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UTILITY OF NECK CIRCUMFERENCE, A SIMPLE AND NOVEL MEASURE AS ANTHROPOMETRIC MARKER OF OBESITY IN ADULTS

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ABSTRACT

Introduction: According to WHO,obesity is increasing alarmingly worldwide.Neck circumference is a relatively new method of differentiating between normal and abnormal fat distribution. **Aim:**To determine association of Neck Circumference (NC) with other anthropometric measures in males & females and to define Neck Circumference cutoff levels for overweight and obesity according to existing Asian Indian BMI cutoff levels in males & females. **Materials And Methods:** A community based cross-sectional study was conducted & prospectively recruited 840 males & 511 females.

Anthropometric variables were tested by using Independent t test and Pearson's correlation coefficient.ROC analysis was done for NC against BMI &WC. **Result Analysis:** Mean NC of the males (36.48 ± 5.70) was significantly higher than in females(34.12 ± 5.70). NC> 36cm for males &> 32cm for females was the best cutoff levels for determining the overweight/obese subjects with BMI > 23 kg/m², using ROC analysis . NC> 38cm for males & > 36cm for females was the best cutoff levels for determining the central obesity subjects with WC> 90cm in males & WC>80cm in females, using ROC analysis. **Conclusion:**NC>36cm for males & >32cm for females was the best cutoff levels for determining the overweight/obese subjects. NC >38cm for males & >34cm for females was the best cutoff levels for determining the central obesity in the subjects.NC could be a potential, inexpensive, easily measured clinical screening tool for evaluating central obesity.

Key Words: Neck circumference, Obesity.

INTRODUCTION

According to WHO, obesity is increasing alarmingly worldwide including India. This might be due to more sedentary life style & more intake of energy rich diet,& is associated with various chronic diseases thus posing a major public problem.[1] The rising prevalence of overweight and obesity in India has a direct correlation with the increasing prevalence of obesity-related co-morbidities; hypertension, the metabolic syndrome, dyslipidemia, type 2 diabetes mellitus (T2DM), and cardiovascular disease (CVD).[2,3]

India is following the trend of other developing countries that are steadily becoming obese. The prevalence of obesity in India is estimated to be 5% . According to NFHS survey in 2007 in Karnataka the prevalence of obesity in males 14% & in females it is 17.3%.These figures seem to be increasing.[4,5] Obesity is not just limited to urban & affluent society ,but also affects the rural places & persons belonging to lower socio economic strata.

Usually, BMI has been used as a measure to diagnose obesity.International obesity task force gives the WHO guideline classification for adult underweight, normal, overweight & obese. Later Revised guidelines for diagnosis of obesity, abdominal obesity, and metabolic syndrome in Asian Indian populations were put forward by a consensus group in India. According to these guidelines, the criteria are -a healthy body-mass index of 18.0–22.9 kg/m^2, an overweight body-mass index of 23.0–24.9 kg/m^2, and obesity greater than or equal to 25 kg/m^2. The healthy waist circumference limits are 90 cm for men and 80 cm for women.[6]

Other types of anthropometric measures like waist circumference (WC), waist to hip ratio (W/H) and index of central obesity (ICO) have all been associated with increased body fat & have predicted the distribution of body fat. [1] Neck circumference (NC) is a relatively new method of differentiating between normal and abnormal fat distribution. [7] It is a mark of upper body subcutaneous adipose tissue distribution. Adipose tissue is found in specific locations, which are referred to as adipose depots. Adipose tissue contains several cell types, with the highest percentage of cells being adiposities, which contain fat droplets. [8]

The mission of International association of study of obesity is to make an impact on the national and international research agenda so that better care becomes available for those afflicted with weight problems. [9] As Asian Indians manifest clustering of cardiovascular risk factors and T2DM at lower levels of obesity, all adults must be screened for obesity to

prevent morbidity & mortality ,thus screening should be simple, noninvasive & easily feasible.

Indices of obesity have been derived to assess body composition and health at the present, and to predict future health. A method has to be developed specifically for self-monitoring by lay people.For clinical use, anthropometric methods are useful tools for diagnosis and monitoring patients.The most appropriate methods may vary depending on whether the need is for cross-sectional or longitudinal assessment. In research studies, physiological characterization of individuals is assessed by a range of anthropometric measurements. The aim of this study was to determine association of NC with other anthropometric measures in males & females and to define NC cutoff levels for overweight and obesity according to existing Asian Indian BMI & WC cutoff levels in males & females.

OBJECTIVES

1. To correlate the association of neck circumference with BMI,Waist-circumference, hip circumference, waist hip ratio in males & females.
2. To determine the NC cutoff levels for overweight/obesity with existing Asian Indian BMI & WC cutoff levels in males & females.

MATERIALS AND METHODS

After receiving institutional review board approval, a community based cross –sectional study was conducted & prospectively recruited 1351 (840-males & 511-females) aged to 18-65 years at RL Jalappa Hospital & Research Centre, Kolar . Informed consent was taken from all subjects prior to the study. Anthropometric measures like BMI, waist circumference, hip circumference & neck circumference were measured. Weight was measured with light clothing & without shoes. Height was measured without shoes.BMI was calculated by dividing weight (Kg) with the square of height (m). Waist circumference (cm) was taken horizontally to within 1 mm, using plastic tape measure at midpoint between the costal margin and iliac crest in the mid-axillary line, with the subject standing and at the end of a gentle expiration. Hip circumference (HC) was measured in centimetres, at the level of greater trochanters, with the legs close together.

Neck circumference was measured in the midway of the neck, between mid cervical spine and mid anterior neck, to within 1 mm, with non stretchable plastic tape with the subjects standing upright. In men with a laryngeal prominence (Adam's apple), it was measured just

below the prominence. While taking this reading the subject was asked to look straight ahead, with shoulders down, but not hunched. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement. Subjects with any thyroid disorders, Cushing's disease, Pregnant & lactating women were excluded from the study.

SPSS17.0 software was used for data analysis.The significance for gender differences in the anthropometric variables was tested by using Independent t test and Pearson's correlation coefficient was used to explore association between NC &other anthropometric variables by sex were done.

ROC analysis was done to find the optimal , maximal sensitivity & specificity for NC against BMI &WC. All reported P values are 2-sided, and a *P* value of <0.05 was considered to be significant.

RESULT ANALYSIS

Table -1 Baseline characteristics of various anthropometric parameters of the study population in males & females

Parameters	Males(n=840)	Females(n=511)	
	Mean+SD	Mean+SD	*P* value
Age(yrs)	46.78±13.82	43.65±16.58	<0.001**
Wt(Kg)	68.09±12.46	61.94±11.80	<0.001**
Ht(meters)	1.65±0.08	1.56±0.06	<0.001**
BMI(Kg/m^2)	24.84±4.40	25.38±4.89	<0.037*
WC (cms)	90.47±12.09	86.56±12.09	<0.001**
HC(cms)	91.41±8.56	91.73±9.49	0.512
W/H	0.98±0.09	0.94±0.11	<0.001**
NC(cms)	36.48±5.70	34.12±5.70	<0.001**

Among the 1351 adults in our study sample, 62% were males and 38% females.

Table 1 shows the baseline characteristics of various anthropometric parameters & statistical significance of the study population according to gender. Mean NC of the males(36.48±5.70) was significantly higher than in females (34.12±5.70)(*P*<0.001).Similarly, other anthropometric parameters were significantly higher in males compared with females except for hip circumference.

Table 2 Details the Pearson's correlation coefficients between NC and other anthropometric variables for males and females.

variables	NC(cms)			
	Males(n=840)		Females(n=511)	
	r	P	R	P
Age(yrs)	0.044	0.199	0.608	0.001**
Wt(Kg)	0.623	0.001**	0.643	0.001**
Ht(meters)	0.125	0.001**	0.047	0.291
BMI(Kg/m2)	0.559	0.001**	0.334	0.001**
WC (cms)	0.705	0.001**	0.637	0.001**
HC(cms)	0.558	0.001**	0.408	0.001**
W/H	0.432	0.001**	0.373	0.001**

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Table 2-shows a moderate correlation was between NC and weight, height, waist and hip circumferences, BMI and waist: hip ratio for men and women ($P<0.001$) except for age in males & Ht in females. The strongest correlation was found between NC and WC($r = 0.705$ for males and r= 0.637 for females), followed by BMI($r = 0.559$ for males and 0.334 for females). So, the recommended cut off points for BMI and WC only were used as standards to predict the NC cut off points.

NC 32cm for females was the best cutoff levels for determining the overweight/obese subjects with BMI > 23 kg/m², using ROC analysis with prevalence of obesity 65.8%, AUC 0.675 and 63.99% sensitivity, 68% specificity, with positive likely-hood ratio of 2.00in females.(fig-1)

NC 36cm for males was the best cutoff levels for determining the overweight/obese subjects with BMI > 23 kg/m², using ROC analysis with prevalence of obesity 65%, AUC 0.780 & 71.25 % sensitivity, 80.61% specificity, with positive likely-hood ratio of3.67 in males.(fig-2)

NC 34cm for females was the best cutoff levels for determining the overweight/obese subjects with WC > 80 cm, using ROC analysis with prevalence of obesity 63.2%, AUC 0.824 and 60.68% sensitivity, 87.23% specificity, with positive likely-hood ratio of 4.75 in

females.(fig-3) NC 38cm for males   was the best cutoff levels for determining the overweight/obese subjects with WC > 90cm, using ROC analysis with prevalence of obesity 42.6%, AUC 0.864 & 72.35 % sensitivity, 83.82% specificity, with positive likely-hood ratio of3.67 in males.(fig-4)
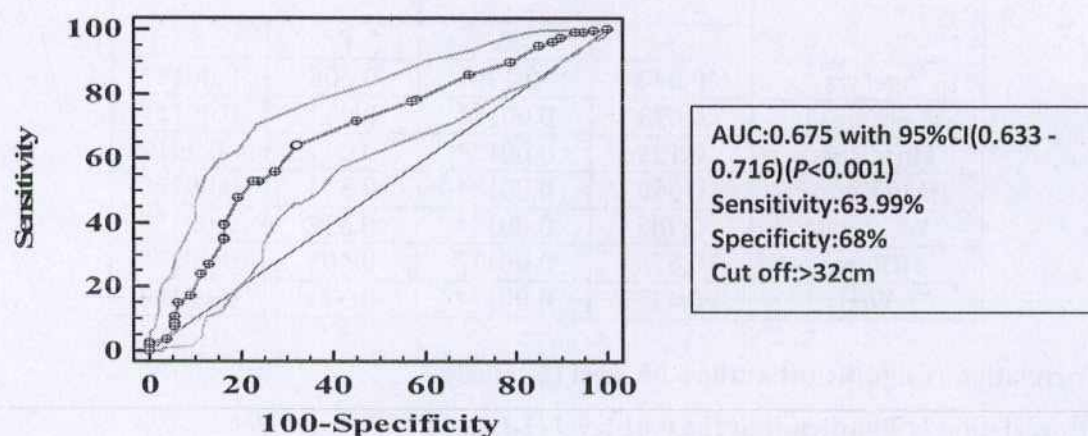

AUC:0.675 with 95%CI(0.633 - 0.716)($P<0.001$)
Sensitivity:63.99%
Specificity:68%
Cut off:>32cm

FIG-1 Neck Circumference (cm) cutoff levels for determining the overweight and obese females (BMI > 23 Kg/m²) using ROC   analysis.

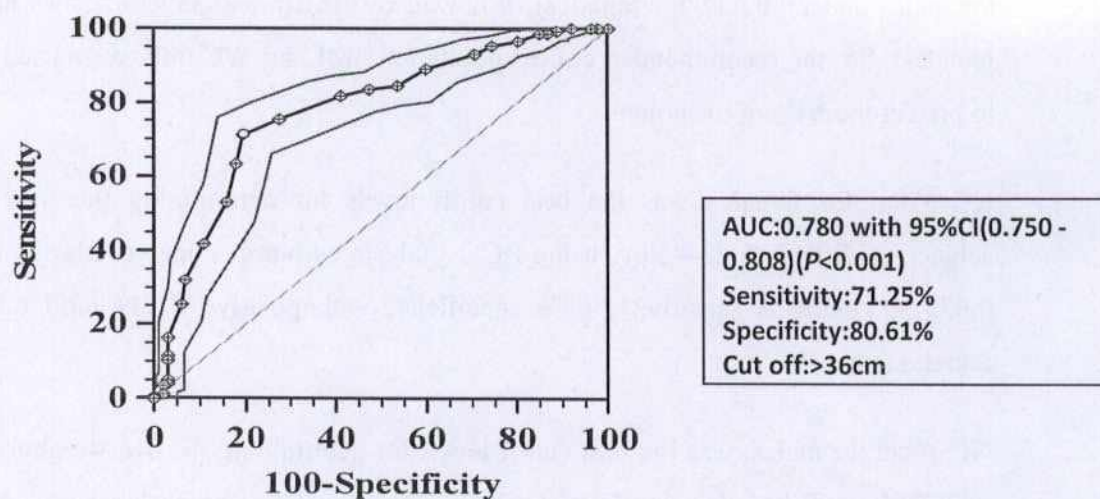AUC:0.780 with 95%CI(0.750 - 0.808)($P<0.001$)
Sensitivity:71.25%
Specificity:80.61%
Cut off:>36cm

FIG-2 Neck Circumference (cm) cutoff levels for determining the overweight and obese males(BMI > 23 Kg/m²) using ROC analysis.

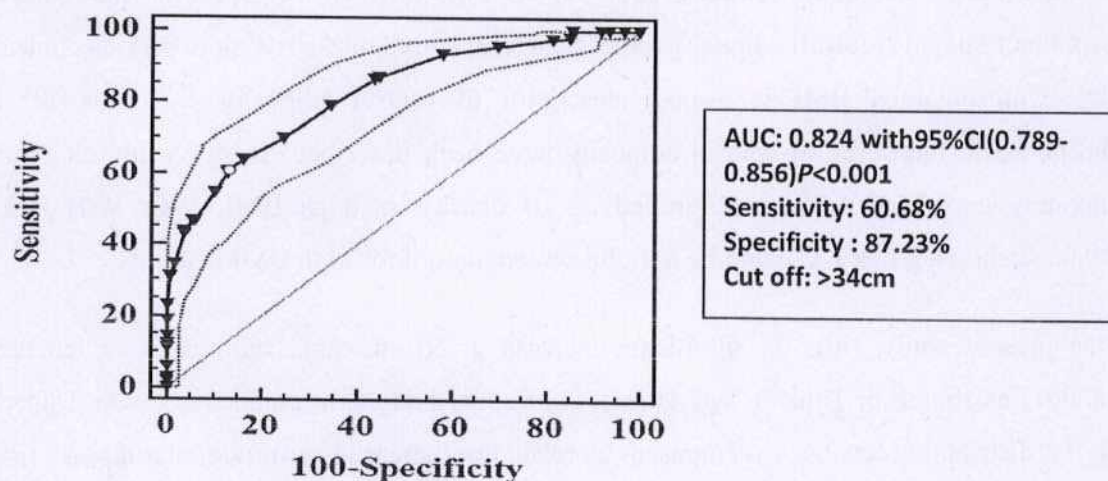AUC: 0.824 with95%CI(0.789-0.856)P<0.001
Sensitivity: 60.68%
Specificity : 87.23%
Cut off: >34cm

FIG-3:Neck Circumference (cm) cutoff levels for determining the overweight and obese females(WC>80cms) using ROC analysis.

AUC:0.864
With 95%CI(0.839-0.886)
(P<0.001)
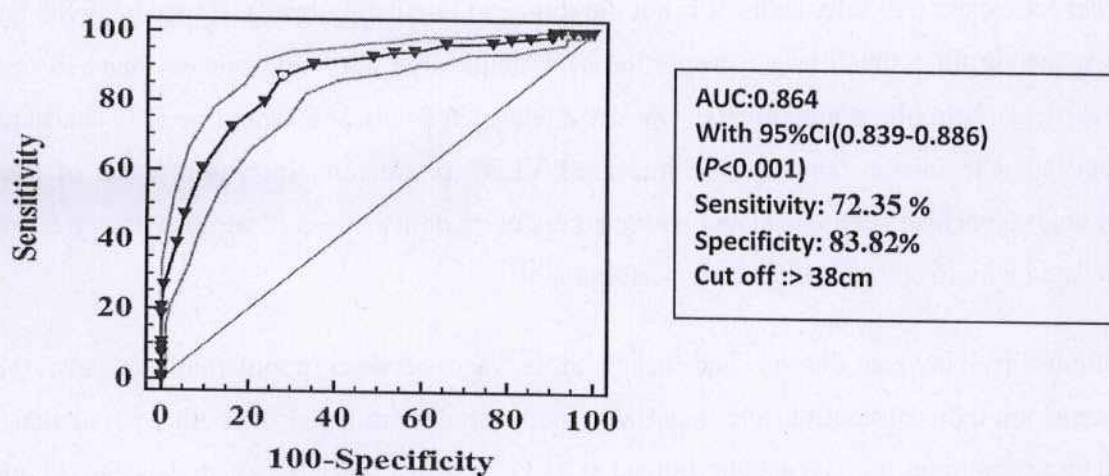Sensitivity: 72.35 %
Specificity: 83.82%
Cut off :> 38cm

FIG-4 Neck Circumference (cm) cutoff levels for determining the overweight and obese males(WC>90cms)usingROCanalysis

DISCUSSION

Obesity is a medical condition described as excess body weight in the form of fat. When accumulated, this fat can lead to severe health impairments. It has become highly prevalent and chronic disorder currently threatening the health of Asian Indians.[10] In this prospective, cross-sectional study of adults aged 18-65 years, males(n=840) where 65% of them were in BMI >23Kg/m^2 & females(n=511) 65.8% of them >23Kg/m^2.

The most widely used index of excess body fatness is the BMI. However, recent studies have shown that regional (central) adiposity rather than total body fatness is a more serious clinical entity. Unfortunately, BMI is a poor descriptor of central adiposity. [11] Thus, other anthropometric measures of central adiposity have been described. In our study NC was moderately correlated with common indices of obesity such as BMI, WC, W/H ratio ($P<0.05$) indicating that NC could be a useful screening tool for high BMI in adults.

In the present study, there is significant increase in NC in males compared to females ($P<0.001$) as shown in Table-1. NC is related to upper body sub- cutaneous tissue. Upper-body fat distribution has been recognised as related to increased cardiovascular disease risk & neck skin fold or neck circumference.[12] Upper-body subcutaneous fat is a novel ,easily measured fat depot & may lead to a better understanding of the differential effects of adiposity in males & females. Free fatty acid release from upper-body subcutaneous fat was reported to be larger than that from lower-body subcutaneous fat. [13] Visceral fat may be a marker for excess free fatty acids, it is not the source of circulating levels. Upper-body SC fat is responsible for a much larger proportion of systemic free fatty acid release than visceral fat, particularly in obese individuals. Obesity & elevated levels of plasma free fatty acids are associated with insulin resistance & increased VLDL production. Increased levels of free fatty acids have also been correlated with markers of oxidative stress & vascular injury & are associated with the development of hypertension. [11]

Relationships between obesity and health risks vary between populations. Asians, for example, are more susceptible and thus BMI risk thresholds are lower than other populations, with an action point for overweight defined at 23 kg/m^2.Most other Indian studies carried out have used the WHO criteria for BMI cutoff values. In our study Asian Indian standard BMI cut off values for overweight & obesity has been used & correlated with NC. Several investigators have shown that Asian Indians are more predisposed to develop insulin resistance and cardiovascular risk factors at lower levels of BMI as compared to other ethnic groups.[14,15,16] Excess clustering of cardiovascular risk factors could be attributed to a large extent by differences in body composition of Asian Indians vs white Caucasians. Asian Indians have higher percentage body fat, abdominal adiposity at lower or similar BMI levels as compared to white Caucasians. [17, 18]

Our study confirms previous findings in adults done in 2001 by Ben et al, it was found that validated group had >37cm for males & 34 cm for females as the cutoff for the BMI of

$> 25Kg/m^2$,that   NC is strongly correlated with BMI and could indeed be used as an additional and practical screening tool for identifying males & females who are obese. [7]

The present study provides gender-derived cutoff values for overweight & obesity screening adults for high BMI that could be used in a busy clinical setup. The ROC analysis for BMI of $>23Kg/ m^2$,NC cutoff values determining overweight & obesity in this study is >32cm in females & >36cm in males.

The prevalence of central obesity was 63.8% in females & 42.6% in males. The ROC analysis for WC of >80cm,NC cutoff values determining central obesity in this study for females is >34cm & the ROC analysis for WC of >90cm,NC cutoff values determining central obesity in this study for males is >38cm.Patients above these levels require a more comprehensive evaluation of their overweight or obesity status. Prevention of obesity is more cost effective ,than is the treatment of risk factors resulting from obesity. A 2–3% reduction in energy intake or an extra 10–15 min of walking or yoga each day could off- set weight gain.

Obesity is an important cause of morbidity, disability and premature death (WHO, 2004). Obesity increases the risk for a wide range of chronic diseases. BMI is thought to account for about 60% of the risk of developing type-2 diabetes.The disability attributable to obesity and its consequences due primarily to ischemic heart disease and type- 2 diabetes. (9)In our previous study, the risk of central obesity is more in diabetics (NC>36cm) compared to non-diabetics (NC>37cm). [19]

Obesity has also great social impact on individuals who are obese, such as depression & low self- esteem which can affect the individual's quality of life, mental health etc. It has substantial direct & indirect impact on costs that put a strain on healthcare & social resources. Thus it is necessary to screen individuals who are at risk for central obesity &change their lifestyle modifications. Though there are various methods of assessing overweight & obesity at primary health care facilities (BMI, WT, HT,&WC) & research purposes(ultrasound, CT,& MRI),it is not practical to use these techniques & are expensive. [20]

As a first step to achieve obesity control, NC can be used as a quick, reliable, simple screening tool for the assessment of obesity in primary care clinics, & also by health care workers. One potential benefit of NC measurement is that it has cultural advantage,

especially in females where it can be measured easily with -out much awkwardness. Other anthropometric measures have their own limitations. BMI does not account for factors such as body fat distribution, specifically abdominal obesity, and cannot distinguish between lean and fat body mass. [21] WC has its own disadvantages as subjects are required to wear thin clothes during the measurement, so that the thickness of clothing does not influence the result. The measurement is typically conducted before eating and after emptying bladder. Subjects should be asked to breathe normally and at the time of the measurements, and asked to breathe out gently. So, it involves discomfort to the subject.

Upper-body fat deposition as in neck circumference is less cumbersome, easily measured fat depot, which may be an important predictor of obesity and overweight ultimately leading to preventable risk like diabetes, hypertension and metabolic syndrome. A well targeted basic research is needed to provide insight into examine the relationship between neck circumference and obesity in community setting and their correlations with obesity co-morbidities &feasible strategies for prevention of obesity and its complications. As Revised guidelines for diagnosis of obesity, abdominal obesity, and metabolic syndrome in Asian Indian populations are put forwarded by consensus group in India, similarly a consensus has to be made for the NC cutoff values in India.

Obesity is now reaching pandemic proportions across much of the world, and its consequences are set to impose unprecedented health, financial and social burden on public, unless effective actions are taken to reverse the trend. Thus NC can be used as an anthropometric marker to screen central obesity & its related co-morbidities & can be used for self-monitoring by lay people.

CONCLUSION

NC was positively correlated with other indices of obesity in males & females. NC> 36cm for males & > 32cm for females was the best cutoff levels for determining the overweight/obese subjects. NC > 38cm for males & > 34cm for females was the best cutoff levels for determining the central obesity in the subjects.NC could be a potential, inexpensive, easily measured clinical screening tool for evaluating central obesity.

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