 0.567), BMI (r = 0. 561), waist circumference (r = 0.618), hip circumference (r = 0.565) and it was statistically significant (P<0.01*).

The patients were divided into two groups overweight/obese and normal based on the BMI cut-off points (BMI <23 Kg/m²) and NC was compared between these two categories. In male diabetic patients, the mean ± SD of NC was higher for over

Table 3: Independent t-test Comparing NC values between Overweight/Obese and Normal patients of Type 2 Diabetes

BMI (kg/m²)	Neck Circumference (cm)		p-value
	Subjects (%)	Mean ± SD	
Males			
Overweight/Obese (BMI >23)	38 (27%)	39.15±2.94	**<0.001***
Normal (BMI <23)	14 (10%)	34.75±1.34	
Females			
Overweight/Obese (BMI >23)	69 (48.9%)	35.08±2.80	**<0.001***
Normal (BMI <23)	20 (14.1%)	31.85±1.66	

*p<0.05 is considered significant

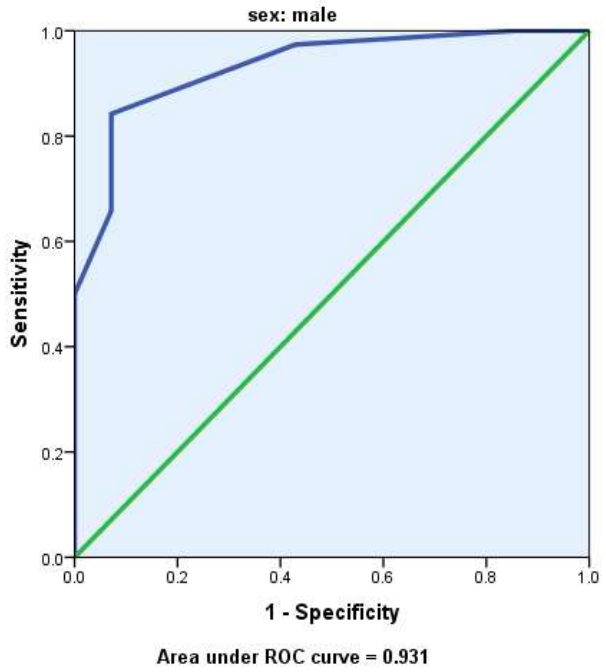

Figure 3: Receiver operating characteristic curve related to neck circumference and obesity (BMI >23 Kg/m²) in male diabetic patients

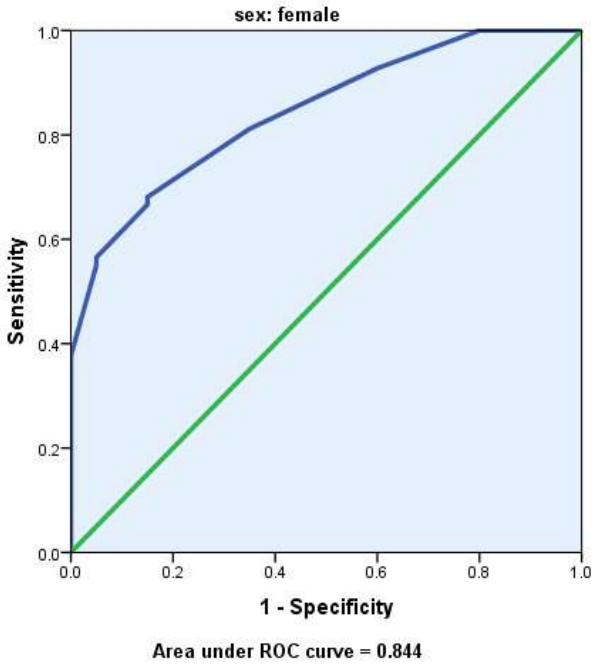

Figure 4: Receiver operating characteristic curve related to neck circumference and obesity (BMI >23 Kg/m²) in female diabetic patients

weight/obese (39.15±2.94 cm) compared to diabetic patients with normal BMI (34.75±1.34 cm), and the difference was statistically significant. Similarly in female diabetic patients, the mean ± SD of NC (35.08±2.80 cm) was found to be higher in overweight/obese than normal BMI patients (31.85±1.66 cm) and the difference was statistically significant. The results were tabulated in **Table 3**.

ROC curve analysis was done to define cut-off values of NC for overweight/ obesity (based on BMI>23 Kg/m²) for both genders respectively. The area under curve (AOC) for NC and overweight/obesity was 0.931(95% CI: 0.859 – 1.00) in male diabetic patient and 0.844 (95% CI: 0.759 – 0.930) in female diabetic patient. NC ≥36.5 cm is the best cut-off value to ascertain overweight/obesity with a sensitivity of 84% and specificity of 93% in diabetic male patients. In the case of diabetic females, NC ≥33.2 cm is the perfect cut-off value to determine overweight/obesity with a sensitivity of 68% and specificity of 85%. The results were shown in **Figure 3 and 4**.

DISCUSSION

This community-based analytical study was done to evaluate whether Neck circumference is a valid anthropometric measure to determine overweight/obesity in type II diabetes patients. In our study, the mean age was 55.44±11.15 years in male diabetic patients and 57.52±8.45 years in female diabetic patients. The mean ± SD of BMI in male diabetic patients was 25.34±4.67 Kg/m² and in female diabetic patients, it was 26.19±4.15 Kg/m².

In our study, neck circumference was positively correlated with age and most of the anthropometric parameters such as Weight, BMI, WC, and HC irrespective of gender, and the results are found to be statistically significant. Similarly, the study done by Ben Noun et al showed a significant positive correlation between NC and age, weight, BMI, WC, and HC in both sexes.[20] Another study done by Ashok et al depicted the positive correlation between NC and the majority of anthropometric parameters such as

Weight, BMI, WC, and HC in both genders respectively, which was also similar to our study.[10]

This present study compared NC between overweight/obese and patients with normal BMI in both males and females respectively. Among 52 diabetic male patients, 38(27%) are overweight/obese and out of 89 female diabetic patients, 69% (48.9%) are overweight/obese. In both genders, NC was bigger in overweight/obese patients compared to a patient with normal weight, and the difference was found to be statistically significant (P<0.01*). Similar to our study, Sharma et al also observed that NC is significantly higher in overweight/obese than diabetic patients with normal BMI in both males and females respectively.[15]

Our study depicted an NC cut-off value of 36.5 cm for males and 33.2 cm for females for determining overweight/obesity in diabetic patients through Receiver operating curve analysis with greater sensitivity and specificity. Similarly, Verma et al conducted a study that showed an NC cut-off value of 36.5 cm for males and 34.05 cm for females through the same ROC curve analysis.[5] A study by aswathappa et al showed that 36 cm was the best cut-off value through ROC analysis for determining overweight/obese in the diabetic patient without considering gender differences which were also close to our study.[11]

CONCLUSION

This analytical study deduced that NC is a valid anthropometric measurement for diagnosing obesity among Type II diabetes mellitus with plausible sensitivity and specificity. NC acts as an outstanding marker in differentiating obese from those with normal BMI with a cut-off value of ≥36.5 cm for males and ≥33.2 cm for females in Type II diabetes mellitus patients. Keeping count on its simplicity, applicability, affordability, and cultural consideration, it can be a perfect tool for diagnosing obesity among Type II diabetes mellitus patients in primary health care.

LIMITATION

Present study has a few limitations. This study does not consider separate cut-off points for determining overweight and obesity independently. The established cut-off points for identifying obesity can be applied only to the Asian Diabetic population, hence the generalizability is the issue. This study identified the diagnostic ability of NC concerning the BMI, in the future more studies involving a large sample size will be required to identify cut-off points relative to other anthropometric measurements as well.

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