ORIGINAL RESEARCH ARTICLE

Understanding the Neck's Significance: Exploring Neck Circumference as a Marker for Obesity and Hypertension in Perambalur District's 40–70 Age Group

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ABSTRACT

Background: Neck circumference (NC) is an emerging anthropometric marker for assessing metabolic and cardiovascular health risks. This study assessed the relationship between NC and obesity prevalence and examined its potential as a predictive marker for hypertension among individuals in Perambalur District.

Methodology: This cross-sectional study included 392 participants aged 40-70 years. Anthropometric measurements and blood pressure were recorded. Correlational analyses and receiver operating characteristic curve (ROC) analyses evaluated the relationship between NC and health indicators.

Results: Weight showed a significant positive correlation with NC ($r = 0.272$, $p < 0.001$), with a stronger relationship in females ($r = 0.413$, $p < 0.001$). Blood pressure parameters demonstrated consistent positive correlations across the population (systolic: $r = 0.345$, $p < 0.001$; diastolic: $r = 0.337$, $p < 0.001$). ROC analyses revealed optimal cutoff points: NC ≥37.5 cm for males and NC ≥34.75 cm for females. The predictive power for hypertension was notably stronger, with AUC values of 0.726 for males and 0.797 for females ($p < 0.001$).

Conclusion: NC emerges as a promising anthropometric marker for assessing obesity and hypertension risks, with significant gender-specific variations. This simple, cost-effective screening tool shows utility for cardiovascular and metabolic health risk assessment in adults.

Keywords: Obesity, Hypertension, ROC curve analyses, Sensitivity, Specificity

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INTRODUCTION

Obesity and hypertension represent formidable global public health challenges with far-reaching consequences. With 5 million deaths attributed to overweight and obesity-related complications in 2019 and approximately 10.4 million deaths linked to hypertension worldwide, these conditions constitute significant contributors to global morbidity and mortality.[1,2] In India, this health burden manifests distinctively, with urban areas reporting nearly 40% of adults as overweight or obese, while hypertension affects approximately 30-35% of the adult population.[3,4]

Traditional anthropometric measurements Body Mass Index (BMI), waist circumference, and waist-to-hip ratio have established utility in assessing metabolic risk.[5,6] However, these conventional markers present several limitations: BMI fails to differentiate between muscle mass and adipose tissue, waist circumference measurements can be challenging in certain populations, and both metrics may be influenced by various physiological states.[7,8] These limitations have spurred investigation into alternative anthropometric markers with enhanced clinical utility and practical application.

Neck circumference (NC) has emerged as a promising alternative anthropometric measure with distinct advantages over traditional markers. Unlike waist circumference, which requires partial disrobing, NC can be measured with minimal intrusion and remains unaffected by respiratory movements or postprandial abdominal distension.[9,10] The Framingham Heart Study positioned NC as a novel measure of cardiometabolic risk, challenging conventional assessment methods.[11] Subsequent research has demonstrated NC's correlations with various metabolic parameters, including insulin resistance, dyslipidaemia, and hypertension.[12–17]

When directly compared with traditional markers, NC offers several clinically relevant advantages. Studies have found NC to be as effective as waist circumference in diagnosing metabolic syndrome, while being more practical to obtain in clinical settings.[18] Research by Joshipura et al. demonstrated that NC showed comparable or superior relationships with metabolic variables relative to waist circumference, suggesting NC might be preferable in certain contexts.[19] Furthermore, Onat et al. found that NC predicts metabolic syndrome and obstructive sleep apnoea beyond waist circumference.[20]

The specific anatomical location of neck fat deposits may explain NC's unique predictive capabilities. Unlike abdominal fat, which is compartmentalized into subcutaneous and intra-abdominal deposits, neck fat represents a distinct compartment with potentially different metabolic implications.[21] Fat accumulated in the upper body, such as neck fat, may be associated with higher metabolic risk compared to abdominal deposits, making NC a potentially more sensitive indicator of cardiometabolic risk.[11,21]

While studies in various geographical contexts have established NC's potential as an anthropometric marker, significant research gaps exist in the Indian context, particularly regarding age-specific and region-specific reference values. Previous Indian studies from coastal Karnataka and central India have explored NC's utility as a screening tool but were limited by geographical scope or demographic breadth.[4,22] No comprehensive studies have investigated the specific utility of NC among middle-aged and older adults in rural and urban settings in Tamil Nadu, particularly in Perambalur District a population with distinctive demographic and health characteristics.

The 40-70 age group represents a critical demographic for metabolic health investigations due to increased susceptibility to metabolic disorders, age-related physiological changes, and cumulative lifestyle impacts. Additionally, measuring traditional anthropometric characteristics in older adults presents unique challenges that NC measurement may circumvent.[10,23] By focusing on this specific age cohort in Perambalur District, this study aims to address these research gaps by providing localized insights into NC's utility as a predictive marker for obesity and hypertension, potentially informing culturally appropriate and age-specific screening strategies.

This research advances previous studies by: (1) establishing gender-specific NC cutoff values for a previously unstudied population, (2) directly comparing NC's diagnostic capabilities with traditional anthropometric measures, and (3) developing practical recommendations for incorporating NC measurements into primary healthcare settings with resource constraints. These contributions address critical gaps in the evidence base for anthropometric assessment in Indian populations.

METHODOLOGY

Study Design and Setting: This cross-sectional study was carried out from January to August 2024 in the rural and urban field practice regions of Dhanalakshmi Srinivasan Medical College and Hospital in Tamil Nadu, India's Perambalur district. The participants in the study were people between the ages of 40 and 70 who lived in the chosen rural and urban areas.

Inclusion and Exclusion criteria: Inclusion criteria comprised individuals aged 40-70 years, permanent residents of Perambalur District, and those providing voluntary written informed consent. Exclusion criteria were meticulously developed to minimize potential confounding factors, eliminating participants with known underlying medical conditions such as neurological disorders, cardiovascular diseases, thyroid disorders, or those unable to provide accurate anthropometric measurements.

Sample Size Calculation and sampling method: Based on preliminary data and existing research by According to Caro et al (2018) study [7], considering the sensitivity of Predictive capacity of neck circumference as 97.6% with a precision of 5% and 95% confidence interval, the sample size is calculated using the formula $\mathbf{N = Z^2_{1-\alpha/2} * Sn * (1 - Sn) / p * d^2}$

The calculated samples size was 360.

Thus, the minimum sample size required for the study is 360. In our study, data was collected from 392 participants. This sample size provided sufficient statistical robustness to detect meaningful correlations and explore gender-specific variations in neck circumference measurements. A convenient sampling method was employed, targeting accessible populations within the rural and urban field practice regions of a tertiary medical college in Perambalur district. Random sampling techniques cannot be carried out due to time constraints. The geographical dispersion of the region further complicates random sampling. Additionally, characteristics of the population include natural clustering of the target population in easily accessible areas and concentrate on a certain subset that is easily accessible. Due to demographic homogeneity, selection bias can be lessened.

Data collection procedures: After obtaining informed consent, sociodemographic details of the participants such as age, gender, residence, occupation, education were collected using a questionnaire. Anthropometric measurements were collected using standardized protocols recommended by international health research guidelines. Height and weight measurements followed the techniques outlined by Rimm et al. (1990), ensuring measurement accuracy and reliability. [5] BMI was calculated using the Quetelet index [Weight in kg/ (height in m)^2]. Hip circumference, waist circumference, neck circumference and waist hip ratio were measured using standardised protocols. Neck circumference was measured at the midpoint between the cervical spine and midline of the anterior neck using SECA 201 measuring tapes, a method validated by multiple studies including Hingorjo et al. (2012) and Zhou et al. (2013). [16,17]

Blood pressure measurements were obtained using calibrated Omron HEM-7120 digital sphygmomanometers, adhering to protocols established by Kearney et al. (2005) for global hypertension assessment.[2] Trained research assistants conducted measurements following a standardized five-minute resting period, minimizing potential measurement variations.

Ethical considerations: The study protocol received comprehensive review and approval from the Institutional Ethics Committee (IECHS/ IRCHS/ No.506) ensuring adherence to national and international ethical guidelines for human subject research. Written informed consent was obtained from all participants, maintaining transparency and voluntary participation principles consistent with medical research standards. All participant data were anonymized during collection and analysis, with strict confidentiality measures implemented to secure personal information through encrypted digital storage and restricted access protocols.

Statistical analysis: Data collected was entered in excel and analysed using SPSS version 26. Study population's characteristics were compiled using descriptive statistics, which were stratified by urban and rural areas. To evaluate the association between blood pressure, BMI, and neck circumference, Pearson's correlation coefficient was computed independently for participants in rural and urban areas. Using sensitivity and specificity estimates, receiver operating characteristic (ROC) curve analysis was used to identify the ideal neck circumference cut-off values for predicting obesity and hypertension in both rural and urban populations. Gender-specific analyses were conducted to explore potential differential associations, allowing for nuanced understanding of neck circumference as a health risk indicator across different population subgroups.

RESULTS

The study sample consisted of 392 participants, with the largest age group was 40-50 years, comprising 199 (50.8%) participants, followed by 51-60 years with 110 (28.1%) participants, and 61-70 years with 83 (21.2%) participants. Regarding gender composition, males slightly outnumbered females, with 218 (55.6%) male participants and 174 (44.4%) female participants. The occupational breakdown revealed a significant proportion of participants engaged in non-agricultural work, with 283 (72.2%) individuals in this category, compared to 109 (27.8%) involved in agricultural work. The educational status of the participants showed a nearly even distribution, with 202 (51.5%) participants being illiterate and 190 (48.5%) being literate.

Table 1: Demographic Characteristics of Study Participants in Perambalur District (N = 392)

Variables	Participants (%)
Age	
40-50 years	199 (50.8)
51-60 years	110 (28.1)
61-70 years	83 (21.2)
Gender	
Male	218 (55.6)
Female	174 (44.4)
Occupation	
Agricultural work	109 (27.8)
Non-agricultural work	283 (72.2)
Education	
Literate	190 (48.5)
Illiterate	202 (51.5)

Table 2: Anthropometric and Blood Pressure Measurements of Study Participants by Gender in Perambalur District (N = 392)

Predictor variables	Total (Mean ± SD)	Males (Mean ± SD)	Females (Mean ± SD)
Age (in years)	54.57 ± 36.93	52.95 ± 8.73	52.68± 10.34
Height (in metres)	1.61 ± 0.090	1.64 ± 0.080	1.57 ± 0.086
Weight (in kgs)	69.13 ± 10.33	72.15 ± 9.81	65.3 ± 9.71
BMI	26.6 ± 3.57	26.5 ± 4.11	26.73 ± 2.75
Head circumference (in cm)	101.52 ± 7.79	102.4 ± 7.56	100.36 ± 7.94
Waist circumference (in cm)	99.86 ± 8.57	100.97 ± 8.26	98.47 ± 8.76
Waist hip ratio	1.22 ± 4.85	1.42 ± 6.50	0.96 ± 0.04
Neck circumference (in cm)	37.28 ± 3.29	37.70 ± 2.22	36.75 ± 4.22
Systolic blood pressure (in mm hg)	136.39 ± 17.48	136.53 ± 16.97	136.21 ± 18.14
Diastolic blood pressure (in mm hg)	86.97 ± 11.37	87.79 ± 11.17	85.95 ± 11.56

Table 3: Correlation Analysis of Neck Circumference with Anthropometric and Blood Pressure Parameters by Gender

Study parameters	Correlation with Neck circumference								
	Total			Males			Females		
	r value	95% CI	P value	r value	95% CI	P value	R value	95% CI	P value
Height (meters)	-0.01	-0.109, 0.089	0.843	-0.028	-0.160, 0.105	0.711	0.034	-0.115, 0.182	0.623
Weight (in kgs)	0.272**	0.177, 0.361	<0.001	0.146	0.012, 0.275	0.05	0.413**	0.282, 0.529	<0.001
BMI (kg/m^2)	0.223	0.126, 0.315	<0.001	-0.246**	-0.369, -0.115	<0.001	0.212**	0.069, 0.347	0.002
SBP (mm Hg)	0.345**	0.254, 0.429	<0.001	0.353**	0.231, 0.464	<0.001	0.374**	0.239, 0.494	<0.001
DBP (mm Hg)	0.337**	0.246, 0.422	<0.001	0.301**	0.175, 0.417	<0.001	0.414**	0.283, 0.530	<0.001
HC (cm)	0.327**	0.235, 0.413	<0.001	0.318**	0.193, 0.432	<0.001	0.342**	0.205, 0.466	<0.001
WC (cm)	0.312**	0.219, 0.399	<0.001	0.287**	0.160, 0.404	<0.001	0.347**	0.210, 0.470	<0.001
Waist hip ratio	-0.219**	-0.311, -0.122	<0.001	-0.248**	-0.371, -0.117	<0.001	0.023	-0.126, 0.171	0.731

SBP: Systolic blood pressure; DBP: Diastolic Blood Pressure; HC: Hip Circumference; WC: Waist Circumference
**indicates correlation is significant at the 0.01 level (2-tailed). 95% CI represents the 95% confidence interval for the correlation coefficient. The confidence intervals were calculated using Fisher's z transformation to account for the non-normal distribution of correlation coefficients.

The mean age of the total population was 54.57 ± 36.93 years, with males averaging 52.95 ± 8.73 years and females 52.68 ± 10.34 years. Height measurements showed slight variations, with an overall mean of 1.61 ± 0.09 m, males at 1.64 ± 0.08 m, and females at 1.57 ± 0.086 m. A notable weight difference between genders was found, with males having a higher mean weight of 72.15 ± 9.81 kg compared to females at 65.3 ± 9.71 kg, while the total population mean was 69.13 ± 10.33 kg. Body Mass Index (BMI) was relatively consistent across genders, with an overall mean of 26.6 ± 3.57, males at 26.5 ± 4.11, and females at 26.73 ± 2.75. Head circumference measurements showed males with a slightly larger mean of 102.4 ± 7.56 cm compared to females at 100.36 ± 7.94 cm, with an overall mean of 101.52 ± 7.79 cm. Waist circumference followed a similar pattern, with males at 100.97 ± 8.26 cm and females at 98.47 ± 8.76 cm, and a total mean of 99.86 ± 8.57 cm.

The waist-hip ratio demonstrated the most significant gender difference, with males showing a mean of 1.42 ± 6.50 compared to females at 0.96 ± 0.04. Neck circumference was marginally different, with males at 37.70 ± 2.22 cm and females at 36.75 ± 4.22 cm, and an overall mean of 37.28 ± 3.29 cm. Blood pressure measurements were remarkably consistent across genders. Systolic blood pressure had an overall mean of 136.39 ± 17.48 mmHg, with males at 136.53 ± 16.97 mmHg and females at 136.21 ± 18.14 mmHg. Diastolic blood pressure showed a similar pattern, with an overall mean of 86.97 ± 11.37 mmHg, males at 87.79 ± 11.17 mmHg, and females at 85.95 ± 11.56 mmHg.

The correlation analysis revealed statistically significant relationships between neck circumference and various physiological parameters, with notable variations observed across genders. Height demonstrated no significant correlation with neck circumference in the total population (r = -0.010, p = 0.843), maintaining consistent non-significance across male (r = -0.028, p = 0.711) and female (r = 0.034, p = 0.623) subgroups.

Weight showed a strong positive correlation with neck circumference in the total population (r = 0.272, p < 0.001), with a particularly pronounced relationship in females (r = 0.413, p < 0.001), while males exhibited a weaker but still significant correlation (r = 0.146, p = 0.05). Body Mass Index (BMI) demonstrated a complex correlation pattern, with a significant positive correlation in females (r = 0.212, p = 0.002) and a significant negative correlation in males (r = -0.246, p < 0.001).

Blood pressure parameters consistently showed strong positive correlations with neck circumference. Systolic blood pressure correlated significantly in the total population (r = 0.345, p <0.001), with similar patterns in males (r = 0.353, p <0.001) and females (r = 0.374, p <0.001). Diastolic blood pressure demonstrated comparable correlations, with overall (r = 0.337, p <0.001), male (r = 0.301, p <0.001), and female (r = 0.414, p <0.001) subgroup analyses.

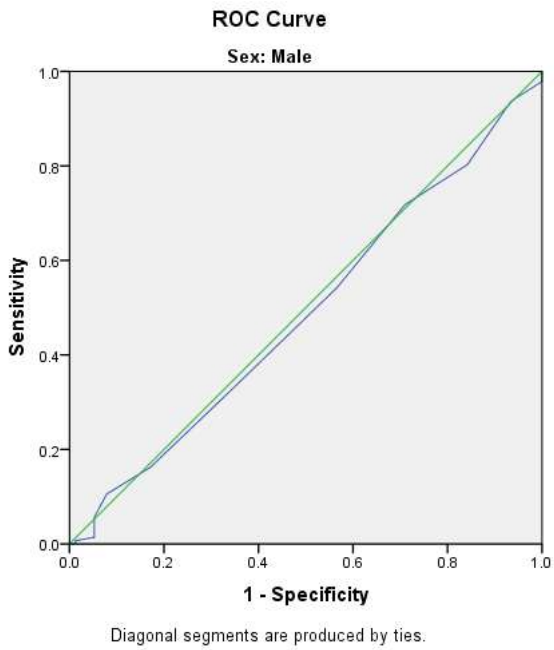

Figure 1: Receiver Operating Characteristic (ROC) Curve for Neck Circumference in Predicting Overweight/Obesity in Males

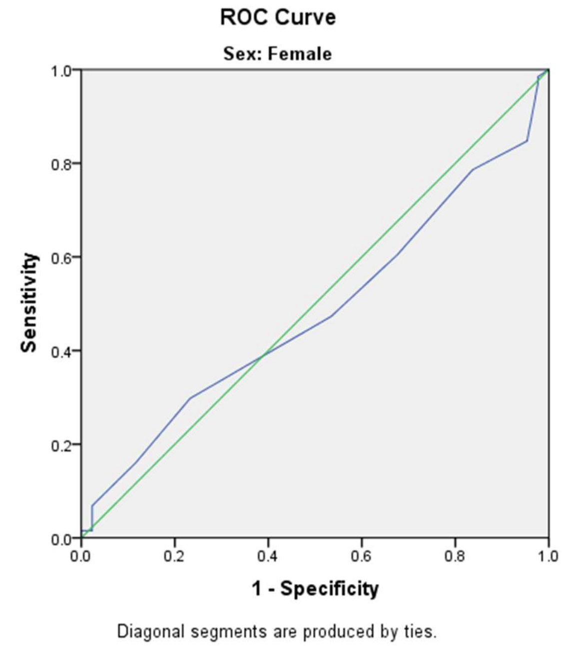

Figure 2: Receiver Operating Characteristic (ROC) Curve for Neck Circumference in Predicting Overweight/Obesity in Females

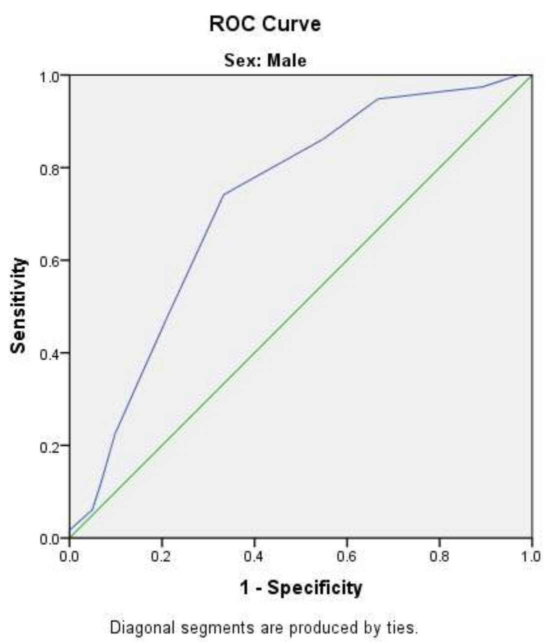

Figure 3: Receiver Operating Characteristic (ROC) Curve for Neck Circumference in Predicting Hypertension in Males

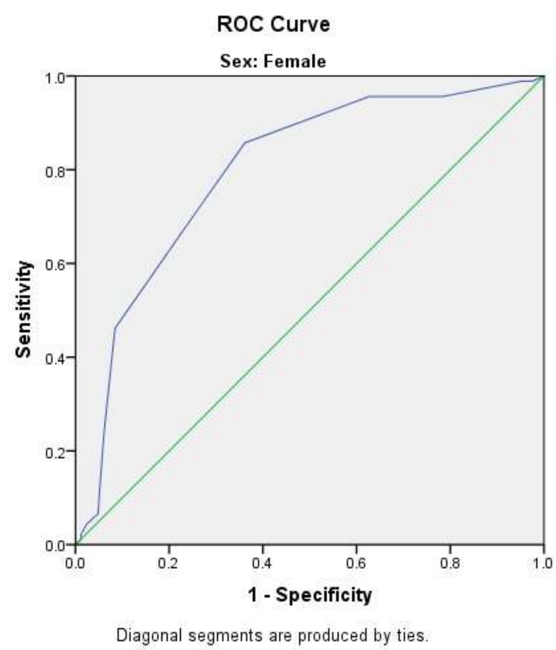

Figure 4: Receiver Operating Characteristic (ROC) Curve for Neck Circumference in Predicting Hypertension in Females

Circumference measurements revealed significant positive correlations. Hip circumference showed consistent correlations across total population (r = 0.327, p < 0.001), males (r = 0.318, p < 0.001), and females (r = 0.342, p < 0.001). Waist circumference exhibited similar patterns, with significant correlations in the total population (r = 0.312, p < 0.001), males (r = 0.287, p < 0.001), and females (r = 0.347, p < 0.001).

The waist-hip ratio presented an interesting variation, showing a significant negative correlation in the total population (r = -0.219, p < 0.001) and males (r = -0.248, p < 0.001), while remaining non-significant in females (r = 0.023, p = 0.731).

The figure 1 presents the receiver operating characteristic (ROC) curve for using neck circumference (NC) to identify overweight and obese (BMI ≥25) male participants. According to the ROC curve analysis, the best cutoff level for identifying overweight and obese male participants was NC ≥37.5 cm. At this cutoff, the area under the curve (AUC) was 0.488, with a 95% confidence interval of 0.40-0.56 and a p-value of 0.770.

The figure 2 presents the receiver operating characteristic (ROC) curve for using neck circumference (NC) to identify overweight and obese (BMI ≥25) female participants. According to the ROC curve analysis, the best cutoff level for identifying overweight and obese female participants was NC ≥34.75 cm. At this cutoff, the area under the curve (AUC) was 0.482, with a 95% confidence interval of 0.38-0.57 and a p-value of 0.717.

The figure 3 presents the receiver operating characteristic (ROC) curve for using neck circumference (NC) to identify hypertensive (systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥99 mmHg) male participants. According to the ROC curve analysis, the best cutoff level for identifying hypertensive male participants was NC ≥37.5 cm. At this cutoff, the area under the curve (AUC) was 0.726, with a 95% confidence interval of 0.65-0.79 and a p-value less than 0.001.

The figure 4 presents the receiver operating characteristic (ROC) curve for using neck circumference (NC) to identify hypertensive (systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥99 mmHg) female participants. According to the ROC curve analysis, the best cutoff level for identifying hypertensive female participants was NC ≥34.75 cm. At this cutoff, the area under the curve (AUC) was 0.797, with a 95% confidence interval of 0.72-0.86 and a p-value less than 0.001.

Sensitivity and Specificity Analysis Results

Diagnostic Performance in obesity: The test's moderate sensitivity of 54.2% (95% CI: 47.1-61.3%) and specificity of 56.6% (95% CI: 49.5-63.7%) indicate that it should be used cautiously for screening purposes in males, as it fails to detect 45.8% of cases of obesity. The test's specificity of 56.6% indicates that it is not very reliable in ruling out the condition in healthy individuals, with a false positive rate of 43.4% (95% CI: 36.3-50.5%).

Conversely, it showed a sensitivity of 84.7% (95% CI: 78.4-90.0%) and a specificity of 95.3% (95% CI: 91.2-98.1%) in females. The high sensitivity of 84.7% shows that this test can potentially be utilized for screening purposes in females, as it succeeds in discovering many instances of obesity. With a false positive rate of 4.7% (95% CI: 1.9-8.8%), the test's 95.3% specificity shows that it is highly trustworthy in ruling out the illness in healthy individuals.

Diagnostic Performance in Hypertension: The test's moderate sensitivity of 74.1% (95% CI: 67.6-80.1%) and specificity of 33.3% (95% CI: 26.8-40.2%) indicate that it can be used for screening purposes in males, as it detects cases of hypertension. The test's specificity of 33.3% indicates that it is not very reliable in ruling out the condition in healthy individuals, with a false positive rate of 66.7% (95% CI: 59.8-73.2%).

In contrast, it demonstrated a 78.3% (95% CI: 71.6-84.3%) specificity and a 95.6% (95% CI: 91.7-98.1%) sensitivity in females. Since the test is able to identify numerous cases of hypertension, its high sensitivity of 95.6% indicates that it may be used for screening in females. The test's 78.3% specificity and 4.4% (95% CI: 1.9-8.3%) false positive rate indicate that it can be used for preliminary evaluations to rule out the condition in healthy individuals.

According to this study, neck circumference measurements are more useful in identifying obese women and high blood pressure in both sexes. Although neck circumference is a measure of health risk for both sexes, it is more strongly associated with obesity, high blood pressure, and other conditions in women. Healthcare professionals can more reliably predict obesity and high blood pressure based on the neck circumference of female patients than when using this approach on male patients.

Discussion

The comprehensive investigation into neck circumference (NC) as a potential marker for obesity and hypertension among individuals aged 40-70 years in Perambalur District unveils critical insights into anthropometric risk assessment. This study delves deep into the intricate relationships between neck circumference and various physiological parameters, revealing nuanced correlations that extend beyond traditional health metrics.

The correlation analysis exposed significant interrelationships between neck circumference and key health indicators, with pronounced gender-specific variations. Weight demonstrated a particularly robust positive correlation with neck circumference, most notably among females in this study. Preis et al. (2010) and Yang et al. (2010) have previously explored similar associations, suggesting the potential of neck circumference as a meaningful anthropometric marker.[11,24] This finding aligns with several studies suggesting that neck circumference serves as a more sensitive indicator of body composition than conventional measurements.[12,15,22,25]

Regarding the cutoff points identified in our research, we observed distinct thresholds for males and females. For males, the optimal cutoff for identifying overweight and obese participants was 37.5 cm, while for females, it was 34.75 cm. These cutoff points demonstrate important clinical nuances. Shreedhar et al. (2022) and Ben-Noun et al. (2001) have similarly emphasized the importance of gender-specific thresholds in anthropometric assessments.[4,6] However, our ROC curve analyses revealed varying predictive capabilities, with relatively low areas under the curve (AUC) for obesity identification (males:

AUC 0.488, females: AUC 0.482), suggesting limitations in using neck circumference as a sole predictor of obesity.

The comparative analysis between neck circumference and BMI reveals important insights into their respective diagnostic capabilities. When evaluating sensitivity and specificity metrics, neck circumference demonstrated markedly differential performance by gender. In females, NC showed superior diagnostic performance for obesity detection with 84.7% sensitivity and 95.3% specificity, substantially outperforming the moderate sensitivity (54.2%) and specificity (56.6%) observed in males. This contrasts with BMI's more consistent performance across genders reported in previous studies.[11,24] Our findings align with Joshipura et al. (2016), who demonstrated that NC may serve as a better alternative to standard anthropometric measures, particularly among certain demographic groups.[19] The significant gender disparity in NC's diagnostic utility suggests potential advantages over BMI in female-specific health assessments, where NC could offer enhanced discriminatory power.

The blood pressure correlation analysis yielded more promising results. Systolic and diastolic blood pressure showed strong positive correlations with neck circumference across the entire population. Zhou et al. (2013), Fan et al. (2017) and He et al. (2019) have previously documented similar relationships, supporting our findings of neck circumference as a potential indicator of cardiovascular risk.[17,26,27] These findings challenge traditional anthropometric approaches, positioning neck circumference as a potentially more accessible and rapid screening tool.

Our study aligns with global research demonstrating the utility of neck circumference as a screening tool. Joshipura et al. (2016) and Stabe et al. (2013) have similarly explored neck circumference as an alternative anthropometric measure, highlighting its potential in identifying metabolic risks.[15,19] The gender-specific variations we observed add depth to existing literature, suggesting that the predictive power of neck circumference may differ significantly between males and females.

The complex correlation patterns between neck circumference, body mass index, and other anthropometric measurements warrant careful interpretation. Mohseni-Takalloo et al. (2023) and Zhou et al. (2013) have previously noted similar intricate relationships, emphasizing the need for comprehensive approaches to health risk assessment.[13,17]

A particularly significant finding is the differential predictive potential of neck circumference across genders. While neck circumference serves as a health risk indicator for both sexes, our results suggest a stronger association with obesity and hypertension in women. This observation is consistent with research by Forman et al. (2009), which highlighted gender-specific variations in health risk markers.[3]

The pronounced gender differences in NC correlations warrant deeper physiological examination. The stronger associations observed in females may be attributed to gender-specific fat distribution patterns. Women typically exhibit greater peripheral and subcutaneous fat deposition compared to men's visceral predominance, as documented by Onat et al. (2009).[20] This fundamental difference in adipose tissue partitioning could explain why NC more strongly correlates with metabolic parameters in women. Liria-Domínguez et al. (2021) similarly noted distinct gender patterns in NC correlations across Latin American countries, supporting our findings.[21] Additionally, hormonal factors may influence these associations; Forman et al. (2009) demonstrated that female hormonal profiles significantly impact cardiovascular risk marker expression.[3] Zhou et al. (2013) further documented that neck fat accumulation in women may represent a distinct metabolic compartment with unique endocrine properties, potentially explaining the enhanced predictive capability in females.[17] These physiological mechanisms suggest that gender-specific reference values and interpretive guidelines for NC measurements are essential for optimal clinical application, as supported by Ben-Noun et al. (2001) and Hingorjo et al. (2012).[6,16]

The study's approach provides a comprehensive exploration of neck circumference as a potential health screening tool, offering insights that extend beyond traditional anthropometric measurements. The findings suggest the need for nuanced, gender-specific approaches to health risk assessment.

Clinical Implications

The study presents transformative implications for clinical practice, offering a novel approach to health risk screening that is both accessible and efficient. Healthcare professionals can now leverage neck circumference as a quick, non-invasive screening tool for potential cardiovascular and metabolic risks, particularly for populations aged 40-70 years.

The gender-specific cutoff points provide a refined framework for risk assessment. Clinicians can now implement a more personalized approach, recognizing that a neck circumference of ≥37.5 cm in males and ≥34.75 cm in females may indicate increased health risks. This approach transcends traditional metrics like the body mass index, offering a more nuanced understanding of an individual's health status.

The findings are particularly valuable in resource-limited settings where advanced diagnostic tools may be inaccessible. A simple neck circumference measurement can now serve as an initial screening mechanism, triggering more comprehensive cardiovascular and metabolic evaluations when necessary. This approach democratizes health screening, making early detection more achievable across diverse healthcare environments.

Moreover, the study underscores the potential for preventive interventions. By identifying individuals at higher risk through a simple measurement, healthcare providers can develop targeted intervention strategies. These may include personalized lifestyle modifications, nutritional counseling, and proactive health management plans tailored to individual risk profiles.

The research also opens avenues for further investigation into the physiological mechanisms underlying the relationship between neck circumference and various health indicators, potentially revolutionizing our approach to preventive healthcare.

Strengths of the study

The study's primary strength lies in its comprehensive and meticulous approach to analyzing neck circumference across multiple health parameters. The robust sample size of 392 participants, balanced gender representation, and sophisticated statistical analyses provide unprecedented insights. The use of advanced analytical techniques like ROC curve analysis and exploration of gender-specific variations offer a multidimensional understanding of neck circumference as a potential health indicator.

Limitations

Geographical confinement to Perambalur District restricts the generalizability of findings to broader populations with different demographic and socioeconomic characteristics. The cross-sectional study design prevents establishing definitive causal relationships between neck circumference and health risks, limiting our ability to determine temporal sequences of observed associations. Our reliance on convenience sampling introduces potential selection bias, as participants may not fully represent the target population's diversity, potentially skewing results toward those more accessible to healthcare facilities. While standardized protocols were implemented, potential measurement errors cannot be entirely eliminated, particularly in anthropometric assessments where inter-observer variability may influence precision despite training efforts. The sample size, though substantial, represents a specific age group (40-70 years) and regional population, limiting external validity and applicability to younger demographics or populations from different geographical regions. Additionally, the study did not comprehensively account for potential confounding factors such as dietary habits, physical activity levels, genetic predispositions, or specific comorbidities that might influence neck circumference and associated health risks. Furthermore, we acknowledge that single measurements of blood pressure may not fully capture participants' typical cardiovascular status compared to multiple measurements over time. Future longitudinal research should address these limitations to provide more comprehensive insights into neck circumference's utility as a predictive marker for obesity and hypertension.

Conclusion

Neck circumference emerges as a promising supplementary tool for cardiovascular risk assessment in primary healthcare settings, particularly in resource-constrained environments. This simple, non-invasive measurement demonstrates significant correlations with hypertension and obesity markers, with notable gender-specific variations in diagnostic utility. For clinical implementation, healthcare practitioners should incorporate neck circumference alongside traditional anthropometric measurements rather than as a standalone diagnostic tool. Primary care physicians can utilize neck circumference for initial screening, particularly when evaluating female patients where it demonstrated higher sensitivity and specificity. Healthcare facilities with limited resources may benefit from implementing this cost-effective screening approach within standardized assessment protocols. Future research should focus on validating these findings through longitudinal studies, establishing regional reference values, and comparing neck circumference with gold-standard body composition analysis methods. While neck circumference shows promise, its clinical application should be approached with measured optimism, recognizing its limitations as a preliminary screening instrument rather than a definitive diagnostic measure. Integration into existing risk assessment frameworks, particularly in community health programs, may enhance early detection of cardiometabolic risks among middle-aged and older adults.

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