ORIGINAL ARTICLE

Neck Circumference: A valid anthropometric tool to predict Obesity in Adults of Davanagere, South India

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Abstract | Introduction | Methodology | Results | Conclusion | References | Citation | Tables / Figures

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Citation

Murthy SSN, Davalagi S, Huchappa RK. Neck Circumference: A valid anthropometric tool to predict Obesity in Adults of Davanagere, South India. Indian J Comm Health. 2019;31(4):457-463.

Source of Funding: Nil **Conflict of Interest:** None declared

Article Cycle

Received: 14/11/2019; **Revision:** 15/12/2019; **Accepted:** 25/12/2019; **Published:** 31/12/2019

Abstract

Background: Neck Circumference (NC) can prove as a useful tool to predict obesity and overweight due to its advantages over the other anthropometric measurements. There have been fewer studies to assess its validity in a South Indian population. **Aim & Objective**: To validate Neck Circumference as a screening tool to predict obesity and to identify critical cut off points for obesity in Adults using Neck Circumference. **Settings and Design**: A cross sectional study involving 512 study subjects was conducted in the field practice area of a tertiary care hospital. Stratified sampling was used. **Methods and Material**: Data was collected using a pre designed semi structured questionnaire which included clinico-social details and anthropometric measurements of the respondents as per standard guidelines. **Statistical analysis used**: Data was analyzed using MS Excel and SPSS v.16.0 **Results**: In our study population BMI and body fat % was greater in females. NC showed positive correlation with Weight, Height, Waist Circumference and BMI. A cut off for NC of 36 cm in males and 29 cm in females was obtained with a sensitivity of 83.3% and 65.6% respectively. **Conclusions**: Neck circumference can be an important screening tool for overweight and obesity in adult population.

Keywords

Neck Circumference; Anthropometric tool; Adults; India

Introduction

Obesity was once considered a problem of high-income countries. As of 2016, 1.9 billion adults over the age of 18 years are either overweight or obese. (1)

India is currently in the heart of an epidemiological transition. In the past India predominantly had to tackle undernutrition but in the recent years' obesity is rapidly taking a centre stage. As per NFHS-4 data overweight and obesity in the rural population has doubled over just a span of 10 years. (2)

Overweight and obesity are linked to more deaths worldwide than under underweight. (1) Although BMI is the accepted standard for defining obesity worldwide, its actual calculation at the community level by regular health workers can be challenging.

Neck circumference is one of the recent anthropometric measurements which has shown promise to identify not only obesity but also pathological upper body fat deposition and act as an indicator of metabolic syndrome. (3-9)

Aims & Objectives

1. To validate neck circumference as a screening tool to predict obesity in Adults
2. To identify critical cut off points for neck circumference in Adults

Material & Methods

Study Type: Cross sectional study
Study population: Adults aged 30 years & above
Study area: Davanagere
Study duration: August 2018 –January 2019
Sample size estimation: The sensitivity and specificity of the Neck circumference to measure overweight and obesity was assumed to be 50%. Prevalence of overweight and obesity in India was taken as 19.7% as per WHO. (10) An allowable error of 10% was taken at 95% confidence interval. The minimum number of diseased needed was 97 and a total minimum sample size required came up to 493 which was rounded off to 512.
Inclusion criteria: All patients and their attenders above 30 years of age who came to the general outpatient department of the urban health training centre were included in the study.
Exclusion criteria: Individuals who had history of thyroid disorders or showed any signs of thyroid enlargement were excluded from the study.
Sampling: Stratified sampling was employed for including the individuals in the study. The study subjects were stratified according to their age and sex.
Data collection: Data was collected in a predesigned, pre tested, semi structured questionnaire using Epicollect software v2.0.6; a freely available mobile and web application. Once the questionnaire was filled with basic sociodemographic details from the participants. They were taken to a separate room for anthropometric measurements. The anthropometric measurements taken for the study were Weight, Height, Waist Circumference, Hip Circumference, Body fat percentage and Neck Circumference.
The weight of the study participant was measured in kilograms using a digital weighing scale. (SECA 874 U digital scale). (11) The study participants were asked to stand in the centre of the scale platform facing the examiner with hands at sides and looking straight ahead. Once the reading on the scale stabilized the weight was recorded. (12)
The height of study participants was measured using stadiometer (SECA 213). (11) The participant was instructed to stand up straight against the backboard with heels together, toes apart and both feet flat on the platform. It was ensured that the back of the head, shoulder blades, buttocks and heels were in contact the backboard before taking the reading.
Waist circumference was measured at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest at the end of normal expiration. (12) Hip circumference was measured at the widest portion of the buttocks with the tape parallel to the floor. A non-stretchable tape was used which was placed snugly around the body. (12)
Body fat percentage was measured using a commercially available bio impedance analyzer (HBF-375, Karada Scan- Body Composition Monitor). This device worked on the principal of Bioelectrical Impedance /Biological Resistance method. Tissues with more water content like muscles and veins conduct electricity more easily when compared to fat which conducts almost no electricity. Based on this principle body resistance was measured by using weak currency (50kHz, 500 µA) flowing through both the hands and both the feet.

The Neck Circumference was measured with a calibrated plastic tape in the midway of the neck, between mid-cervical spine and mid anterior neck within 1 mm. In men with a laryngeal prominence it was measured just below the prominence.
In cases where the first two measurements differed by 0.5cm, a third measure was taken, and the average of all the measurements was considered.
Ethical approval: Prior permission and ethical clearance was taken from the institutional review board to conduct the study.
Data Analysis: Body Mass Index was considered as the standard for defining obesity and overweight. Modified BMI classification for Asian population was used. BMI of 18.5- 22.99 kg/m2 was considered normal. BMI of 23-24.99 kg/m2 was categorized as overweight and BMI more than or equal to 25kg/ m2 was defined as obese.(13) Central obesity was defined by standard cut off points of Waist circumference ≥ 80cms in females and ≥90cms in males.(14) Body fat% of 20% and 30% were considered the upper limit for males and females respectively.(15)
Statistical Package for the Social Sciences (SPSS) for windows version 16.0 was used for analysis of the data collected (Figure 1)

Results

Out of the 512 participants, 256 males and females were part of the study with 64 in each age group (30-39,40-49, 50-59 and more than 60). Mean age of the 512 participants was 49.64±12.7. Average age of the male participants was 50.02±13.2 and females was 49.3±12.4.

Our study did not find any statistically significant difference in variation of BMI, Neck Circumference or Body Fat % with age.

In our study population average weight, height, waist circumference and neck circumference of males was higher as compared to females. (Table 1) except for BMI and Body fat % which was found to be higher in females.

Out of 512 patients, as per Asian cut off values for BMI, 274 (54.3%) participants were found to be obese. Among them 144 (52.6%) were females and 130 (47.4%) were males.

18.6% of the study population were found to be overweight out of which majority (52%) were males. Average Waist circumference, a measure of abdominal obesity was higher than normal cut off values in both in males and females (Table 1). Among study participants, 180 (70.3%) females and 132 (51.5%) males had a waist circumference greater than standard cut off values. 195 (76.1%) males and 188 (73.4%) females had a Waist hip ratio greater than the standard cut off values of 0.9 and 0.8 respectively.

As per Pearson's correlational analysis Neck circumference was found to be positively correlating with Weight r = 0.491 ($p< 0.05$), Height r = .361 ($p< 0.00$), Waist circumference r = .372 ($p < 0.00$), Hip circumference r = 0.110 ($p<0.000$) and Body mass index r = 0.313 ($p< 0.000$).(Table 2)

Using ROC Curve analysis, the Neck Circumference cut off values for males was 36cm having Sensitivity = 83.3% and Specificity = 84.4% and that for females was 29cm with high specificity of 94.8%. (Table 3) and (Table 4).(Figure 2) and (Figure 3)

(Table 3) and (Table 4) depict there is a statistically significant association between Neck Circumference and BMI in both males and females($p<0.001$) using the cut off values obtained from our ROC analysis.

Neck Circumference was found to have a good discriminatory power to predict obesity as per modified criteria of BMI classification on receiver operating characteristic (ROC) analysis. It was compared against Body fat % and Upper body % with reference line laid according to BMI classification modified for Asian population.

In males the Area Under the Curve (AUC) was highest for NC and in females' Upper body fat% had the highest AUC followed by NC

Discussion

Although obesity results in metabolic abnormalities, upper body obesity is more strongly associated with glucose intolerance, hyperinsulinemia, diabetes, hypertriglyceridemia, gout and uric calculus disease than lower body obesity.(16,17) Systemic free fatty acid concentration is primarily determined by upper body subcutaneous fat, suggesting that this fat depot can play a vital role in risk factor pathogenesis.(18)

Body mass index (BMI) is the standard anthropometric measurement usually used to define obesity; but in community settings BMI as a screening tool for obesity can pose a lot of practical problems like the calculation itself can be cumbersome, lack of calibrated weighing scales. Additionally, BMI doesn't give an insight into regional adiposity which poses a greater risk for cardio metabolic disorders. (5)

Another important anthropometric measure which is predominantly used to define abdominal obesity is Waist circumference and Waist to hip ratio. Both these measures can be difficult to measure in conservative populations especially in females and they tend to show diurnal variation and vary with meal intakes. (6)

With this background it becomes all the more important to look for easier and more practical alternatives for screening in community settings for obesity. Many studies have shown that Neck circumference can be a novel anthropometric alternative for measuring overweight and obesity. (3-9,11,19-24)

Neck circumference requires minimal expertise, equipment and skill to measure. It is more culturally acceptable than WC and most importantly it has the advantage of predicting many other cardiometabolic risks other than obesity. (3-9)

A study was undertaken in China showing that NC independently correlated with Visceral fat. NC of 38.5 cm in males and 34.5 cm in females were found to be the optimal cut offs for identifying visceral obesity. (6)

There were two different studies conducted in Odisha and Turkey among adolescents and younger population (18-24yrs) which concluded that NC had

a positive correlation with BMI, WC, WHR.(19,20) The study in Odisha described cut off values for NC for screening for obesity to be 30.75 cm and 29.75 cm in males and females respectively. (19)

A systemic review and meta-analysis of 11 articles showed that 71% considered NC an accurate measure to diagnose over weight and obesity. Best sensitivity was found for 19 years of age, females and obese. (6)

There are few studies conducted to validate Neck Circumference in an Indian setting. A study in Kolar among adults determined a NC cut off of 36 cm for males same as our study; but with a lower Sensitivity of 71.25% as compared to ours (83.3%). (21) For females, NC cut off was taken to be 32 cm with a sensitivity of 71.25% which is higher than what we obtained probably owing to their larger sample size of 511 females in contrast to 256 females taken for our study. (21)

A similar study was undertaken in rural central India to see if NC can be used as a predictor for obesity. Their study findings suggest NC cut off values of 38cm in males and 34.7 cm in females. (22) The reason for higher values in this study as compared to our findings might be because in this study they took universal cut off values for BMI as opposed to Asian BMI cut off values of 22.9kg/m2.

Two more studies conducted in Maharashtra and Haryana, states in Northern India obtained the cut off values of 36.5 cm for male population similar to our findings. (23,24)

An important thing to note is that NC cut offs obtained for females shows variations ranging from 34.7 cm[22], 34 cm[23], 32.5 cm[24], 32 cm[21], and 29 cm as obtained from our study. Thereby calling for the need to do more studies concentrating on female population only.

Conclusion

This study, conducted among urban slum populace, concludes that men with NC ≥36 cm and women with NC ≥ 29 cm are to be considered obese.

Recommendation

NC is a reasonably valid screening tool to predict obesity with many advantages over other anthropometric measurements. NC measurement can be used as a simple, culturally acceptable tool & time-saving screening measure among general population to identify overweight and obesity. It is an inexpensive tool that can be used by any of the grass root level health workers in the community as it requires only a non-stretchable measuring tape.

Limitation of the study

Limitations of our study are that we could not check for intra observer or inter observer errors in measuring NC therefore making it hard to comment on repeatability of NC as an anthropometric measurement.

Relevance of the study

The strengths of our study is that we have seen the association of NC with not only the routine anthropometric measurements but also compared it with body fat % which is more significant for cardio metabolic risks. Our study has also thrown some light in variations with cut off values obtained for females as compared to males.

Authors Contribution

SSN, SDB, RKH: Conceived & designed the analysis; SSN, SDB: Collected the data; SSN, SDB, RKH: Contributed data & analysis tools; SSN, SDB: Wrote the paper.

Acknowledgement

We would like to thank the interns & staff our urban health training centre who helped in data collection & study participants who cooperated for the study

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Tables

TABLE 1 ANTHROPOMETRIC MEASUREMENTS OF THE STUDY POPULATION

Sl. No.	Anthropometric measurements	Male	Female	Total
1	Weight (kg)	67.13±12.2	61.3±13.2	64.24±13.0
2	Height (cm)	164.2±8.4	152.4±7.6	158.3±2.5
3	Body Mass Index (kg/m2)	24.87±6.1	26.36±5.3	25.61±4.7
4	Waist Circumference (cm)	90.46±10.9	85.71±13.5	88.0±12.5
5	Hip Circumference (cm)	96.2±9.3	100.2±13.5	98.2±11.7
6	Waist Hip Ratio	0.93±.12	0.85±.03	0.89±.21
7	Body fat (%)	28.77±6.1	39.76±4.6	34.24±7.7
8	Neck Circumference (cm)	37.16±4.8	31.9±4,5	34.5±5.3

TABLE 2 CORRELATION OF NECK CIRCUMFERENCE WITH OTHER ANTHROPOMETRIC MEASUREMENTS

Neck Circumference	Waist Circumference	Hip Circumference	Height	Weight	Body Mass Index
Pearson Correlation	.372	.110	.361	.491	.313
p value	.000	.013	.000	.000	.000

*WC-Waist Circumference, HC- Hip Circumference, Ht.- Height, Wt. – Weight, BMI- Body Mass Index, NC- Neck Circumference

TABLE 3 COMPARISON BETWEEN NECK CIRCUMFERENCE AND BODY MASS INDEX IN MALES

Neck Circumference in males						
		NC ≥ 36 cm	NC < 36 cm			
		Obese	Not Obese	Total		
BMI	Obese	121	8	130	$\chi^2 = 102.03$ $p < 0.001$	Sn-83.3% Sp-84.4%
	Not Obese	42	85	127		
	Total	163	93	256		

TABLE 4 COMPARISON BETWEEN NECK CIRCUMFERENCE AND BODY MASS INDEX IN FEMALES

Neck Circumference in females						
		NC ≥ 29 cm	NC < 29 cm			
		Obese	Not Obese	Total		
BMI	Obese	144	1	145	$\chi^2 = 127.02$ $p < 0.001$	Sn-65.6% Sp-94.8%
	Not Obese	39	72	111		
	Total	183	73	256		

TABLE 5 COMPARISON OF NECK CIRCUMFERENCE, BODY FAT% AND UPPER LIMB FAT% TO PREDICT OBESITY USING ROC CURVE

Anthropometric variable	Males			Females		
	AUC	95% CI	p value	AUC	95% CI	P value
NC	0.856	0.757-0.955	0.001	0.747	0.603-0.891	0.001
BF%	0.754	0.618-0.890	0.001	0.729	0.591-0.867	0.002
Upper BF%	0.812	0.686-0.938	0.001	0.802	0.702-0.902	0.001

Figures

FIGURE 1 SELECTION OF STUDY SUBJECTS BASED ON STRATIFIED SAMPLING

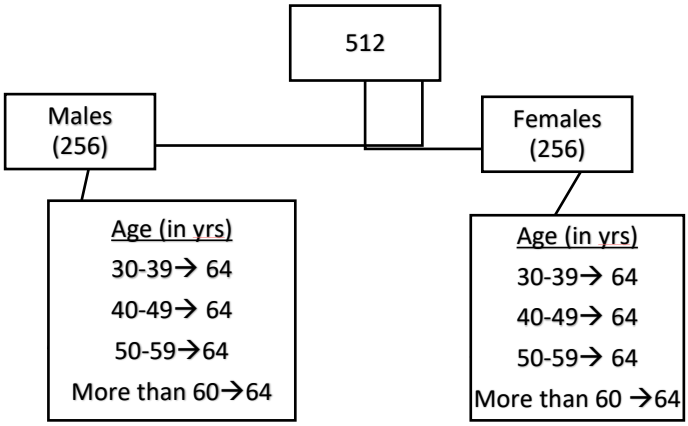

FIGURE 2 RECEIVER OPERATING CHARACTERISTIC (ROC) CURVE FOR NECK CIRCUMFERENCE IN MALE PARTICIPANTS',NB: NECK CIRCUMFERENCE CUT OFF VALUE: 36CM

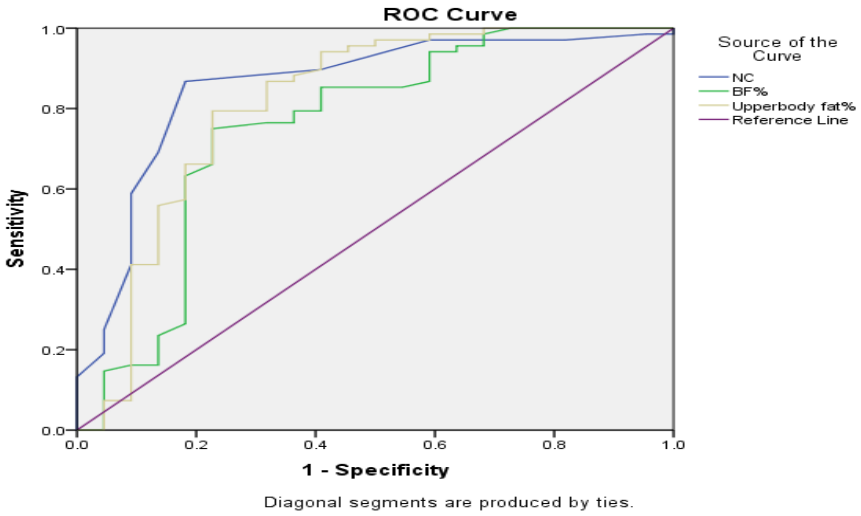

FIGURE 3 RECEIVER OPERATING CHARACTERISTIC (ROC) CURVE FOR NECK CIRCUMFERENCE IN FEMALE PARTICIPANTS, NB: NECK CIRCUMFERENCE CUT OFF VALUE: 29CM