ORIGINAL RESEARCH ARTICLE

Neck Circumference: A Novel Anthropometric Tool for Screening Obesity Among Young Adults

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ABSTRACT

Background: Obesity is a global health concern characterized by excessive fat accumulation, posing significant health risks that affect all age groups. Particularly among young adults, including medical students, obesity can lead to physical and psychosocial consequences, emphasizing the need for effective screening. The study was conducted to evaluate the effectiveness of using neck circumference as a screening tool for detecting obesity among young adults by assessing its correlation with other anthropometric measurements and determining the appropriate cut-off points

Methodology: A cross-sectional study was conducted among 146 medical students at the Apollo Institute of Medical Sciences and Research, Chittoor, Andhra Pradesh. Data were collected using a semi-structured questionnaire and various anthropometric measurements, including neck circumference.

Results: Neck circumference was higher among males, with a mean of 34.4±2.1cm for males and 30.2±1.9cm for females. Neck circumference showed significant positive correlations with height, weight, Body Mass Index, waist-hip ratio, hip and waist circumference. Neck circumference is proposed as a screening tool for assessing obesity among young adults, with cut-off values of 34cm for males and 30cm for females.

Conclusions: Neck circumference is an effective screening tool for obesity among young adults, correlating with conventional anthropometric measures.

Keywords: Anthropometry, Body Mass Index, Medical students, Neck circumference

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INTRODUCTION

Obesity is recognized as an escalating global epidemic. The World Health Organization (WHO) defines overweight and obesity as the excessive or abnormal accumulation of fat, which poses substantial health risks. The WHO classifies adults with a body mass index (BMI) over 25 as overweight, and those with a BMI over 30 as obese for the global population.[1] In 2022, among the 2.5 billion adults aged 18 and older who were overweight, over 890 million were classified as obese. This indicates that 1 in 8 people worldwide was affected by obesity.[2] The prevalence of overweight or obesity in India increased from 18.9% to 22.9% in men and from 20.6% to 24% in women as per fourth and fifth rounds of the National Family Health Survey (NFHS).[3]

Obesity is a multifaceted issue with significant physical, psychosocial implications, affecting people across all ages and socioeconomic statuses. It significantly increases the risk of non-communicable diseases like stroke, diabetes mellitus, hypertension, cardiovascular diseases, and various cancers. The health impacts include a heightened risk of early mortality and morbidity that can drastically diminish quality of life.[1]

Various anthropometric measurements are used worldwide to determine obesity. Body mass index (BMI) has frequently been used to analyse obesity in the general population; however, it cannot determine body fat distribution or distinguish between muscle and body fat mass.[4] Measuring waist circumference has limitations due to its time-consuming nature, cultural acceptability, and the need to uncover parts of the body. Additionally, waist circumference can be influenced by factors such as pregnancy, postprandial distension of the abdomen, and respiration.[5] Neck circumference (NC) offers several practical advantages due to its simplicity, time efficiency, and non-invasive nature. NC does not require uncovering the body, making it more culturally acceptable and easier to measure consistently across diverse populations particularly among females. It is also less affected by temporary conditions such as bloating, fluid retention, or recent food intake, providing a more stable and reliable indicator of adiposity. NC is also useful for special populations, such as those who are pregnant or have undergone abdominal surgery, where other measurements may be difficult to perform. It is especially beneficial in resource-limited settings and in clinical settings where quick and accurate assessments are essential.

Given these limitations, there is a need for more acceptable and reliable indicators for assessing obesity. Researches have highlighted neck circumference (NC) as a novel screening tool for measuring obesity.[5-7] Neck circumference also serves as an indicator of upper body fat distribution.[8] The Framingham Heart Study found that neck circumference, a marker of upper-body subcutaneous fat, is linked to cardiometabolic risk independently of visceral adipose tissue (VAT) and Body Mass Index (BMI).[9] There is a positive correlation between neck circumference and metabolic risk factors, establishing it as an independent determinant for cardiometabolic syndrome.[10] Additionally, there is a positive correlation between neck circumference and other indicators like BMI, waist-to-hip ratio (WHR) and waist circumference (WC).[11] Given its non-invasive and cost-effective nature, neck circumference measurement holds significant potential for widespread use in various populations.

Obesity in young adults can have profound adverse effects on their lives. Medical undergraduate students are particularly prone to obesity due to sedentary lifestyles and erratic eating habits, which increase the risk of obesity-related health issues. Academically, young adults with obesity often experience diminished performance, potentially due to factors such as reduced physical activity, social stigma, and related psychological issues like depression and anxiety. Furthermore, the social stigma associated with obesity can result in lower self-esteem and social isolation, exacerbating mental health issues and hindering personal and professional development.[12] Thus, early screening for obesity is essential. Thus, this study seeks to evaluate the effectiveness of neck circumference as a novel screening method for detecting obesity among young adults.

Objectives

To evaluate the effectiveness of using neck circumference as a screening tool for detecting obesity among young adults by assessing its correlation with other anthropometric measurements and determining the appropriate cut-off points.

METHODOLOGY

Study design and setting: From September to October 2023, a cross-sectional study was carried out among the medical undergraduate students at Apollo Institute of Medical Sciences and Research in Chittoor, Andhra Pradesh, including those from all four academic years who provided written informed consent, while excluding individuals with thyroid enlargement or neck abnormalities.

Sample size estimation and sampling method: Based on a prior study by Raju A et al.,[4] which found an 84.4% sensitivity of neck circumference for assessing obesity in young adult females, sample size was determined to be 146. This calculation was based on a 95% confidence level, 80% power, and 6% absolute precision. Students were chosen through simple random sampling using a random number generator.

Data Collection Method: Data were gathered using a semi-structured questionnaire that had been pretested and validated, which included details regarding socio-demographic data and anthropometric measurements. Anthropometric measurements such

as neck circumference, hip circumference, waist circumference, waist-hip ratio, weight, height, and BMI, were assessed. Anthropometric measurements were conducted in a dedicated room to ensure privacy. The collected data were kept confidential.

Assessment tool: Height was recorded with a stadiometer, accurate to the nearest 10 mm, while weight was measured using an analogue weighing scale with 0.1 kg precision.[13] Body mass index (BMI) was determined by dividing weight (kg) by the square of height (m^2). Waist and hip circumferences were gauged with a measuring tape, precise to 0.1 cm, and the waist-to-hip ratio was computed.[11] Neck circumference was assessed at the midpoint of the cervical spine and the midpoint of the anterior neck while the participant stood with arms relaxed, using a non-stretchable plastic tape. For men with a laryngeal prominence, the measurement was taken just below it.[14] All observations were recorded in the study proforma.

Statistical methods: The collected data after entering into Excel was analysed with SPSS version 26. Descriptive statistics were presented as percentages and mean/standard deviations. The Pearson correlation coefficient (r) was used to assess the relationship between neck circumference and various anthropometric measurements. Receiver operating characteristic (ROC) analysis was conducted to determine the cutoff values for classifying obesity versus non-obesity. Diagnostic accuracy was evaluated, and a p-value of less than 0.05 was deemed statistically significant.

Ethical considerations: Approval for the study was granted by the Institutional Ethics Committee [UG/22/IEC/AIMSR/2023]. Participants meeting eligibility criteria were enrolled after taking written informed consent.

Table 1: Anthropometric Measurements of Participants Based on Gender

Anthropometric Measurements	Male (n=72) Mean ± SD*	Female (n=74) Mean ± SD*
Height (cm)	173 ± 13.8	157.2 ± 6.1
Weight (Kg)	77.55 ± 12.9	64.14 ± 13.07
BMI (Kg/m^2)	25.85 ± 4.3	24.4 ± 5.1
Waist circumference (cm)	100.6 ± 8.7	99.1 ± 13.5
Hip circumference (cm)	87.3 ± 11.1	82.57 ± 11.4
Waist Hip ratio	0.84 ± 0.06	0.79 ± 0.06
Neck circumference (cm)	34.4 ± 2.1	30.2 ± 1.9

*SD -Standard deviation

Table 2: Distribution of BMI Categories of Participants Based on Gender

BMI Category*	Male (n=72) (%)	Female (n=74) (%)
Underweight (< 18.5 Kg/m^2)	7 (9.72%)	12 (16.22%)
Normal (18.5 to 22.99 Kg/m^2)	18 (25%)	16 (21.62%)
Overweight (23–24.99 Kg/m^2)	12 (16.67%)	12 (16.21%)
Obese I and II (≥ 25 Kg/m^2)	35 (48.61%)	34 (45.95%)

*Categorised based on the WHO BMI classification for Asian adult population[15]

Table 3: Association between the Neck Circumference and various Anthropometric Measurements

Anthropometric Measurements	Male		Female	
	r**	p	r**	p
Height (cm)	0.486	0.01*	0.427	0.02*
Weight (Kg)	0.724	<0.01*	0.711	<0.01*
BMI (Kg/m^2)	0.761	<0.01*	0.735	<0.01*
Hip circumference(cm)	0.774	<0.01*	0.849	<0.01*
Waist circumference (cm)	0.681	<0.01*	0.582	<0.01*
Waist Hip ratio	0.425	<0.01*	0.339	0.01*

*p-value <0.05, considered as statistically significant.
**r- Pearson's correlation coefficient

RESULTS

Socio-Demographic Characteristics of the Participants: Among the 146 participants, 72 (49.32%) were males, and 74 (50.68%) were females. The average age of the study subjects was 20.0± 1.0 years. The average age for male participants was 21.1 ± 1.0 years, whereas for female participants, it was 20.0 ± 1.0 years. The participants were predominantly Hindu, with 128 (87.67%), followed by 13 Muslims (8.90%) and 5 Christians (3.42%).

Anthropometric Measurements of Participants Based on Gender: The anthropometric indicators like neck circumference, height, weight, BMI, hip circumference, waist circumference, and waist-hip ratio were evaluated. The mean neck circumference was 34.4 ± 2.1 cm for males and 30.2 ± 1.9 cm for females. All anthropometric measurements were higher among male participants compared to female participants. [Table 1]

Distribution of BMI Categories of Participants Based on Gender: The participants were categorized based on the WHO BMI classification for Asian adult population.[15] The prevalence of obesity was 35 (48.61%) among male participants and 34 (45.95%) among female participants. [Table 2]

Association between Neck Circumference and Other Anthropometric Measurements: Pearson correlation coefficients were calculated between neck circumference and other anthropometric measurements, stratified by gender. Neck circumference was positively correlated with weight, height, BMI, waist-hip ratio, hip circumference, and waist circumference in both genders, with all relationships being statistically significant ($p < 0.05$). The correlation coefficients between neck circumference and hip circumference were the highest for both males ($r=0.774$) and females ($r=0.849$), and these associations were statistically significant ($p<0.01$) in both genders. [Table 3]

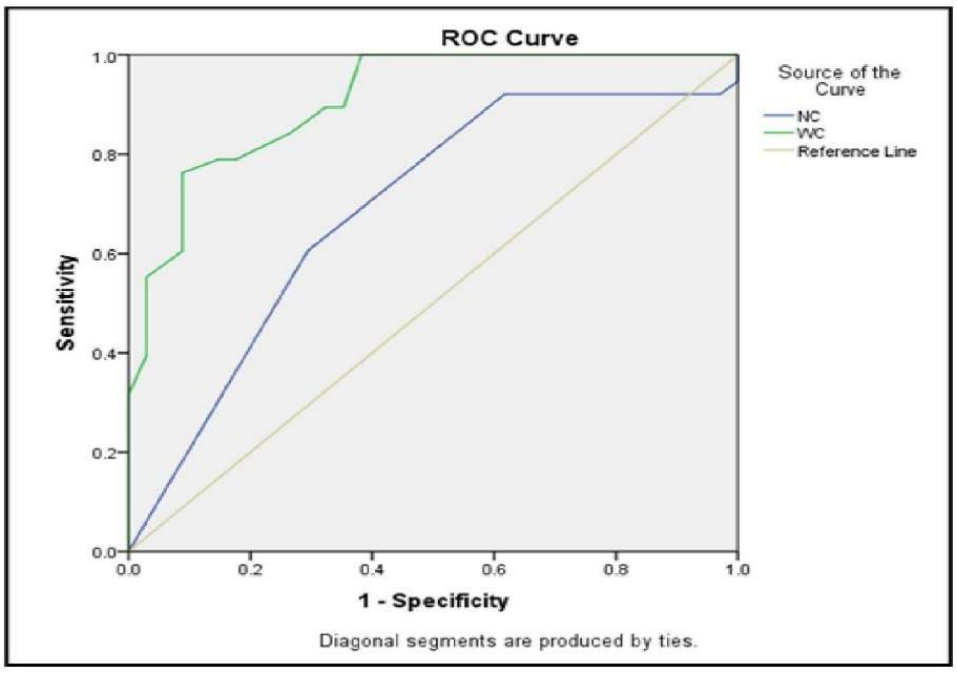

Figure 1: ROC Curve among Male study participants

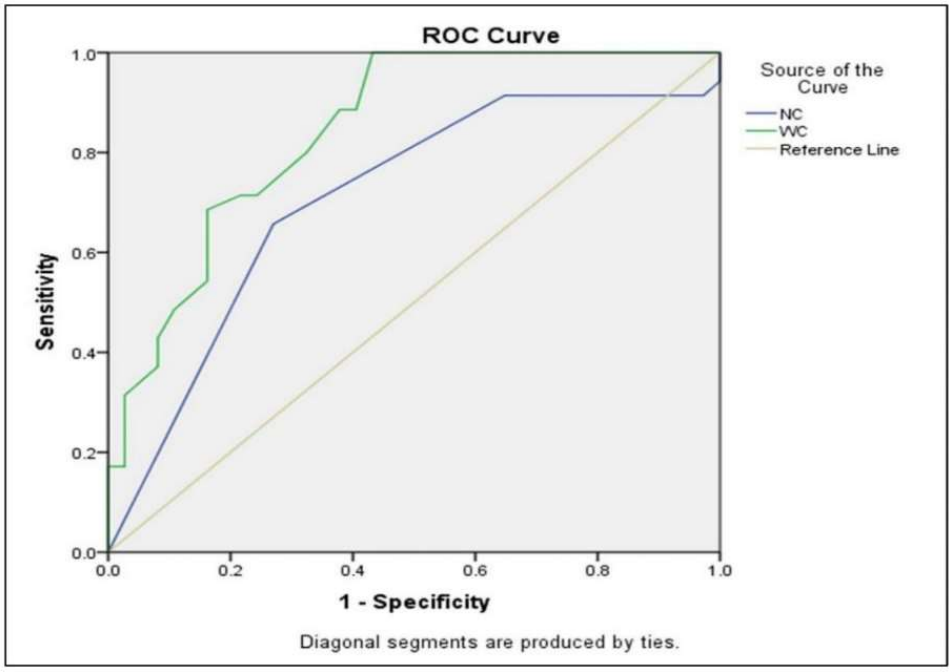

Figure 2: ROC Curve among Female study participants

Table 4: Relationship between Neck Circumference and BMI among Male study participants

Males	Obese (NC≥34cm)	Non-Obese (NC<34cm)	Total	Sensitivity & Specificity
Obese (BMI ≥ 25 kg/m²)	25 (48.08%)	12 (60%)	37	Sensitivity= 77.3%
Non-obese (BMI < 24.9 Kg/m²)	27 (51.92%)	8 (40%)	35	Specificity = 69.6%
Total	52 (100%)	20 (100%)	72	

Table 5: Relationship between neck circumference and BMI in Female study participants

Females	Obese (NC ≥30cm)	Non-Obese (NC <30cm)	Total	Sensitivity & Specificity
Obese (BMI ≥ 25 Kg/m²)	28 (50.91%)	6 (30%)	34	Sensitivity =75.4%
Non-obese (BMI < 24.9 Kg/m²)	27 (49.09%)	14 (70%)	40	Specificity =71.7%
Total	55 (100%)	20 (100%)	74	

Area under Receiver Operating Characteristic (ROC) curve of neck circumference against BMI was 0.707 (0.584-0.830) for males and 0.729 (0.611-0.847) for females. The analysis was performed using a BMI cutoff of ≥ 25 Kg/m^2. Before plotting ROC curve of neck circumference against waist circumference (WC), WC was categorized into 2 groups as normal (<90cms in males & <80cms in females) and abnormal (≥ 90cms in males & ≥ 80cms in females) waist circumference as per gender specific - Asian cut-off points for adults.[15] Considering NC as test variable which is a continuous variable and WC as a categorical variable (normal and abnormal), ROC curve was plotted for males and females separately. The AUC for neck circumference against waist circumference was 0.744 (0.630-0.858) for males and 0.844 (0.756-0.933) for females. [Figures 1 and 2].

The best cut-off for males was 34 cm, with a sensitivity of 77.3% and a specificity of 69.6%. [Table 4] For females, the best cut-off was 30 cm, with a sensitivity of 75.4% and specificity of 71.7%. [Table 5] These ROC curves indicate that neck circumference is a viable measure for assessing obesity in males and females.

Discussion

In this study, the average neck circumference was 34.4 ± 2.1 cm for male participants and 30.2 ± 1.9 cm for female participants. These findings are consistent with previous studies,[4,11,17] Consistent with prior research, males exhibited higher mean values across all anthropometric measurements compared to females[11,18] This study reports obesity prevalence rates of 48.61% among male participants and 45.95% among female participants, according to the WHO BMI classification for the Asian adult population. In comparison, a study by Raju A et al. among medical students in Pondicherry found obesity prevalence rates of 57% for males and 45% for females.[4] The higher obesity prevalence in these studies may be attributed to the homogeneous nature of the participants, who are all young adults.

In this study, we identified neck circumference cut-offs of 34 cm for males and 30 cm for females, which demonstrated good sensitivity and specificity for predicting obesity. These cut-offs are comparable to those found in a study conducted among young adults in Puducherry, India.[4] However, higher cut-offs were observed in studies from other countries,[18,19] possibly due to ethnic, genetic, and environmental differences. The present study found that neck circumference was statistically significant and positively correlated with weight, height, BMI, waist-hip ratio, hip circumference, and waist circumference in both genders. A study done by Raju A et al. also found statistically significant correlation between neck circumference and various anthropometric measurements similar to this study, except for height in both genders and waist-hip ratio in females.[4] Previous research done among young adults has also shown a statistically significant correlation between neck circumference and conventional anthropometric measures of obesity.[4,7,11,17,18] Studies done among children,[20] adolescents[16] and adults,[14,21] have also shown positive correlations of neck circumference with other anthropometric measurements.

In the present study, neck circumference is proposed as a screening tool for young adults. Previous research has similarly recommended neck circumference as an obesity predictor for young adults.[4,11,13,22] Other studies have suggested neck circumference as a screening tool for obesity in children,[20] adolescents,[16] and adults.[14,21] Furthermore, several studies have associated increased neck circumference with cardiovascular risk factors and metabolic syndrome.[23-25] R K et al. found that participants preferred neck circumference measurements over other anthropometric methods.[22] Neck circumference is a tool that can be easily integrated into primary care for screening of obesity. Its use in clinical examinations can effectively identify a significant risk factor for non-communicable diseases. The neck circumference measurement is quick, applicable in various environments, and unaffected by factors such as fasting-satiety, clothing, ambient temperature, and sociocultural limitations. It is less intrusive than waist circumference and less cumbersome than BMI. Additionally, it is cost-effective, making it suitable for use in developing countries like India. Thus, neck circumference has the potential to be an alternative, low-cost, and practical screening indicator of obesity among young adults. Implementing neck circumference measurements in routine clinical practice could enhance obesity screening and early identification of individuals at risk for obesity-related health conditions.

The study's cross-sectional design restricts the ability to determine causality in the observed associations. As the study population comprises solely young adults from a single medical college, this may restrict the generalizability of the results. Employing a multicentric approach involving diverse age groups and institutions could have improved the generalizability. Furthermore, the study was conducted on a relatively small population size, demanding further research with larger sample sizes to validate the identified cut-off values for defining obesity.

Further large-scale studies are needed to establish standardized thresholds based on ethnicity, age, and other factors. Standardized neck tapes with a colour-coded range could facilitate easy screening and grading of obesity. This study underscores the need to promote healthy lifestyles, balanced diets, and physical activity among young adults. Heightened awareness about obesity and its associated complications is essential, necessitating the implementation of screening sessions and awareness programs.

Conclusion

The study highlighted neck circumference as an efficient predictor of obesity among young adults. Obesity is becoming a major health issue in this demographic group, as revealed by the noteworthy prevalence rate of obesity among the study participants. Neck circumference is found to be an easy-to-measure screening tool for obesity among young adults, offering good sensitivity and specificity. It demonstrated statistically significant correlations with conventional anthropometric measurements and established reliable cut-off points for identifying obesity in both genders. Neck circumference showed a positive correlation with BMI, which indicates general obesity, as well as with waist circumference, which reflects central obesity. Thus, it can be considered as a feasible alternative to more cumbersome measures such as BMI and waist circumference.

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