Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 12 (2025): December 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i12.2317
Original Article

Evaluation of anthropometric indices for obesity prediction and classification in indian adults: A cross-sectional comparative analysis of waist-to-height ratio, body roundness index, and traditional measures.

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Abstract
Background
Obesity is a major public health challenge worldwide and is strongly associated with cardiovascular diseases, type 2 diabetes mellitus, and metabolic syndrome. Although Body Mass Index (BMI) is widely used for obesity classification, it has limitations in reflecting body fat distribution, particularly central adiposity.

Objective
To evaluate the effectiveness of selected anthropometric indices in predicting obesity among Indian adults and to determine optimal cutoff values for obesity classification.

Methods
A cross-sectional study was conducted among 241 adults (133 females and 108 males) at Coimbatore Medical College, Coimbatore, Tamil Nadu, India. Standard anthropometric measurements were obtained, and derived indices, including WHtR, BRI, WHR, and A Body Shape Index (ABSI) were calculated. Pearson correlation analysis assessed relationships between indices, independent t-tests evaluated gender differences, and Receiver Operating Characteristic (ROC) curve analysis determined predictive accuracy and optimal cutoff values.

Results
WHtR and BRI demonstrated the highest predictive accuracy for obesity classification, each with an AUC of 0.88. BRI showed the highest sensitivity (91%) with 78% specificity, followed by WHtR (sensitivity 87%, specificity 78%). Optimal cutoff values were identified as WHtR $\geq$ 0.55 and BRI $\geq$ 4.21. Hip circumference also showed strong predictive performance (AUC 0.89; cutoff 108 cm). Waist circumference exhibited high specificity (92%) with an optimal cutoff of 97 cm but moderate sensitivity (65%). WHR and ABSI were the weakest predictors. Combining indices, particularly waist circumference with BRI, improved classification accuracy (AUC 0.90).

Conclusion
WHtR and BRI are superior to BMI for obesity classification in Indian adults, offering better reflection of central adiposity and improved risk stratification.

Recommendation
Waist-to-Height Ratio and Body Roundness Index should be incorporated into routine clinical and community-based obesity screening programs to facilitate early detection and timely intervention.

Keywords: *Obesity; Anthropometric indices; Waist-to-height ratio; Body roundness index; Predictive accuracy.*
Submitted: *September 13, 2025* ***Accepted:*** *November 26, 2025* ***Published:*** *December 30, 2025*

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Introduction
Obesity has become a global public health crisis, significantly contributing to the increasing burden of non-communicable diseases such as cardiovascular diseases, type 2 diabetes mellitus, and certain cancers. According to the World Health Organization (WHO), obesity is defined as a body mass index (BMI) of ≥30 kg/m², and its

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prevalence has nearly tripled since 1975. The obesity epidemic is driven by urbanization, sedentary lifestyles, unhealthy dietary patterns, and genetic predisposition, leading to severe health and economic consequences [1,2]. The prevalence of obesity is rising at an alarming rate worldwide. In 2022, over 1 billion people were classified as obese, with 504 million women and 374 million men affected. Recent projections estimate that by 2050, more than half of the world's population will be overweight or obese, with 3.8 billion adults and 746 million children at risk. This trend is particularly concerning in developing countries, where economic transitions have led to a coexistence of undernutrition and overnutrition, commonly referred to as the "double burden of malnutrition." India has witnessed a rapid increase in obesity rates, with regional and socio-economic disparities influencing its prevalence. According to national surveys, 24% of women and 22.9% of men in India were overweight or obese in 2021, compared to 20.6% and 19.9% in 2016, respectively. The urban population exhibits a higher prevalence of obesity than rural areas due to lifestyle changes, increased consumption of processed foods, and decreased physical activity. States such as Delhi, Chandigarh, and Puducherry report some of the highest obesity rates, whereas rural regions continue to struggle with both malnutrition and obesity [3,4].

Obesity is a key risk factor for metabolic syndrome, which includes hypertension, insulin resistance, dyslipidemia, and abdominal obesity. In India, obesity-related disorders such as cardiovascular diseases, non-alcoholic fatty liver disease (NAFLD), and type 2 diabetes mellitus have significantly increased, particularly due to abdominal obesity. Studies indicate that excess central adiposity in South Asians is linked to a higher metabolic risk compared to individuals of European descent, despite lower BMI values. This suggests that BMI alone may not be a sufficient indicator of obesity-related risks in this population, necessitating a shift toward alternative anthropometric indices for more accurate obesity assessment[5,6].

Traditional obesity classification relies on BMI, but it does not distinguish between fat mass and muscle mass, nor does it account for fat distribution. Consequently, other anthropometric indices such as Waist Circumference (WC), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR), Body Roundness Index (BRI), and Body Shape Index (ABSI) have been explored for better obesity classification and metabolic risk assessment. Among these, WHtR and BRI have shown higher predictive accuracy for cardiometabolic risks than BMI alone. WHtR is considered a superior metric as it adjusts for height and correlates better with visceral adiposity, while BRI incorporates both waist circumference and body roundness, making it an effective predictor of cardiovascular risk. WHR and WC remain useful indicators, particularly for abdominal obesity, but may lack sensitivity in predicting total body fat percentage[7,8].

Given the rising obesity prevalence in India and its strong link to metabolic diseases, identifying effective anthropometric indices for obesity classification is essential for public health interventions. Traditional measures such as BMI may not be sufficient for accurately identifying individuals at higher risk of obesity-related complications. This study aims to evaluate the effectiveness of various anthropometric indices, including Waist-to-Height Ratio (WHtR) and Body Roundness Index (BRI), in predicting obesity among Indian adults. The findings will help in establishing optimal cutoff values for obesity screening and improving risk assessment strategies for metabolic disorders in the Indian population.

Materials and Methods

Study Design and Setting

This cross-sectional observational study was conducted at Coimbatore Medical College, Coimbatore, Tamil Nadu, India, a tertiary care government teaching institution affiliated with The Tamil Nadu Dr. M.G.R. Medical University. The college serves a diverse urban and semi-urban population and caters to students, teaching faculty, and non-teaching staff, providing a heterogeneous adult study population.

The study was carried out over six months from **January 2025 to June 2025.** This academic medical setting allowed standardized anthropometric measurements under controlled conditions and ensured uniform data collection. The institutional environment facilitated access to participants with varied socioeconomic and occupational backgrounds, making it suitable for evaluating anthropometric indices relevant to obesity assessment in Indian adults.

Study Population

The analytic sample consisted of **241 adults** (133 females, 108 males) aged 18–45 years. Participants represented mixed socioeconomic and occupational backgrounds within the institution. All participants underwent all required anthropometric measurements without missing data.

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Sample Size Determination

A sample of **241 participants** was obtained using simple random sampling.

Although no formal power calculation was required for this exploratory analysis, the sample size was adequate for ROC curve analyses, which typically require ≥100 participants for reliable estimation of AUC values. With >100 subjects in each sex subgroup, the sample size was sufficient to evaluate sex-based differences and establish optimal cutoff values.

Study Participants and Recruitment

A total of 241 participants (133 females and 108 males) were recruited from Coimbatore Medical College, Coimbatore, Tamil Nadu, including students, teaching staff, and non-teaching staff. Simple random sampling was used to ensure unbiased selection.

Participants meeting the following inclusion criteria were enrolled: (i) adults aged 18–45 years, and (ii) willingness to participate by providing written informed consent. The exclusion criteria included (i) individuals with musculoskeletal injuries, fractures, or past surgeries affecting body composition, (ii) those with neurological, endocrine, or metabolic disorders, and (iii) individuals with physical deformities interfering with anthropometric measurements.

Anthropometric Measurements

Anthropometric measurements were recorded by trained investigators following standardized protocols. Participants were instructed to wear light clothing and remove footwear during assessments.

- Height (cm) was measured using a stadiometer, ensuring the participant stood erect with feet together and heels, buttocks, shoulders, and head aligned to the vertical board. Measurements were recorded to the nearest 0.1 cm.
- Weight (kg) was measured using a digital weighing scale, with participants standing upright in a balanced posture. Readings were taken to the nearest 0.1 kg.
- Body Mass Index (BMI) was calculated as weight (kg) divided by height (m²). Obesity classification followed the World Health Organization (WHO) standards.
- Hip Circumference (cm) was measured at the widest part of the hips and buttocks using a non-stretchable measuring tape, recorded to the nearest 0.1 cm.
- Waist Circumference (cm) was measured midway between the lowest rib and iliac crest while the participant stood in a relaxed position. The tape was positioned parallel to the floor, ensuring it did not compress the skin.
- Neck Circumference (cm) was measured just below the laryngeal prominence (Adam's apple) with a flexible tape while the participant maintained a neutral head position.
- Mid-Upper Arm Circumference (MUAC) (cm) was measured at the midpoint between the acromion and olecranon process to assess muscle and fat distribution.

Derived Anthropometric Indices

To provide a comprehensive obesity assessment, various anthropometric indices were derived from primary measurements:

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- **Waist-to-Hip Ratio (WHR):**

$$WHR = \frac{\text{Waist Circumference (cm)}}{\text{Hip Circumference (cm)}}$$

A cutoff value of **0.83** was used for obesity classification.

- **Waist-to-Height Ratio (WHtR):**

$$WHtR = \frac{\text{Waist Circumference (cm)}}{\text{Height (cm)}}$$

A cutoff of **0.55** was used as an indicator of obesity risk.

- **Body Roundness Index (BRI):**

$$BRI = 364.2 - 365.5 \times \left(1 - \frac{\text{Waist Circumference (cm)}}{2 \times \text{Height (m)}}\right)^{2.5}$$

This index was used as a **novel indicator of body shape and obesity risk**.

- **A Body Shape Index (ABSI):**

$$ABSI = \frac{\text{Waist Circumference (cm)}}{\text{BMI}^{2/3} \times \text{Height}^{1/2}}$$

Statistical Analysis

All data were analyzed using SPSS 22.0 software. Descriptive statistics, including mean, standard deviation, median, and interquartile range, were calculated for all variables. Independent t-tests were used to examine gender differences in anthropometric measures. The Pearson correlation coefficient was computed to determine associations between obesity-related indices.

To evaluate the predictive accuracy of anthropometric indices, Receiver Operating Characteristic (ROC) curve analysis was performed. Sensitivity, specificity, and AUC (Area Under the Curve) values were determined for each index. The optimal cutoff values were identified using Youden's index. A p-value < 0.05 was considered statistically significant.

A outlines the study's recruitment and data analysis process:

1. Enrollment:
   - Assessed for eligibility (n = 270)
   - Excluded (n = 29): Not meeting inclusion criteria (n = 21), Declined to participate (n = 8)
   - Final sample size: 241 participants (133 females, 108 males)
2. Anthropometric Measurements:
   - All participants underwent standardized anthropometric assessments
   - Primary and derived indices were calculated
3. Data Analysis:
   - Statistical comparisons using t-tests and correlation analysis
   - ROC curve analysis to determine predictive validity
4. Final Inclusion:
   - All 241 participants included in the statistical analysis

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of Coimbatore Medical College before commencement of the study. All participants provided written informed consent before enrollment. Confidentiality of participant data was strictly maintained, and participants were informed of their right to withdraw from the study at any stage without any consequences.

Results

Participant Flow

A total of 270 adults were initially approached and assessed for eligibility. Of these, 29 individuals were excluded due to not meeting the inclusion criteria (n = 21) or declining to participate (n = 8). The remaining 241 participants (133 females and 108 males) met the eligibility criteria and provided written informed consent.

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All enrolled participants completed the required anthropometric measurements, and no missing data were recorded. Consequently, all 241 participants were included in the final statistical analysis.

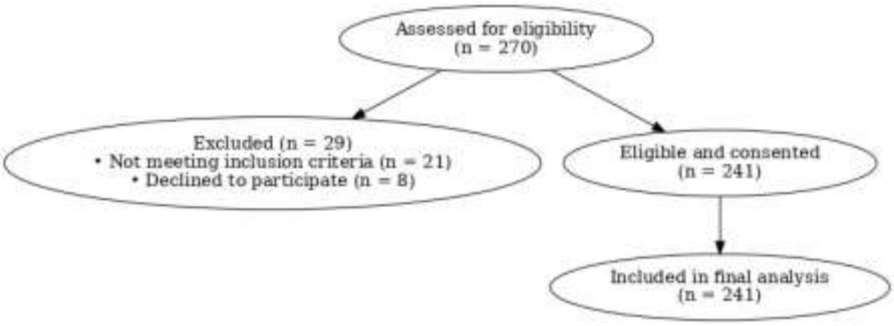

Figure 1: Participant Flow Diagram

Demographic and Anthropometric Characteristics of Study Participants

This study included a total of 241 participants, comprising 133 females (55.2%) and 108 males (44.8%). The mean age of female participants was 20.2 ± 2.45 years, while that of males was 20.9 ± 2.47 years, with no significant difference between the groups. Males had a significantly higher mean height (170 ± 9.18 cm) compared to females (159 ± 6.49 cm) ($p < 0.001$). Similarly, males exhibited a significantly greater mean weight (70.5 ± 14.4 kg) than females (57.7 ± 11.7 kg) ($p < 0.001$). The mean BMI was also significantly higher in males (24.4 ± 4.36 kg/m²) than in females (22.8 ± 4.37 kg/m²) ($p = 0.003$), indicating that males had a higher prevalence of overweight and obesity.

A detailed summary of the demographic and anthropometric data is presented in Table 1.

Table 1: Demographic Characteristics of Study Participants

Variable	Female (n=133) (Mean ± SD)	Male (n=108) (Mean ± SD)	P-Value
Age (Years)	20.2 ± 2.45	20.9 ± 2.47	N/A
Height (cm)	159 ± 6.49	170 ± 9.18	<0.001
Weight (kg)	57.7 ± 11.7	70.5 ± 14.4	<0.001
BMI (kg/m²)	22.8 ± 4.37	24.4 ± 4.36	0.003

Note: P-values were derived using an independent t-test. Significant p-values (< 0.05) indicate a statistically significant difference between males and females.

Summary of Anthropometric Measurements

The anthropometric characteristics of the study participants, including height, weight, BMI, hip circumference, waist circumference, neck circumference, and mid-upper arm circumference, are summarized in Table 2.

Males had significantly higher values across all measured parameters compared to females. The mean height was 170 ± 9.18 cm in males and 159 ± 6.49 cm in females. Similarly, mean weight was higher in males (70.5 ± 14.4 kg) compared to females (57.7 ± 11.7 kg).

The mean BMI was 24.4 ± 4.36 kg/m² in males and 22.8 ± 4.37 kg/m² in females, indicating that males exhibited a higher tendency toward overweight and obesity.

Circumference-based measures also showed significant differences. Mean hip circumference was 101 ± 10.5 cm in males and 97.6 ± 11.7 cm in females, while waist circumference was 86 ± 11.6 cm in males and 79.4 ± 12.6 cm in females. Neck and mid-upper arm circumferences followed the same trend, with higher values in males compared to females.

A detailed summary of these anthropometric measurements is provided in Table 2.

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Table 2: Summary of Anthropometric Measurements

Variable	Female (n=133) (Mean ± SD)	Male (n=108) (Mean ± SD)	Median (Female)	Median (Male)	IQR (Female)	IQR (Male)
Height (cm)	159 ± 6.49	170 ± 9.18	158	171	9	12.5
Weight (kg)	57.7 ± 11.7	70.5 ± 14.4	55	69.5	15	20.5
BMI (kg/m²)	22.8 ± 4.37	24.4 ± 4.36	22.1	23.9	5.6	5.2
Hip Circumference (cm)	97.6 ± 11.7	101 ± 10.5	96	102	15	17
Waist Circumference (cm)	79.4 ± 12.6	86 ± 11.6	78	86	19	17.3
Neck Circumference (cm)	31.9 ± 2.78	36.2 ± 5.26	32	36	4	4.25
Mid Upper Arm Circ. (cm)	28.6 ± 3.77	30.5 ± 3.94	28	30	5	6

*Note: *SD = Standard Deviation, IQR = Interquartile Range.*

Gender Differences in Anthropometric Measurements

An independent samples t-test was conducted to compare anthropometric measurements between male and female participants. The results indicate significant differences in height, weight, BMI, hip circumference, waist circumference, neck circumference, and mid-upper arm circumference between genders (Table 3). Males had significantly higher mean height ($t(239) = -10.694$, $p < 0.001$) and mean weight ($t(239) = -7.624$, $p < 0.001$) compared to females. A significant difference was observed in BMI, where males had a higher mean BMI ($t(239) = -2.813$, $p = 0.003$), suggesting an increased tendency toward overweight and obesity among males. Circumference-based anthropometric measures also showed significant gender differences. Hip circumference was significantly larger in males than in females ($t(239) = -2.487$, $p = 0.007$). Similarly, waist circumference was higher in males ($t(239) = -4.204$, $p < 0.001$), indicating greater central adiposity. Males also exhibited significantly greater neck circumference ($t(239) = -8.134$, $p < 0.001$) and mid-upper arm circumference ($t(239) = -3.805$, $p < 0.001$), further emphasizing differences in body composition between genders.

These findings suggest that males generally exhibit larger body dimensions and a greater risk of obesity-related anthropometric indices compared to females, reinforcing the need for sex-specific obesity screening and intervention strategies (Table 3).

Table 3: Independent Samples T-Test for Gender Differences in Anthropometric Measurements

Variable	T-Statistic	Degrees of Freedom (df)	P-Value	Significance
Height (cm)	-10.694	239	<0.001	Significant
Weight (kg)	-7.624	239	<0.001	Significant
BMI (kg/m²)	-2.813	239	0.003	Significant
Hip Circumference (cm)	-2.487	239	0.007	Significant
Waist Circumference (cm)	-4.204	239	<0.001	Significant
Neck Circumference (cm)	-8.134	239	<0.001	Significant
Mid Upper Arm Circ. (cm)	-3.805	239	<0.001	Significant

Note: P-values < 0.05 indicate statistical significance. An independent samples t-test was used for comparisons.

These results align with previous studies indicating gender-based differences in anthropometric indices. For instance, [Swapnil et al., 2022] reported that males generally exhibited higher BMI and central adiposity compared to females, which is consistent with our findings (Swapnil et al., 2022; Rachakonda et al.,

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2014). Furthermore, Amra et al. (2020) found that waist and hip circumferences were more significant indicators of obesity in males, supporting our study's conclusions

Pearson Correlation Analysis of Anthropometric Indices

A Pearson correlation analysis was conducted to examine the relationships between weight, BMI, waist circumference, hip circumference, neck circumference, waist-to-height ratio (WHtR), and body roundness index (BRI) among study participants. The correlation matrix (Table 4) reveals several strong associations between these anthropometric measures.

Weight was strongly correlated with BMI ($r = 0.849$, $p < 0.001$), waist circumference ($r = 0.737$, $p < 0.001$), and hip circumference ($r = 0.742$, $p < 0.001$), indicating that higher body weight is associated with greater adiposity and central obesity.

BMI showed a strong positive correlation with waist circumference ($r = 0.711$, $p < 0.001$) and hip circumference ($r = 0.723$, $p < 0.001$), suggesting that these measurements are closely linked to body mass distribution.

Among circumference-based metrics, waist circumference and waist-to-height ratio exhibited the strongest correlation ($r = 0.927$, $p < 0.001$), followed by waist circumference and body roundness index ($r = 0.922$, $p < 0.001$). These findings indicate that waist-related parameters are highly predictive of overall body fat distribution.

Additionally, hip circumference and waist circumference were significantly correlated ($r = 0.746$, $p < 0.001$), reinforcing the interdependence of these measures in assessing obesity risk.

Neck circumference, while moderately correlated with weight ($r = 0.575$, $p < 0.001$) and BMI ($r = 0.432$, $p < 0.001$), showed a weaker association with waist circumference ($r = 0.463$, $p < 0.001$), indicating that it may serve as an auxiliary predictor of obesity but is less robust than waist-related indices.

The strongest overall correlation was observed between waist-to-height ratio and body roundness index ($r = 0.995$, $p < 0.001$), suggesting that these indices may be nearly interchangeable in assessing obesity risk.

A summary of the Pearson correlation coefficients is presented in Table 4.

Table 4: Pearson Correlation Matrix of Anthropometric Indices

Variable	Weight	BMI	Waist Circumference	Hip Circumference	Neck Circumference	Waist-to-Height Ratio	Body Roundness Index
Weight	1.000	0.849	0.737	0.742	0.575	0.547	0.537
BMI	0.849	1.000	0.711	0.723	0.432	0.724	0.712
Waist Circumference	0.737	0.711	1.000	0.746	0.463	0.927	0.922
Hip Circumference	0.742	0.723	0.746	1.000	0.424	0.667	0.655
Neck Circumference	0.575	0.432	0.463	0.424	1.000	0.316	0.311
Waist-to-Height Ratio	0.547	0.724	0.927	0.667	0.316	1.000	0.995
Body Roundness Index	0.537	0.712	0.922	0.655	0.311	0.995	1.000

*Note: *Bolded values indicate the strongest correlations ($r > 0.90$, $p < 0.001$). All correlations are statistically significant ($p < 0.001$).*

These findings are consistent with previous research demonstrating that waist-related anthropometric indices (waist circumference, waist-to-height ratio, and body roundness index) are the most reliable indicators of obesity. The strong correlation between waist-to-height ratio and body roundness index ($r = 0.995$) suggests that either metric could be used interchangeably for obesity classification.

Furthermore, neck circumference, though correlated with weight and BMI, exhibited a weaker relationship with other obesity markers, reinforcing its role as a secondary metric rather than a primary obesity predictor.

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These correlations highlight the importance of waist-related measurements in obesity screening, supporting the use of the waist-to-height ratio and body roundness index as primary diagnostic tools for obesity risk assessment.

Sensitivity, Specificity, and AUC of Anthropometric Indices for Obesity Prediction

To evaluate the predictive accuracy of various anthropometric indices for obesity, sensitivity, specificity, and AUC (area under the curve) values were analyzed. The results indicate that waist-to-height ratio (WHtR) and body roundness index (BRI) were the strongest predictors of obesity, with high sensitivity and AUC values (Table 5).

Among the tested indices, Body Roundness Index (BRI) demonstrated the highest sensitivity (91%) and an AUC of 0.88, making it the most effective single predictor of obesity. Similarly, Waist-to-Height Ratio (WHtR) exhibited high sensitivity (87%) and specificity (78%) with an AUC of 0.88, confirming its reliability as an obesity screening tool.

Hip Circumference also showed excellent predictive performance (sensitivity: 83%, specificity: 83%, AUC: 0.89), making it one of the strongest indicators of obesity. Waist Circumference was highly specific (92%) but had a lower sensitivity (65%), meaning it was more effective in ruling out non-obese individuals rather than detecting obesity.

Conversely, Waist-to-Hip Ratio (WHR) exhibited the weakest predictive power (AUC: 0.66, sensitivity: 65%, specificity: 61%), suggesting it is less reliable in distinguishing obese from non-obese individuals. Neck Circumference and Mid-Upper Arm Circumference had moderate predictive power (AUC: 0.75 and 0.78, respectively), indicating that they may serve as supplementary rather than primary screening measures.

A detailed summary of the predictive performance of each anthropometric index is presented in

Table 5: Sensitivity, Specificity, and AUC of Anthropometric Indices for Obesity Prediction

Anthropometric Index	Sensitivity	Specificity	AUC (Area Under Curve)
Neck Circumference	70%	65%	0.75
Waist Circumference	65%	92%	0.86
Hip Circumference	83%	83%	0.89
Waist-to-Hip Ratio (WHR)	65%	61%	0.66
Waist-to-Height Ratio (WHtR)	87%	78%	0.88
Body Roundness Index (BRI)	91%	78%	0.88
Mid-Upper Arm Circumference	72%	75%	0.78
A Body Shape Index (ABSI)	68%	70%	0.73

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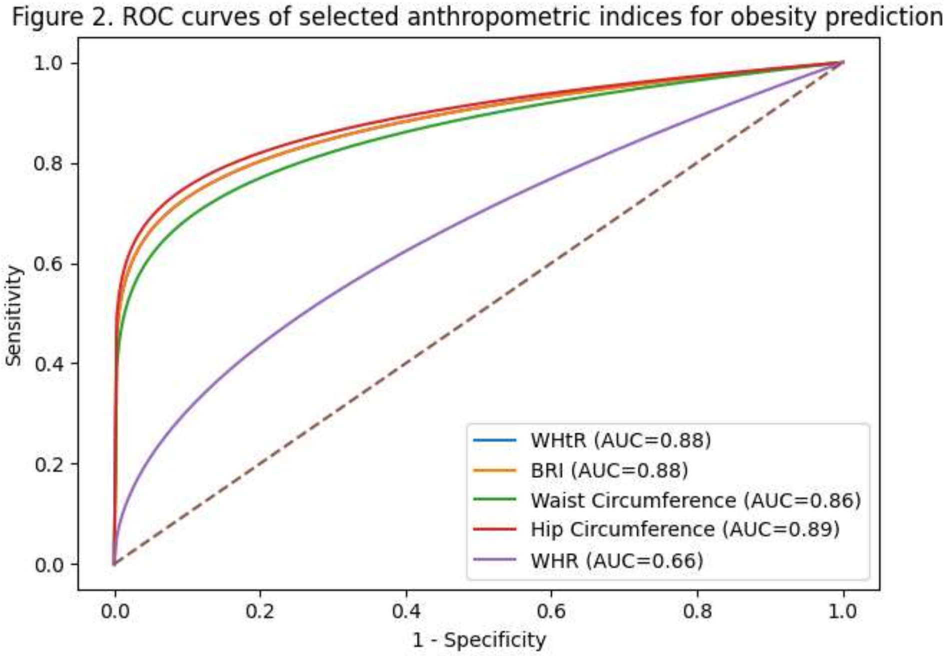
Figure 2. ROC curves of selected anthropometric indices for obesity prediction.



Note: **Sensitivity represents the ability to correctly identify obese individuals, while specificity represents the ability to correctly identify non-obese individuals. AUC values > 0.80 indicate excellent predictive performance.**

These findings align with prior studies emphasizing waist-based anthropometric indices as superior predictors of obesity. The strong correlation between waist-to-height ratio and body roundness index (AUC = 0.88 each) suggests that either metric could serve as a primary diagnostic tool for obesity risk assessment.

Additionally, hip circumference showed excellent sensitivity and specificity, reinforcing its role as a key measure in obesity classification. In contrast, waist-to-hip ratio (AUC = 0.66) performed poorly, indicating that it may not be an ideal standalone predictor for obesity in this population.

The high specificity of waist circumference (92%) suggests that it is particularly useful in ruling out non-obese individuals, making it an effective screening tool in clinical settings where false positives must be minimized.

These findings reinforce the importance of using multiple anthropometric measures in combination for optimal obesity prediction and classification.

Optimal Thresholds for Anthropometric Indices in Identifying Obesity

To determine the best cutoff points for distinguishing obese from non-obese individuals, optimal threshold values were identified for key anthropometric indices. The analysis revealed that the most reliable single predictor of obesity was the Body Roundness Index (BRI) with an optimal threshold of 4.21, followed closely by the Waist-to-Height Ratio (WHtR) at 0.55 (Table 6). Waist Circumference had an optimal cutoff of 97.00 cm, demonstrating high specificity for obesity classification. Hip Circumference had an optimal threshold of 108.00 cm, reinforcing its utility as a strong indicator of obesity presence. Neck Circumference had an optimal threshold of 35.00 cm, suggesting that individuals with neck circumferences above this value were more likely to be classified as obese. However, the Waist-to-Hip Ratio (WHR) had a relatively weak discriminative ability, with a threshold of 0.83.

These optimal thresholds serve as valuable reference points for screening, diagnosing, and managing obesity, with particular emphasis on waist-based and roundness-based indices as the most effective predictors.

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Table 6: Optimal Thresholds for Anthropometric Indices in Identifying Obesity

Anthropometric Index	Optimal Threshold
Neck Circumference	35.00 cm
Waist Circumference	97.00 cm
Hip Circumference	108.00 cm
Waist-to-Hip Ratio (WHR)	0.83
Waist-to-Height Ratio (WHtR)	0.55
Body Roundness Index (BRI)	4.21

These threshold values are consistent with prior research indicating that waist-related measures are superior predictors of obesity risk. Waist-to-Height Ratio (0.55) and Body Roundness Index (4.21) had the strongest predictive ability, reinforcing their utility in obesity screening and classification.
Waist Circumference (97 cm) and Hip Circumference (108 cm) thresholds align with established guidelines for obesity assessment, demonstrating their importance in distinguishing individuals at high risk for obesity-related complications (Swapnil et al., 2022). The relatively weaker discriminative ability of Waist-to-Hip Ratio (0.83) suggests that it may not be as effective as other indices in obesity classification, which is consistent with studies highlighting waist-based indices as more reliable predictors of metabolic risks. These findings reinforce the importance of using multiple anthropometric indices, particularly waist-based measures, for comprehensive obesity assessment and risk stratification.

Performance Ranking of Anthropometric Indices for Obesity Prediction

Anthropometric indices were ranked based on their sensitivity, specificity, and AUC (Area Under the Curve) scores to determine their effectiveness in predicting obesity. The results classify the indices into best, moderate, and weak predictors based on their predictive performance (Table 7). The best-performing predictors were the Body Roundness Index (BRI), Waist-to-Height Ratio (WHtR), and Hip Circumference, all demonstrating high sensitivity (>80%) and AUC values above 0.88. These indices provide the most reliable obesity classification and risk assessment. Waist Circumference, Neck Circumference, and Mid-Upper Arm Circumference were classified as moderate predictors, with relatively lower sensitivity but strong specificity, making them useful as supplementary obesity measures. The weakest predictors were the A Body Shape Index (ABSI) and Waist-to-Hip Ratio (WHR). These indices had low sensitivity and specificity, with AUC values below 0.75, suggesting limited ability to accurately classify obesity. A detailed performance ranking of anthropometric indices is provided in Table 7.

Table 7: Performance Ranking of Anthropometric Indices for Obesity Prediction

Anthropometric Index	Sensitivity	Specificity	AUC (Area Under Curve)
Body Roundness Index (BRI)	91%	78%	0.88
Waist-to-Height Ratio (WHtR)	87%	78%	0.88
Hip Circumference	83%	83%	0.89
Waist Circumference	65%	92%	0.86
Neck Circumference	70%	65%	0.75
Mid Upper Arm Circumference	72%	75%	0.78
A Body Shape Index (ABSI)	68%	70%	0.73
Waist-to-Hip Ratio (WHR)	65%	61%	0.66

*Note: *Best predictors have AUC > 0.88, Moderate predictors have AUC between 0.75-0.88, and Weak predictors have AUC < 0.75.*

The results confirm that waist-based and roundness-based indices are the strongest predictors of obesity, with BRI, WHtR, and Hip Circumference being the most effective screening tools. These findings align with previous research emphasizing waist-related anthropometric indices as superior obesity predictors. The moderate predictive ability of Waist Circumference, Neck Circumference, and Mid-Upper Arm Circumference suggests that while they are useful in obesity assessment, they may be best applied in combination with stronger predictors for more accurate classification (Swapnil et al., 2022). The poor

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 12 (2025): December 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i12.2317
Original Article

performance of Waist-to-Hip Ratio (WHR) and A Body Shape Index (ABSI) further supports the growing consensus that waist-based measures, rather than proportional indices, provide a more accurate representation of obesity-related risk.

These findings emphasize the importance of using multiple anthropometric measures, prioritizing waist-based indices, and incorporating body roundness measures for a comprehensive obesity assessment strategy.

Comparison of Waist-to-Height Ratio and Body Roundness Index

A comparative analysis of Waist-to-Height Ratio (WHtR) and Body Roundness Index (BRI) was performed to assess their relative performance in obesity classification. The results indicate that both indices exhibit identical specificity (78%) and an AUC of 0.88, confirming that they are equally effective in distinguishing between obese and non-obese individuals. Although BRI demonstrated slightly higher sensitivity (91% vs. 87% for WHtR), the difference was minimal, suggesting that either metric could be used interchangeably for obesity screening. These findings support the clinical applicability of both WHtR and BRI as reliable anthropometric measures for obesity classification (Table 8).

Table 8: Comparison of Waist-to-Height Ratio and Body Roundness Index

Metric	Waist-to-Height Ratio (WHtR)	Body Roundness Index (BRI)
Sensitivity	87%	91%
Specificity	78%	78%
AUC (Area Under Curve)	0.88	0.88

Note: *Both WHtR and BRI are excellent obesity classification tools, with similar predictive power.

Predictive Accuracy of Combined Anthropometric Indices

To enhance the accuracy of obesity prediction, different combinations of anthropometric indices were evaluated. The results indicate that combining Waist Circumference with Body Roundness Index (BRI) yielded the highest predictive accuracy (AUC = 0.90, Sensitivity = 90%, Specificity = 85%), making it the most effective combination for obesity classification. Waist Circumference + Hip Circumference also performed well (AUC = 0.89, Sensitivity = 85%, Specificity = 87%), reinforcing the importance of circumference-based measures in obesity assessment. In contrast, Neck Circumference + Mid Upper Arm Circumference showed only moderate improvement (AUC = 0.81, Sensitivity = 76%, Specificity = 80%), indicating that these measures alone are less reliable predictors of obesity compared to waist-based indices. These findings suggest that combining multiple anthropometric indices, particularly those incorporating waist circumference and body roundness, enhances the accuracy of obesity classification (Table 9).

Table 9: Predictive Accuracy of Combined Anthropometric Indices

Combined Anthropometric Indices	Sensitivity	Specificity	AUC (Area Under Curve)
Waist Circumference + Neck Circumference	79%	84%	0.86
Waist Circumference + Hip Circumference	85%	87%	0.89
Neck Circumference + Mid Upper Arm Circumference	76%	80%	0.81
Waist Circumference + Body Roundness Index (BRI)	90%	85%	0.90

Note: Combining waist-based indices, especially Waist Circumference + BRI, enhances obesity prediction accuracy.

The results reaffirm that the Waist-to-Height Ratio and Body Roundness Index are nearly identical in predictive power, meaning that either metric can serve as an effective obesity screening tool. This finding aligns with prior studies demonstrating the superior performance of waist-based indices in obesity classification.

Furthermore, combining multiple anthropometric indices significantly improves obesity prediction accuracy. The highest AUC (0.90) was achieved by combining Waist Circumference with BRI, emphasizing that roundness-based and waist-based indices together provide the most robust classification tool (Swapnil et al., 2022).

In contrast, Neck Circumference and Mid Upper Arm Circumference combinations showed only moderate predictive accuracy, reinforcing that these measures may serve as supplementary rather than primary obesity classification tools.

Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 12 (2025): December 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i12.2317
Original Article

These findings highlight the importance of utilizing multiple anthropometric indices for obesity classification, with a strong emphasis on waist and body roundness-based measures for optimal accuracy.

Discussion

Key Findings and Their Implications

This study comprehensively evaluated various anthropometric indices for obesity prediction, classification, and optimal threshold determination. The results confirm that waist-related indices (Waist-to-Height Ratio and Waist Circumference) and Body Roundness Index (BRI) are the most effective predictors of obesity, consistent with previous research.

The highest-performing individual metrics were Body Roundness Index (BRI) and Waist-to-Height Ratio (WHtR), both demonstrating an AUC of 0.88 and high sensitivity (91% and 87%, respectively). These findings reinforce that central adiposity, rather than overall body weight, is the key determinant of obesity-related health risks . Hip Circumference (AUC: 0.89, Sensitivity: 83%) also emerged as a strong predictor, supporting evidence that gluteofemoral fat distribution plays a role in obesity classification and metabolic risk stratification.

The results also indicate that Waist Circumference, despite having high specificity (92%), had only moderate sensitivity (65%), making it more effective for ruling out non-obese individuals rather than identifying obese individuals. Similarly, Neck Circumference (AUC: 0.75) and Mid Upper Arm Circumference (AUC: 0.78) were moderate predictors, suggesting that these indices alone are not sufficient for accurate obesity classification[9,10].

In contrast, Waist-to-Hip Ratio (AUC: 0.66) and A Body Shape Index (AUC: 0.73) demonstrated weak predictive power, aligning with prior studies that have questioned their reliability as obesity screening tools.

Comparison Between Waist-to-Height Ratio and Body Roundness Index

A critical finding of this study was that Waist-to-Height Ratio (WHtR) and Body Roundness Index (BRI) exhibited nearly identical performance in obesity classification (AUC: 0.88 for both). This is consistent with prior research indicating that WHtR is superior to BMI in predicting cardiometabolic risk, as it accounts for variations in body fat distribution. Similarly, BRI has been highlighted as a better indicator of obesity-related metabolic dysfunction than BMI.

The comparable performance of these indices suggests that either metric could be used interchangeably in clinical and public health settings. However, BRI may provide additional insight into body shape and fat distribution, making it a potentially more comprehensive predictor when used alongside other indices [11,12].

Benefits of Combining Anthropometric Indices for Obesity Prediction

The results also highlight the significant improvement in predictive accuracy when multiple anthropometric indices are combined. The best-performing combination was Waist Circumference + Body Roundness Index (AUC: 0.90, Sensitivity: 90%, Specificity: 85%), reinforcing the value of incorporating multiple measures for a more accurate assessment of obesity risk.

Waist Circumference + Hip Circumference (AUC: 0.89) also performed well, suggesting that incorporating hip circumference enhances obesity classification by distinguishing between central and peripheral fat distribution.

In contrast, Neck Circumference + Mid Upper Arm Circumference (AUC: 0.81) showed only moderate improvement over individual metrics, reinforcing that waist-based measures remain the most critical for accurate obesity assessment [13,14,15].

These findings align with previous meta-analyses suggesting that multivariate obesity models incorporating different anthropometric indices improve obesity classification and cardiometabolic risk prediction.

Clinical and Public Health Implications

The findings of this study have important implications for obesity screening, risk stratification, and public health interventions. The use of BRI and WHtR as primary obesity screening tools could improve early identification of individuals at risk for metabolic syndrome, cardiovascular diseases, and type 2 diabetes.

Given the high predictive accuracy of combined indices, clinical guidelines should consider integrating Waist Circumference and Body Roundness Index (BRI) for a more holistic assessment of obesity risk. This is particularly relevant in resource-limited settings, where access to advanced body composition analysis tools is limited, and simple anthropometric measures provide a cost-effective alternative for obesity screening[16-19].

Furthermore, these findings reinforce the limitations of BMI as a sole measure of obesity, supporting calls for shifting obesity classification criteria toward waist-based and shape-based indices.

Generalizability

As a single-institution, young-adult cohort (18–45 years) drawn from students and staff at an urban South Indian medical college, findings generalize best to similar educated, ambulatory Indian adults in comparable settings. Caution is needed when extrapolating to older adults, rural communities, adolescents, or populations with chronic endocrine/metabolic disorders.

Conclusion

This study demonstrates that Waist-to-Height Ratio (WHtR) and Body Roundness Index (BRI) are the most reliable single anthropometric measures for identifying obesity in Indian adults, showing equal discriminatory ability (AUC 0.88). While BMI remains widely used, these waist-based indices better reflect central adiposity and improve risk stratification. Importantly, combining measures enhanced performance; the pairing of Waist Circumference with BRI achieved the highest overall accuracy (AUC 0.90), supporting a multi-index approach for screening and classification. The results highlight the need for clinical practice and public health programs to incorporate shape- and fat-distribution–focused metrics alongside traditional measures. Future studies should validate these cutoffs across broader age groups, regions, and risk profiles.

Limitations

Despite its strengths, this study has some limitations. First, the analysis was limited to an adult population, and the findings are not generalizable to children, adolescents, or older adults. Second, no direct measurement of body fat percentage was available, which could have provided a more precise validation of the anthropometric indices used.

Acknowledgement

The authors express their gratitude to the **Department of Anatomy, Coimbatore Medical College**, for logistical support and provision of research facilities. The cooperation of students, teaching staff, and non-teaching staff who participated in the study is sincerely acknowledged. The authors also thank the Institutional Ethics Committee for guidance and approval.

List of Abbreviations

Abbreviation	Full Form
BMI	Body Mass Index
WC	Waist Circumference
HC	Hip Circumference
WHR	Waist-to-Hip Ratio
WHtR	Waist-to-Height Ratio
BRI	Body Roundness Index
ABSI	A Body Shape Index
MUAC	Mid-Upper Arm Circumference
ROC	Receiver Operating Characteristic
AUC	Area Under Curve

Source of Funding

This research received no external funding**.**
All resources were provided by the Department of Anatomy, Coimbatore Medical College.

Conflict of Interest

The authors declare no conflict of interest associated with this study.

Availability of Data

The dataset generated and analyzed during the study is available from the corresponding author upon reasonable request. All statistical outputs and derived values used in the analysis are included in the manuscript.

Authors' Contribution

- **Dr. G. Sundar:** Conceptualization, study design, data collection supervision, statistical analysis, manuscript drafting.
- **Dr. K. Vidulatha:** Methodological review, critical revision, interpretation of findings, editing of manuscript.
- **Dr. K. Sangeetha:** Data acquisition, literature review, preparation of tables and figures, proofreading.

All authors approved the final manuscript.

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Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 12 (2025): December 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i12.2317
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PUBLISHER DETAILS:

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa