Dr. Mahesha Chikkachannappa
M S (General Surgery), Aster CMI
Hospital, Bengaluru, Karnataka,
India

Edwina Raj
Chief Dietician, Aster CMI
Hospital, Bengaluru, Karnataka,
India

Dr. HV Shivaram
Senior Consultant and Head of The
Department of Bariatric Surgery,
Aster CMI Hospital, Bengaluru,
Karnataka, India

Dr. Mohammed Farooq Khateeb
Consultant Surgeon, Aster CMI
Hospital, Bengaluru, Karnataka,
India

Performance of neck circumference to predict obesity and metabolic syndrome among adults in a tertiary care hospital in India: A prospective cross sectional study

Dr. Mahesha Chikkachannappa, Edwina Raj, Dr. HV Shivaram and Dr. Mohammed Farooq Khateeb

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Abstract
Aims and Objectives: To explore performance of neck circumference to predict obesity and metabolic syndrome among adults.
Materials & Methods: In this prospective study, totally Three hundred cases of both sexes, between 30 to 75 years old, were evaluated. A convenience sampling strategy was used. The sample comprised cases treated at an outpatient clinic for obese children and adolescents in the Hospital. The study included overweight, obese, and normal weight subjects, according to criteria from the *Centers for Disease Control and Prevention* (CDC). Exclusion criteria were: cervical lymph nodes or deformities, goitre, late neuropsychological and motor development, congenital syndromes, hepatopathy, nephropathy, metabolic disorders (such as type 1 diabetes, hypothyroidism, and hyperthyroidism) and use of systemic corticosteroids.
Results: In the present study, 17 cases belongs to age group of less than 31 years, 70 cases belongs to 31 to 40 year group, 43 cases belongs to 41 to 50 year group and 170 cases belongs to more than 50 year age group, 159 cases were male and 131 cases were female, one case belongs to underweight category, 84 cases belongs to normal weight category, 152 cases belongs to overweight category and 63 cases belongs to obese category. In males, 32 cases NC was less than 37 cms and 127 cases was more than 37 cms and In females, 47 cases NC was less than 34 cms and 84 cases was more than 34 cms. 86 cases were suffering from diabetes, 135 cases were suffering from hyperlipidemia, 2 cases were suffering from chronic kidney disease, 4 cases were suffering from coronary artery disease, 29 cases were suffering from hypertension, 15 cases were suffering from hypothyroidism, FBS was normal in range in 174 cases and abnormal in 126 cases, HBA1C was normal in 174 cases and abnormal in 126 cases.
Conclusion: Strength of the study is that it was community based, making it more precise in the results and wider age groups have been included in the study. In spite of all the limitations, measuring upper body fat by neck circumference is a reasonable method to evaluate the obesity status.

Keywords: neck circumference, obesity, BMI, hypertension, metabolic syndrome, diabetes, HBA1C

Introduction

Body fat composition and its distribution are associated with cluster of complications such as dyslipidemia, insulin resistance (IR), type 2 diabetes mellitus and cardiovascular diseases (CVD) in children, adolescents and adults. The gold standard tools for assessing body adiposity are imaging studies - computed tomography, magnetic resonance and dual energy X-ray absorptiometry (DEXA). Because of its high cost, they are not applicable in all circumstances. Application of anthropometric measurements such as body mass index (BMI), waist circumference (WC) and neck circumference (NC) are appreciated in routine clinical practice and in epidemiological studies due it's advantages - being quicker, non-invasive, more accessible, and cheaper than imaging studies [1].

Having international reference standards, BMI is currently the most common method used for the diagnosis of overweight and obesity in children and adolescents. Even though it is not applicable is assessing people's own risks of endocrine and metabolic complications, as it does not calculate body fat distribution. As a predictor of insulin resistance, WC has been involved in the diagnosis of metabolic syndrome (MS) and in the assessment of CVD risk in adolescents. However, utilization of WC measurement have few restrictions in adolescent age group, such as the nonexistence of a standard method of measurement; lack of an international standard due to

Corresponding Author:
Dr. Mahesha Chikkachannappa
M S (General Surgery), Aster CMI
Hospital, Bengaluru, Karnataka,
India

ethnic variation; unavailability of a cutoff point for cardiovascular and metabolic risks; and practical hindrances during measurement, such as the need to undress, particularly during winter. This may also have a psychological effect on this age group [2].

Studies comprising adults have recommended using NC as a substitute to WC because of some benefits over WC measurement. As NC is a simple and more practical anthropometric indicator and does not altered by postprandial abdominal distension or by respiratory movements. According to these studies, this measurement also offer stable results even in the presence of excess subcutaneous fat in the upper body. Increase in NC, as well as visceral fat, is found to be associated with cardiometabolic risks. Studies involving adults also found a positive correlation of NC with IR, components of MS, and cardiovascular risk factors. There is dearth in studies that evaluate NC in adolescents [3].

The epidemic of obesity constitutes a worldwide major health problem; its consequences on the occurrence of cardiovascular diseases, type 2 diabetes are major concerns for physicians because of the associated poor quality of life, increased morbidity and mortality. The risk of obesity are increasing through multiple interplaying factors including changes in dietary habits, and in behavioral factors associated with sedentary lifestyles. Such tremendous lifestyle changes seemed to have fueled the obesity epidemic in the country and resulted in the most rapidly increasing prevalence of obesity in the world. Hence, continuous monitoring of obesity is essential to estimate the magnitude of the problem, allocate resources and to implement effective interventions [4].

As there are some benefits of NC measurement such as simple, cost-effective, stable throughout the day, more reasonable in cold weathers, suitable in conservative communities -Middle East, Gulf countries also, it is applicable in morbidly obese, where the abdominal belly hinders accurate measurements of waist and hip circumferences. In this backdrop the study was designed to explore performance of neck circumference to predict obesity and metabolic syndrome and thus to forecast cardiometabolic risks among adults.

Aims and Objectives
To explore performance of neck circumference to predict obesity and metabolic syndrome among adults.

Research Methodology
In this prospective study, totally Three hundred cases of both sexes, between 30 to 75 years old, were evaluated. A convenience sampling strategy was used. The sample comprised cases treated at an outpatient clinic for obese children and adolescents in the Hospital. The study included overweight, obese, and normal weight subjects, according to criteria from the *Centers for Disease Control and Prevention* (CDC). Exclusion criteria were: cervical lymph nodes or deformities, goitre, late neuropsychological and motor development, congenital syndromes, hepatopathy, nephropathy, metabolic disorders (such as type 1 diabetes, hypothyroidism, and) and use of systemic corticosteroids.

Results

Table 1: Age wise distribution of cases:

Age Group	Number of cases
< 31 Years	17
31 To 40 Years	70
41 To 50 Years	43
>50 Years	170
Total	300

As per table 1, 17 cases belongs to age group of less than 31 years, 70 cases belongs to 31 to 40 year group, 43 cases belongs to 41 to 50 year group and 170 cases belongs to more than 50 year age group.

Table 2: Sex wise distribution of cases

Sex	Number of cases
Male	159
Female	131
Total	300

As per table 2, 159 cases were male and 131 cases were female.

Table 3: Distribution of cases based on BMI:

BMI	Number of cases
Underweight (under 18.5 kg/m^2)	01
Normal weight (18.5 to 24.9)	84
Overweight (25 to 29.9)	152
Obese (30 or more)	63
Total	300

As per table 3, one case belongs to underweight category, 84 cases belongs to normal weight category, 152 cases belongs to overweight category and 63 cases belongs to obese category.

Table 4: Distribution of cases based on neck circumference

Sex	Male (157)		Female (133)	
	<37 CMS	>37CMS	<34CMS	>34CMS
	32	127	47	84
Total	159		131	

As per table 4,
In males, 32 cases NC was less than 37 cms and 127 cases was more than 37 cms
In females, 47 cases NC was less than 34 cms and 84 cases was more than 34 cms.

Table 5: Distribution of cases based on diabetes

Diabetes	Number of cases
Yes	86
No	214
Total	300

As per table 5, 86 cases were suffering from diabetes.

Table 6: Distribution of cases based on hyperlipidemia

Hyperlipidemia	Number of cases
Yes	135
No	165
Total	300

As per table 6, 135 cases were suffering from hyperlipidemia.

Table 7: Distribution of cases based on chronic kideny disease

Chronic kideny disease	Number of cases
Yes	02
No	298
Total	300

As per table 7, 2 cases were suffering from chronic kidney disease.

Table 8: Distribution of cases based on coronary artery disease:

Coronary disease	Number of cases
Yes	04
No	296
Total	300

As per table 8, 4 cases were suffering from coronary artery disease.

Table 9: Distribution of cases based on hypertension:

Hypertension	Number of cases
Yes	29
No	171
Total	300

As per table 9, 29 cases were suffering from hypertension.

Table 10: Distribution of cases based on hypothyroidism

Hypothyroidism	Number of cases
Yes	15
No	185
Total	300

As per table 10, 15 cases were suffering from hypothyroidism.

Table 11: Distribution of cases based on FBS:

FBS	Number of cases
Normal value	174
Abnormal value	126
Total	300

As per table 11, FBS was normal in range in 174 cases and abnormal in 126 cases.

Table 12: Distribution of cases based on neck hba1c:

Hba1c	Number of cases
Normal Value	174
Abnormal Value	126
Total	300

As per table 12, HBA1C was normal in 174 cases and abnormal in 126 cases.

Discussion
Out of 300 study participants, 159 cases were male and 131 cases were female. In the present study, 17 cases belongs to age group of less than 31 years, 70 cases belongs to 31 to 40 year group, 43 cases belongs to 41 to 50 year group and 170 cases belongs to more than 50 year age group. Based on BMI, one case belongs to underweight category, 84 cases belongs to normal weight category, 152 cases belongs to overweight category and 63 cases belongs to obese category. In males, 32

participants had NC less than 37 cms and 127 participants had more than 37 cms and In females, 47 participants had NC less than 34 cms and 84 participants had more than 34 cms. Among the total study participants 86 cases were suffering from diabetes, 135 cases were suffering from hyperlipidemia, 2 cases were suffering from chronic kidney disease, 4 cases were suffering from coronary artery disease, 29 cases were suffering from hypertension, 15 cases were suffering from hypothyroidism. Biochemical parameters like FBS and HBA1C was within normal range in 174 cases and elevated in 126 cases.

A cross-sectional study at Saudi was conducted by Rasmieh A. *et al*., which included 3063 adult Saudis (1156 males and 1907 females) with a mean age of 38.6 ± 14.1 years. In their study NC was compared to appropriate anthropometric measures to predict obesity and MetS using Receiver Operator Characteristic (ROC) analyses. Youden index graph applied to assess the discriminating power between obese and non-obese patients and they estimated the adjusted Odds Ratio (OR) to delineate the association between NC and the outcome variables by multiple logistic regression analysis. They observed the following findings - ROC analyses demonstrated good performance of NC for general obesity, central obesity and MetS; as a predictor of obesity in non-diabetics, Area Under the Curve (AUC) ranged from 0.77–0.86. In MetS, AUC was 0.77 and 0.82 for males and females respectively. The best cutoff values of the NC to predict obesity were ≥ 37.5 cm for males versus ≥ 32.5 cm for females. The results of adjusted logistic regression analysis adjusted for age and waist height ratio, revealed a consistent positive association between NC, general obesity, MetS, and central obesity: ORs were 4.26, 3.03, 1.45 for males versus 4.65, 3.66, and1.47 for females respectively. Thus according to their findings NC stands out as an independent predictor of obesity and the MetS. Because of its stability, easiness of application, low cost and the cultural acceptance, NC measurement among Saudis under community settings substantiate its use as a screening tool for general and central obesity as well as MetS and as an added routine measurement for health professionals [5]. Another cross-sectional study by Cleliani de Cassia da Silva. *et al*., 388 adolescents of both genders from 10 to 19 years old were studied. In this study the adolescents underwent anthropometric and body composition assessment, including neck and waist circumferences, and biochemical evaluation. Receiver Operating Characteristic Curve is used to asses association between the performance of neck circumference and insulin resistance. After the adjustment for percentage body fat and pubertal stage, neck circumference correlated with waist circumference, blood pressure, triglycerides and markers of insulin resistance in both genders. The results showed that the neck circumference is a useful tool for the detection of insulin resistance and changes in the indicators of metabolic syndrome in adolescents. These findings identifies that the easiness of application and cost effectiveness of this measure may allow its use in Public Health services [6].

A cross-sectional study conducted in Thailand by Thunyarat Anothaisintawee. *et al*., which included 1,534 adult patients with prediabetes Measurement of waist circumference has substantial variability and some limitations, while neck circumference is a simple and reliable anthropometric measure. This study aimed to assess the association between neck circumference and waist circumference and to identify the best cutoff of neck circumference that could predict central obesity in prediabetic patients. The correlation between neck circumference and waist circumference was explored by applying pairwise correlation coefficient. Receiver operating characteristic (ROC) curve

analysis was performed and Youden index equal to "sensitivity – (1-specificity)" was calculated. Neck circumference that yielded the maximum Youden index was determined as the optimal cutoff point for prediction of central obesity. They found that, after adjusting for covariables, neck circumference was found to be significantly associated with waist circumference in both females and males, with *β*-coefficients of 1.01 (95% CI: 0.83, 1.20) and 0.65 (95% CI: 0.46, 0.85), respectively. After applying the ROC analysis, neck circumferences ≥ 32 cm in females and ≥ 38 cm in males were determined as the best cutoff values to predict central obesity. Neck circumference is strongly correlated with waist circumference in prediabetics and should be considered as an alternative to the waist circumference measurement in screening for central obesity [7].

Additionally a cross-sectional study by Thunyarat Anothaisintawee. *et al*., involving 623 women aged 18-70 years, designed to evaluate the potency of neck circumference for identifying cardiometabolic risk factors, and determining the neck circumference cutoff value for the prediction of metabolic syndrome (MetS). According to this study it was identified that NC was independently associated with all cardiometabolic risk factors in adult Saudi women (*P*<0.001), except LDLc. After adjusting to odds ratio (95% confidence interval [CI]) values for incremental increases in neck circumference in women were reported for raised fasting glucose levels, 1.70 (1.48–2.94); raised blood pressure, 1.29 (1.15–1.45); high triglycerides, 1.25 (1.13–1.38); insulin resistance, 1.20 (1.02–1.40); and low HDLc, 1.14 (1.02–1.40). Women in the largest neck circumference quartile were 13 times more likely [13.39 (6.35 - 28.23)] to have MetS than the lowest neck circumference quartile after adjusting for confounding factors (*P*<0.01). They proposed that the appropriate neck circumference to predict ≥ 3 cardiometabolic risk factors in Saudi women was 35 cm. This cutoff value was associated with the risk of metabolic syndrome in participants with both high and normal body mass index and waist circumference values [8].

Even though diagnostic accuracy of our study was less when compared to the study conducted by Ben noun *et al* and Xuhong Wang *et al*, A study by Ashwathappa *et al* showed the sensitivity and specificity for their critical cut off point to be 71.25% and 80.61% in males respectively; in females it was 63.99% and 68% respectively. Our study showed higher sensitivity and lower specificity in males and females as compared to their study. A study conducted by Sunilkumar *et al* also showed lower sensitivity but higher specificity in males when compared to our study; in females the sensitivity and specificity were higher when compared to our study. Studies by Sunilkumar *et al* and Ashwathappa *et al* have used similar guidelines for Body mass index as used in our study.

Conclusions
According to the World health Organisation's criteria for a good screening test, our neck circumference measurement tool for evaluation of overweight and obesity fulfilled majority of the criteria. To mention, measuring neck circumference was found to be a fair screening test of an individual to evaluate obesity and overweight. The cutoff of 36.50cm in males and 32.50cm in females will help to screen the population of Asian Indian origin. The sensitivity of this screening test for this cut off was 84.85% and 73.68% in males and females respectively. Measuring neck circumference is easy, less time consuming, less cumbersome and socially acceptable procedure when compared to measurement of waist circumference. On financial point of view, it is very cost effective method. Thus, this method can be used to screen individuals for overweight and obesity in peripheral areas, where the facility of measuring the weight is not available. Training for peripheral workers is easy, because it is a simple to teach them. Hence, for a developing country like India, which is facing a double burden of nutrition transition, neck circumference will be a feasible method to screen obesity in adults. Few limitations of the study are less sample size. Thus, studies with larger sample size, in different ethnicity, geographic locations and studies to establish the intra observer variation and inter observer variations are recommended. Strength of the study is that it was community based study and to making it more precise in the results wider age groups have been included in the study. In spite of the limitations, measuring upper body fat by neck circumference is a reasonable method to evaluate the obesity status.

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