International Journal of Medicine, 14 (1) (2026) 1-11

International Journal of Medicine

Website: www.sciencepubco.com/index.php/IJM
https://doi.org/10.14419/wnxmxc50
Research paper

Evaluation of Alternative Anthropometric Indices for Supporting Body Mass Index in Obesity Screening. Among Predominantly Female Tertiary Students

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Received: November 23, 2025, Accepted: January 10, 2026, Published: January 16, 2026

Abstract

Given the rising prevalence of obesity and its associated health complications, including metabolic and cardiovascular disorders, this study addresses a critical research gap concerning the most reliable indices that support Body Mass Index (BMI) for early obesity screening among young adults. The objectives examine students' sociodemographic characteristics and anthropometric parameters, explore correlations among obesity indices, evaluate sensitivity and specificity in predicting obesity, and identify the most effective indicators by gender and age group. A cross-sectional research design is adopted, involving a sample of 219 students selected through stratified random sampling. Data is collected using structured questionnaires and physical measurements, and analyzed through descriptive and inferential statistics and Receiver Operating Characteristic (ROC) analysis. The findings reveal that in terms of support for Body Mass Index (BMI) in screening for obesity, the Body Adiposity Index (BAI) and Waist-to-Height Ratio (WaHtR) exhibit strong correlations and high diagnostic accuracy, whereas the Waist-to-Hip Ratio (WaHpR). The study concludes that a combined use of BAI, WaHtR, BMI, and CI tailored to gender differences offers a robust method for early obesity detection. It is recommended that universities institutionalize routine health screenings utilizing these indices, enhance awareness of obesity-related risks, and promote healthy lifestyle behaviors among students to curb the increasing burden of obesity.

Keywords: *Obesity; Metabolism; Diabetes; Anthropometric Indices; Lifestyle.*

1. Introduction

Obesity is a global epidemic that continues to pose significant health risks, contributing to the rising incidence of non-communicable diseases (NCDs) such as cardiovascular diseases, type 2 diabetes, and hypertension [1]. The World Health Organization (WHO) estimates that over 1.9 billion adults were overweight in 2016, with more than 650 million classified as obese [2]. In Ghana, the prevalence of obesity is increasing, particularly among university students, who face heightened risks due to lifestyle changes associated with academic stress, poor dietary habits, and sedentary behavior [3]. The transition from high school to university life often involves significant changes in eating patterns, with students favoring fast food and sugary snacks due to convenience and affordability. Coupled with academic pressures, prolonged study hours, and limited physical activity, these lifestyle changes exacerbate the risk of obesity [4]. Consequently, obesity among university students has become a critical public health concern. Beyond physical health, obesity has been shown to negatively impact mental health, academic performance, and overall well-being [6]. This highlights the urgent need for effective tools to screen, diagnose, and manage obesity. Anthropometric indices play a vital role in assessing and diagnosing obesity. These indices are widely recognized as non-invasive, cost-effective, and practical methods for measuring body composition in both clinical and research settings [7]. Among these, Body Mass Index (BMI) is the most commonly used, providing a general measure of obesity by calculating the ratio of an individual's weight to their height squared [8]. However, BMI has limitations, such as its inability to differentiate between fat and lean mass, making it less reliable for individuals with high muscle mass or regular physical activity [9]. To address these limitations, other anthropometric indices have been evaluated to demonstrate their support for BMI in screening obesity. These indices provide more precise insights into fat distribution and associated health risks. For instance, Waist Circumference (WC) measures abdominal fat and is strongly linked to metabolic disorders like insulin resistance and diabetes [10]. Waist-to-Hip Ratio (WaHpR) and Waist-to-Height Ratio (WaHtR) further focus on fat distribution around the waist and hips, which is critical for evaluating risks of metabolic diseases such as cardiovascular conditions and diabetes [12]. Emerging indices, such as the Conicity Index (CI), Body Adiposity Index (BAI), and Relative Fat Mass (RFM), offer even greater precision in assessing variations in body fat distribution and composition, which are crucial for understanding an individual's susceptibility to obesity-related health risks [10]. This study focuses on university students in Ghana, a key demographic that represents the youth population, highly vulnerable to lifestyle-related health challenges. Universities are melting pots, bringing together individuals from diverse demographic, socioeconomic, and cultural backgrounds. Radford University College (RUC), a private institution in East Legon, Accra (Ghana), serves as the focal point of this study. Established in March 2009 and operational since September 2010, RUC is affiliated with Kwame Nkrumah University of Science and Technology (KNUST) and is known for its academic excellence and modern facilities. RUC's strategic location and diverse student population make it an ideal setting for examining obesity-related health profiles among young adults. Students at RUC typically range in age from 18 to 40 years, representing a crucial segment of the predominated female youth population most susceptible to lifestyle-related health challenges. This study aims to contribute to the growing body of knowledge by comparing various anthropometric indices and evaluating their effectiveness in screening for obesity in university students at RUC. By assessing indices such as WC, WaHpR, CI, BAI, and others, the research seeks to identify the most accurate and reliable tools that support BMI for screening obesity, particularly in relation to obesity-related health risks like diabetes. The significance of the study is that it provides valuable insights for improving the early detection and management of obesity and informs targeted health interventions for university students.

2. Method

2.1. Research design

This study adopts a cross-sectional research design. A cross-sectional design is appropriate as it allows for the collection of data at a single point in time, enabling the comparison of various anthropometric indices in screening Obesity among university students. The comparative aspect of the study allows for the evaluation of the effectiveness of different anthropometric measurements, such as Waist Circumference (WC), Waist-to-Hip Ratio (WaHpR), and others, against Body Mass Index (BMI), in identifying students at risk of Obesity[1].

2.2. Study population

The study population consists of 486 students enrolled at Radford University College as of the year (2025) the study was being conducted. Table 1 outlines the population size for each academic programme:

Table 1: Population Size for Each Academic Programme at RUC

Academic Program	Population Size
Business Administration	120
Health Sciences	70
Information Technology	66
Social Sciences	80
Arts and Humanities	150
Total	486

Inclusion Criteria:
1) University students aged 18 – 40 years.
2) Students enrolled at Radford University College at the time of the study.
3) Students who voluntarily agree to participate in the study and sign informed consent.

Exclusion Criteria:
1) Students who have a known diagnosis of Obesity.
2) Students who are pregnant or have conditions that may interfere with the measurement of anthropometric indices, such as severe physical disabilities.
3) Students who are unwilling to participate in the study.

2.3. Sample size

A selected group of students from Radford University College served as the sample for this study. The sample size is determined using Yamane's sample size calculation formula:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where:
- n is the sample size
- N is the population size (486)
- e is the margin of error (0.05 for a 95% confidence level)

We have;

$$n = \frac{486}{1+486(0.05)^2} = \frac{486}{1+486(0.0025)} = \frac{486}{2.215} = 219$$

Thus, the sample size is approximately 219 students.

2.4. Sampling technique

Stratified random sampling is employed to ensure proportional representation of students across academic programs. Table 2 shows the distribution of the sample size for each academic program:

Table 2: Distribution of the Sample Size for Each Academic Programme

Academic Program	Population Size	Proportion of Total Population	Sample Size (n = 219)
Business Administration	120	0.247	54
Health Sciences	70	0.144	32
Information Technology	66	0.136	30
Social Sciences	80	0.165	36
Arts and Humanities	150	0.309	67
Total	486	1.000	219

This approach ensures a fair and proportional representation of students across all academic programmes.

2.5. Data collection procedure and tools

Data Collection Procedure: Data was collected through a combination of physical measurements and a structured questionnaire. The physical measurements were taken by trained research assistants using standardized protocols to ensure consistency and accuracy. The process involved the following steps:

1) Body Mass Index (BMI): [13], Participants were weighed using a calibrated digital scale, and height was measured with a stadiometer. BMI is calculated using the formula

$$BMI = \frac{weight\ (kg)}{height^2\ (m^2)} \tag{2}$$

Categories:

- Normal range: 18.5–24.9 kg/m²
- Overweight: 25.0–29.9 kg/m²
- Obesity: ≥30 kg/m²
- Class 1: 30.0–34.9 kg/m²
- Class 2: 35.0–39.9 kg/m²
- Class 3 (Severe): ≥40 kg/m²

2) Waist-to-Hip Ratio (WaHpR): Waist and hip circumferences were measured, and the ratio is calculated by dividing the waist circumference by the hip circumference. WaHpR is calculated using the formula [30]:

$$WHR = \frac{WC\ (cm)}{HC\ (cm)} \tag{3}$$

Categories:
Normal range: (Women: <0.85, Men: <0.90), High risk:(Women: ≥0.85, Men: ≥0.90)

3) Body Adiposity Index (BAI):

Hip circumference will be measured using a flexible tape, and height will be recorded with a stadiometer. BAI will be calculated using the formula [15]:

$$BAI = \frac{Hip\ Circumference\ (cm)}{Height\ (m)^{1.5}} - 18 \tag{4}$$

Categories:
Normal range: (Women: 18–32%, Men: 8–21%) High body fat:(Women: >32%, Men: >21%)

4) Abdominal Volume Index (AVI): Waist circumference and hip circumference will be measured with a measuring tape. AVI will be calculated as [31]:

$$AVI = \frac{2(WC)^2 + 0.7(WC - HC)^2}{1000} \tag{5}$$

Where: WC = Waist circumference (cm) and HC = Hip circumference (cm)
Categories:
Normal range: Typically ≤ 20 (low risk), Abnormal (high risk): > 25 indicates increased cardiometabolic risk

5) Conicity Index (CI):

Waist circumference, height, and weight will be recorded. CI will be determined using the formula [16]:

$$CI = \frac{WC\ (m)}{0.109\sqrt{\frac{Weight\ (kg}{Height\ (m)^2}}} \tag{6}$$

Categories:
Normal range: CI < 1.25 (low risk), High risk: CI ≥ 1.25 (associated with cardiovascular diseases)

6) Weighted-Adjusted Waist Index (WAWaI):
WAWaI will be calculated based on waist circumference and weight, using the formula [32]:

$$WWI = \frac{WC\ (cm)}{\sqrt{Weight\ (kg)}} \tag{7}$$

Interpretation:
- No universal thresholds established yet.

Higher WAWaI values generally indicate higher central adiposity and risk.
7) Body Roundness Index (BRI):
BRI will be derived using waist circumference and height, with the following formula [17]:

$$BRI = 364.2 - 365.5 \times (\sqrt{(1 - \left(\frac{wc\ (cm)}{2\pi}\right)^2 \div [0.5H(m)]^2} \tag{8}$$

Categories:
- Low body fat: BRI < 4
- Moderate body fat: BRI 4–6
- Abnormal (high risk): BRI ≥ 6 indicates elevated fat levels and health risk

8) Relative Fat Mass (RFM):
Waist circumference and height will be measured, and RFM will be calculated as follows [18]:

$$RFM = 64 - \left(20 \times \frac{Height\ (m)}{WC\ (cm)}\right) + (12 \times Sex\ Adjustment) \tag{9}$$

Categories:
Normal range: (Women: 20–33%, Men: 8–20%), High fat: (Women: >33%, Men: >20%)
9) Waist-to-Height Ratio (WaHtR):
Waist circumference and height will be measured, and WaHtR will be calculated using the formula [14]:

$$WHtR = \frac{WC\ (cm)}{Height\ (cm)} \tag{10}$$

Categories:
- Normal range: WaHtR < 0.5 (healthy), High risk: WaHtR ≥ 0.5 indicates central obesity.

2.6. Data handling and analysis

Data Handling: Data was entered into a Microsoft Excel spreadsheet and SPSS. Inconsistent or missing data was checked against the original records and corrected where possible. A data codebook is developed to ensure proper coding of variables for analysis.
Data Analysis: Data analysis was performed using SPSS. Descriptive statistics (e.g., frequencies, means, standard deviations) are used to summarize demographic and anthropometric data. The effectiveness of each anthropometric index in diagnosing Obesity is assessed using comparative statistical tests such as Correlation, sensitivity analysis, and Principal Component Analysis. Additionally, Receiver Operating Characteristic (ROC) analysis is used to evaluate the diagnostic accuracy of each anthropometric index.

2.7. Ethical considerations

This study adheres to ethical guidelines set by the institutional review board at Radford University College. All participants are provided with clear and comprehensive information about the study's purpose, procedures, and potential risks. Informed consent is obtained from each participant, and confidentiality is maintained throughout the research process. Personal data is stored securely and used solely for research purposes. Participants were given the right to withdraw from the study at any time without any negative consequences.

3. Results

3.1. Gender of respondents

The results in Figure 1 show that 174 respondents (80%) were female, while 45 respondents (20%) were male. This indicates a higher participation rate among female students in this study. The gender disparity could be reflective of the general enrollment patterns within certain academic programs at Radford University College, especially those related to health sciences and social sciences, which tend to attract more female students [24]. Gender differences play a significant role in obesity diagnosis and risk factors, as research suggests that fat distribution, metabolism, and body composition vary between males and females [1]. Therefore, including both genders in the study is crucial for an accurate comparative analysis of anthropometric indices.

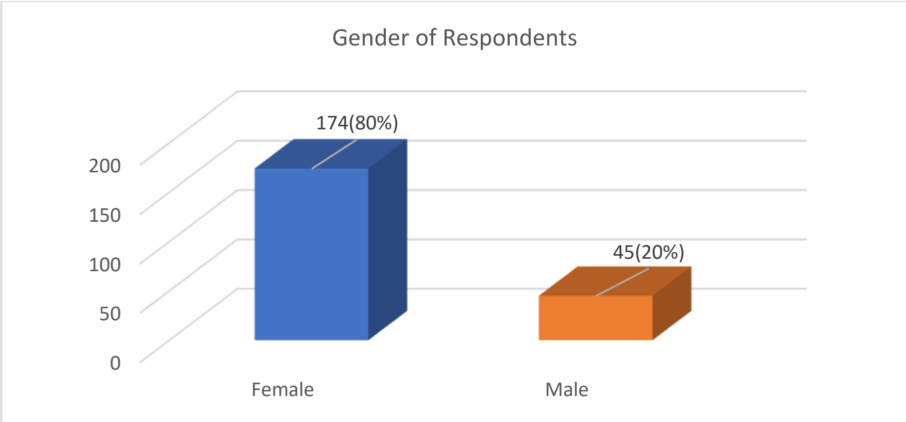

Fig. 1: Gender of Respondents.

3.2. Age of respondents

Figure 2 reveals ages of respondents ranged from 21 to 40 years, with the highest age being 25 years (55 students), followed by 24 years (32 students) and 26 years (31 students). A smaller number of respondents were above 30, with only one respondent each at ages 22, 35, 37, and 40. The distribution suggests the majority of participants are in their mid-twenties, reflecting a typical university population dominated by young adults and, more specifically, females. Age is a critical demographic factor in this study as it influences metabolic rate, lifestyle behavior, and the accuracy of anthropometric indices in diagnosing obesity. Understanding the age spread of respondents enhances the interpretation of obesity risk and helps tailor age-appropriate health interventions within the student population.

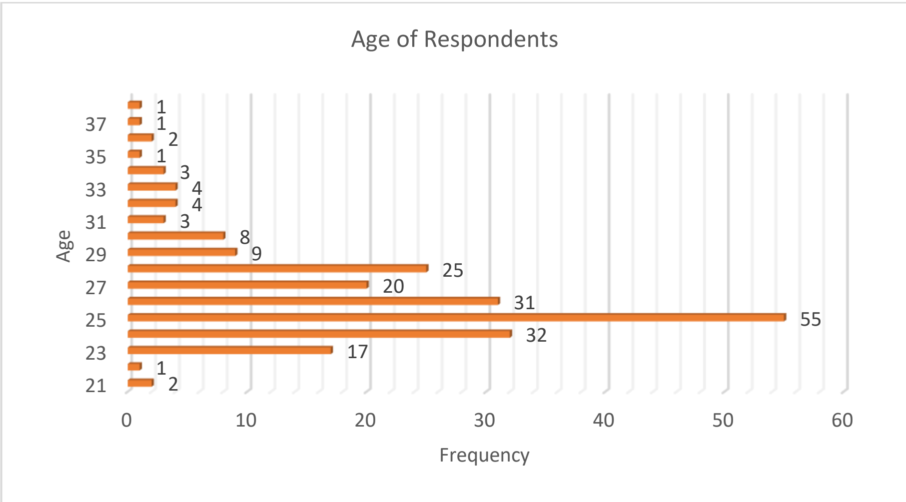

Fig. 2: Age of Respondents.

3.3. Marital status of respondents

The results from Figure 3 indicate 197 respondents (90%) as single, while 18 (10%) are married. A small percentage are cohabitating (3 respondents) or divorced (1 respondent). The predominance of single students is expected, given the university context. Marital status may influence body weight and health behavior. Studies have shown that married individuals tend to gain more weight due to shared eating patterns and less physical activity [5]. While the majority of students in this study are single, comparisons between marital status and obesity indicators can provide insights into lifestyle influences on health.

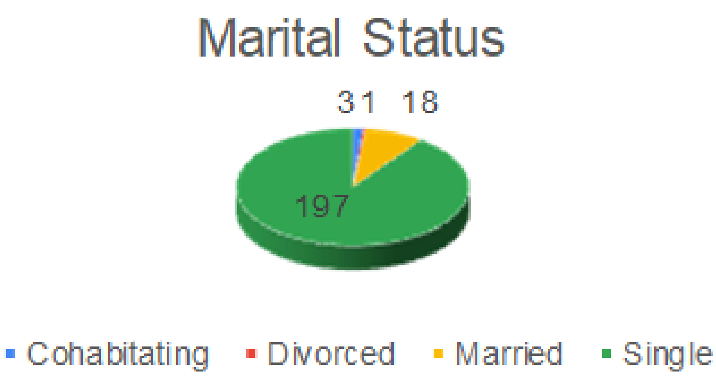

Fig. 3: Marital Status of Respondents

3.4. Educational background of respondents

The data in Figure 4 reveals majority of respondents, 156 out of 219 (71.2%), had attained secondary-level education, while the remaining 63 (28.8%) had completed tertiary education. This distribution reflects the demographic composition of a typical university environment, particularly in private institutions such as Radford University College, where a significant proportion of students are likely to be in transition from secondary to tertiary education. This result may also suggest that most respondents are in their early academic years, which is consistent with the age distribution of university populations globally [21]. Educational background plays a critical role in influencing health-related knowledge, behavior, and attitudes toward obesity prevention.

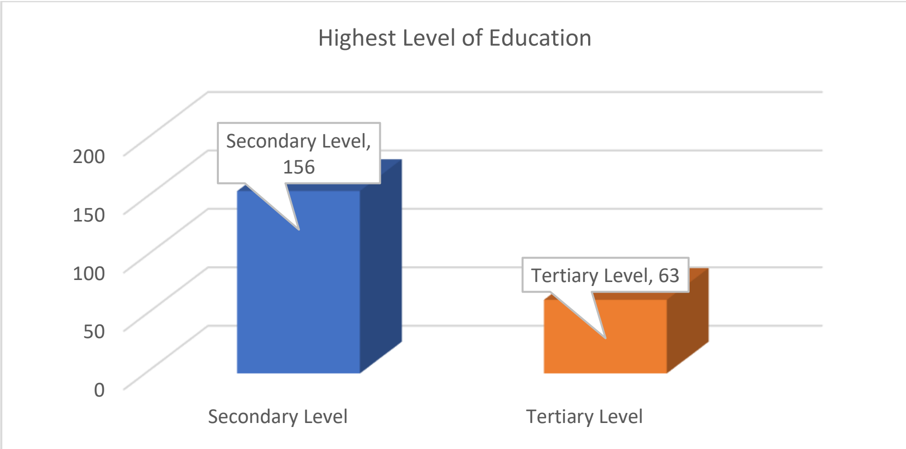

Fig. 4: Educational Background of Respondents.

3.5. Respondents' years of study at the university

Figure 5 shows that the highest proportion of respondents (118 students, 54%) were in their third year of study, followed by fourth-year students (51 students) and second-year students (26 students). First-year and fifth-year students represented smaller portions of the sample. The high number of third-year participants may be due to their availability and exposure to academic research projects, which increases their willingness to participate. Moreover, students at this level may have developed better awareness of health and wellness, which could influence their body composition and lifestyle choices.

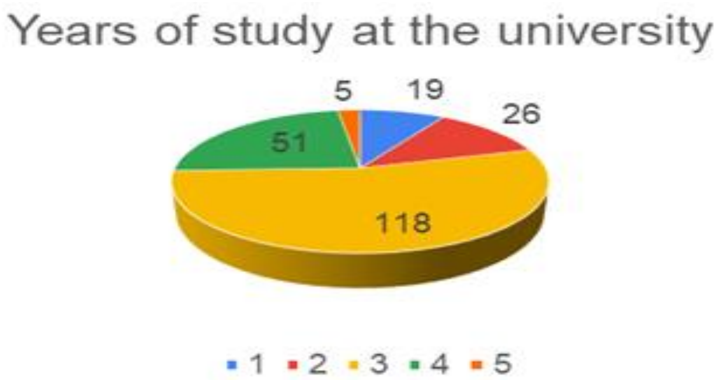

Fig. 5: Respondents' Years of Study in the University.

3.6. Other demographic characteristics of respondents

As shown in Table 3, additional demographic and lifestyle-related characteristics were assessed to provide context for interpreting the anthropometric data. These included respondents' physical activity levels, fatigue, thirst, urination frequency, changes in body weight, shortness of breath, blurred vision, and self-reported diagnoses of hypertension and diabetes. These variables offer valuable insights into early signs of obesity and related metabolic conditions among university students. The findings reveal that 63.5% of respondents reported engaging in frequent exercise, while 31.1% indicated they do not exercise at all. A considerable portion of the respondents (45.2%) had noticed a recent increase in their body weight, while 42.9% had not. Additionally, 56.2% said they do not get tired easily during physical activity, though 30.6% sometimes do. Symptoms commonly associated with metabolic issues, such as shortness of breath, frequent thirst, increased urination, unexplained weight loss, and blurred vision, were also reported, though by smaller percentages. For instance, 12.8% of respondents experienced shortness of breath during simple activities, 14.6% reported increased thirst, and 12.8% indicated they had experienced unexplained weight loss. Most participants (79.5%) denied any recent unexplained weight loss, and 82.6% reported no blurred vision. Moreover, almost all respondents had not been diagnosed with hypertension (99.1%) or diabetes (99.5%), suggesting the sample primarily represents a preclinical population. These findings are consistent with studies that identify lifestyle factors such as physical inactivity, weight gain, and fatigue as early risk markers for metabolic syndrome and obesity [22]. According to Musaiger et al. [11], increased thirst and urination, alongside reduced physical endurance, may signal insulin resistance or early stages of type 2 diabetes, especially when observed in conjunction with high BMI or central obesity. This makes these variables critical in understanding how well anthropometric indices predict not just obesity, but also the early risk of non-communicable diseases (NCDs). These additional characteristics thus provide meaningful support for comparing the effectiveness of various anthropometric indices in screening for obesity and related conditions within this university population.

Table 3: Other Demographic Characteristics of Respondents

Statement	Response	Frequency (N)	PERCENTAGE (%)
How frequently do you exercise	Frequent Exercise	139	63.5%
	More Frequent Exercise	12	5.5%
	Not Exercise at all	68	31.1%
	Total	219	100.0%
Do you get tired easily during physical activities like walking?	No	123	56.2%
	Sometimes	67	30.6%
	Yes	29	13.2%
	Total	219	100.0%
Have you noticed any recent increase in your body weight?	No	94	42.9%
	Not Sure	26	11.9%
	Yes	99	45.2%
	Total	219	100.0%
Do you experience shortness of breath during any simple physical activity?	No	151	68.9%
	Occasionally	40	18.3%
	Yes	28	12.8%
	Total	219	100.0%
How often do you feel fatigued during the day?	Never	15	6.8%
	Rarely	72	32.9%
	Sometimes	132	60.3%
	Total	219	100.0%
Do you feel thirsty more often than usual?	No	141	64.4%
	Sometimes	46	21.0%
	Yes	32	14.6%
	Total	219	100.0%
Do you urinate more frequently than usual during the day?	No	152	69.4%
	Sometimes	40	18.3%
	Yes	27	12.3%
	Total	219	100.0%
Have you experienced any recent unexplained weight loss?	No	174	79.5%
	Not Sure	17	7.8%
	Yes	28	12.8%
	Total	219	100.0%
Do you experience blurred vision?	No	181	82.6%
	Occasionally	18	8.2%
	Yes	20	9.1%
	Total	219	100.0%
Have you been diagnosed with Hypertension	No	217	99.1%
	Yes	2	0.9%
	Total	219	100.0%
Have you been diagnosed with Diabetes?		1	0.5%
	No	218	99.5%
	Total	219	100.0%

Source: Field Data: June 2025.

3.7. Correlations among anthropometric indices

This section presents an analysis of the interrelationships among selected anthropometric indices used to assess obesity among university students at Radford University College. The correlation matrix shows the strength and direction of associations between Body Mass Index (BMI), Waist-to-Hip Ratio (WaHpR), Waist-to-Height Ratio (WaHtR), Body Adiposity Index (BAI), Abdominal Volume Index (AVI), Conicity Index (CI), and Weight-Adjusted Waist Index (WAWaI). Understanding these relationships is important in identifying which indices are closely related and can be used interchangeably or in combination to improve the accuracy of obesity screening tools. From Table 4, BMI has a strong, significant positive correlation with BAI ($r = .643$, $p < 0.01$) and WaHtR ($r = .421$, $p < 0.01$), indicating that as BMI increases, so do BAI and WaHtR. These results support earlier findings by [28], who observed that BAI and WaHtR are good predictors of overall and central obesity due to their strong associations with BMI and visceral fat. Interestingly, BMI shows a negative correlation with CI ($r = –.327$, $p < 0.01$) and WAWaI ($r = –.104$, not significant). This suggests that BMI may not align closely with these indices in certain populations, possibly due to differences in how body shape and weight distribution are captured by CI and WAWaI, as noted by [7]. In contrast, WaHtR shows a very strong positive correlation with AVI ($r = .884$, $p < 0.01$) and WAWaI ($r = .800$, $p < 0.01$), as well as WaHpR ($r = .652$, $p < 0.01$). This confirms WaHtR's role as a reliable measure of central obesity, consistent with findings by [14], who highlighted WaHtR as a better indicator of cardio-metabolic risk than BMI. Similarly, WAWaI strongly correlates with CI ($r = .858$, $p < 0.01$) and AVI ($r = .835$, $p < 0.01$), which implies that these indices may be measuring similar dimensions of abdominal fat and body roundness. These high correlations suggest that AVI, WaHtR, CI, and WAWaI are strongly interconnected and may serve as more refined tools for screening central obesity, particularly when BMI alone may not provide sufficient detail. The weak or non-significant correlations between WaHpR and other indices, especially BMI ($r = .072$) and BAI ($r = .035$), indicate its limited predictive power when used in isolation, which aligns with prior research that questions the reliability of WaHpR in assessing obesity-related health risks across diverse populations [10]. Overall, the correlation matrix highlights the complexity and interplay of various anthropometric indicators. It supports the need for comparing and validating these tools in specific populations, such as university students, to ensure more accurate screening and early intervention for obesity and related metabolic disorders [20], [22].

Table 4: Correlation Matrix

	BMI	WaHpR	WaHtR	(BAI)	(AVI)	CI	(WAWaI)
BMI	1						
WaHpR	0.072	1					
WaHtR	.421**	.652**	1				
BAI	.643**	0.035	.747**	1			

AVI	0.104	.677**	.884**	.529**	1		
CI	-.327**	.613**	.595**	.145*	.818**	1	
WAWaI	-0.104	.656**	.800**	.416**	.835**	.858**	1
** Correlation is significant at the 0.01 level (2-tailed).							
* Correlation is significant at the 0.05 level (2-tailed).							

Source: Field Data: June 2025.

3.8. Correlation among other indices

The correlation matrix in Table 5 provides valuable insight into the interrelationships between key anthropometric and physiological variables such as age, weight, height, waist circumference (WC), hip circumference (HC), and systolic and diastolic blood pressure. Among the strongest observed relationships, waist circumference (WC) showed a significant positive correlation with hip circumference (HC) ($r = .635$, $p < 0.01$), indicating that as abdominal fat increases, so does fat around the hips. This supports previous findings by [14], who emphasized that both WC and HC are important markers of central and peripheral fat distribution, respectively, and often rise concurrently in individuals with increasing adiposity. Furthermore, HC also had a significant positive correlation with weight ($r = .203$, $p < 0.01$), reinforcing the role of HC as a determinant of overall body mass. Interestingly, age was significantly positively correlated with systolic blood pressure ($r = .202$, $p < 0.01$) and moderately with weight ($r = .204$), indicating that as individuals age, both body mass and systolic pressure tend to increase. This aligns with global literature on cardiovascular risk progression, particularly in young adults [19]. Conversely, height had a moderate positive correlation with weight ($r = .305$), which is expected as taller individuals generally weigh more. However, diastolic pressure did not show any significant correlation with the other variables, highlighting that it may be influenced by other external factors such as stress or genetic predispositions rather than anthropometric measures alone [23]. The significant but modest correlations between anthropometric indices suggest that while these measures are interrelated, they capture different aspects of body composition and health, underscoring the importance of multi-indicator approaches in obesity and cardiovascular risk screening.

Table 5: Correlation Matrix for Other Anthropometric Characteristics

	Age	Weight	Height	WC	HC	Systolic	Diastolic
Age	1						
Weight	0.204	1					
Height	-0.106	0.305	1				
WC	.157*	.166*	-0.045	1			
HC	0.085	.203**	0.016	.635**	1		
Systolic	.202**	.136*	0.127	0.04	-0.014	1	
Diastolic	-0.077	0.057	0.039	-0.013	0.047	-0.012	1
* Correlation is significant at the 0.05 level (2-tailed).							
** Correlation is significant at the 0.01 level (2-tailed).							

Source: Field Data: June 2025.

3.9. Sensitivity and specificity of anthropometric indices in predicting obesity

This section evaluates the diagnostic performance of selected anthropometric indices used to support Body Mass Index (BMI) in obesity screening. The indices considered include the Waist-to-Hip Ratio (WHpR), Waist-to-Height Ratio (WHtR), Body Adiposity Index (BAI), Abdominal Volume Index (AVI), Conicity Index (CI), and the Weighted-Adjusted Waist Index (WAWI), assessed for their ability to predict overweight and obesity among university students. The Receiver Operating Characteristic (ROC) analysis was conducted using BMI as the reference measure [29]. The ROC curve, presented in Figure 6, visually depicts each index's balance between sensitivity (true positive rate) and false positive rate (1 – specificity). A key metric in this analysis is the Area Under the Curve (AUC), where a value closer to 1.0 indicates higher diagnostic accuracy. From the ROC analysis and the AUC values in Table 6, among the alternative indices, the Body Adiposity Index (BAI) shows moderate diagnostic performance with an AUC of 0.724, indicating good predictive accuracy in detecting overweight and obese individuals. Similarly, the Waist-to-Height Ratio (WaHtR) recorded an AUC of 0.703, making it another moderate tool for obesity screening. These results align with [14], who advocated for WaHtR over WaHpR due to its better relationship with cardiometabolic risk factors in both sexes. The confidence intervals for BAI (0.657 – 0.791) and WaHtR (0.634 – 0.772) support their statistical reliability, with both indices achieving high significance levels ($p = 0.000$). This suggests that BAI and WaHtR can serve as effective complementary tools in clinical and public health assessments of obesity, especially where BMI measurements alone may not provide comprehensive insights into fat distribution. In contrast, several indices showed relatively weak or poor predictive power. The Abdominal Volume Index (AVI) achieved an AUC of 0.572, indicating only modest discriminative ability, while the Waist-to-Hip Ratio (WaHpR) had a near-random AUC value of 0.523, reflecting limited diagnostic accuracy. Notably, the Conicity Index (CI) and the Weight–Adjusted Waist Index (WAWaI) yielded the lowest AUCs – 0.337 and 0.382, respectively, suggesting that these indices performed worse than chance in this population. These weak outcomes could be attributed to demographic and physiological differences, such as age-related and sex-specific fat distribution patterns, which affect how certain indices reflect adiposity [7], [10]. Furthermore, the ROC analysis indicated that some indices exhibited diagonal segments that likely reflect tied values, which may reduce discrimination in some indices. Overall, this analysis reveals substantial variability in the diagnostic accuracy of anthropometric indices. Alternatives such as BAI and WaHtR offer credible support in screening capabilities, especially in populations where BMI may overlook individuals with high visceral fat but normal weight. The study's findings emphasize the necessity for a multifaceted approach to obesity screening, using both traditional and novel indices to enhance the accuracy of identification and intervention, particularly in youth populations where obesity often goes undiagnosed until adulthood [20], [22].

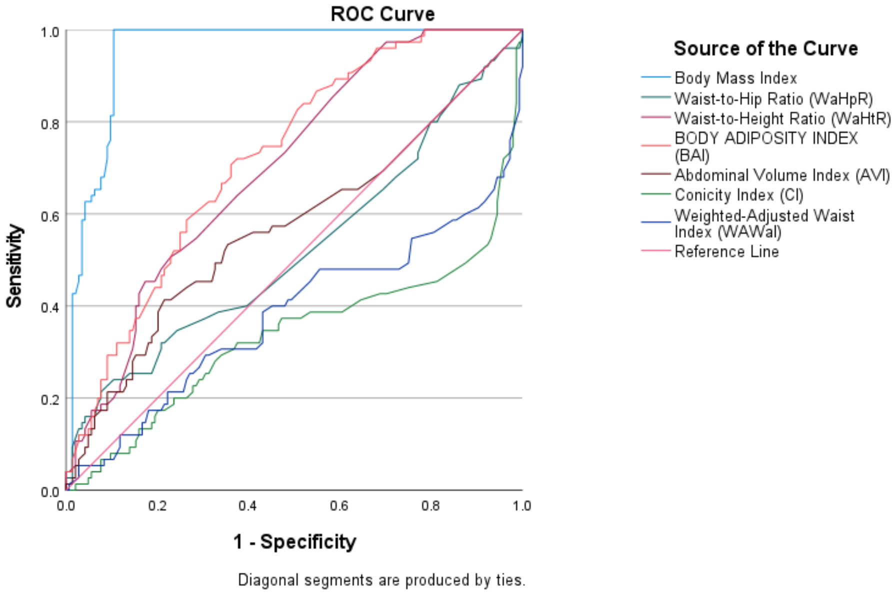

Fig. 6: ROC Curve.

Table 6: Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Waist-to-Hip Ratio (WaHpR)	.523	.043	.573	.438	.608
Waist-to-Height Ratio (WaHtR)	.703	.035	.000	.634	.772
BODY ADIPOSITY INDEX (BAI)	.724	.034	.000	.657	.791
Abdominal Volume Index (AVI)	.572	.043	.081	.488	.656
Conicity Index (CI)	.337	.043	.000	.252	.422
Weighted-Adjusted Waist Index (WAWaI)	.382	.044	.004	.296	.468

Source: Field Data: June 2025.

3.10. Supportive anthropometric indices for screening students

Table 7 presents the classification of respondents according to several anthropometric indices used to assess overweight and obesity risk. The results show a diverse distribution of body weight status based on BMI, with 23.3% categorized as underweight, 35.6% having normal weight, and 20.5% falling into the overweight category. The remaining respondents were classified under the obesity range: 12.3% in Class 1, and 4.1% each in Classes 2 and 3. These findings suggest that while a large proportion of students have normal weight, a considerable number fall within high-risk weight categories, which raises concerns about emerging health issues among the student population. This is consistent with studies by [20], [22], who found that obesity is becoming increasingly common among young adults due to sedentary lifestyles and poor dietary habits. The Waist-to-Hip Ratio (WaHpR) assessment reveals that 90.8% of females and 77.8% of males fall within the normal range, while 9.2% of females and 22.2% of males are in the high-risk category. These figures indicate that male students may be at a relatively higher risk of central obesity based on WaHpR. Similar observations were made by [14], who noted that WaHpR, although commonly used, can vary in diagnostic strength across genders and may be more predictive in males. Regarding Waist-to-Height Ratio (WaHtR), 90.9% of students were within the normal range, and 9.1% were considered at high risk, reinforcing WaHtR's effectiveness as a practical screening tool with minimal gender disparity, as also supported by [10]. Furthermore, the Body Adiposity Index (BAI) classification shows that a majority of both females (67.2%) and males (75.6%) fall within the low-fat category. However, 12.1% of females and 6.7% of males fall into the high-fat range, suggesting some gender variation in body fat distribution. The Abdominal Volume Index (AVI) results indicate that 94.5% of respondents are within the normal range, and only 5.5% are classified as high risk. Similarly, the Conicity Index (CI) shows 80.8% within the normal range, with 19.2% identified as high risk, reinforcing the idea that certain indices like CI and AVI may capture risks not immediately visible through BMI alone. These results highlight the importance of using multiple anthropometric indices to identify obesity risk more accurately, as some individuals with a normal BMI may still fall within high-risk categories on other indices [7], [11]. This part of the analysis demonstrates that while traditional indices such as BMI remain useful, emerging indices like WaHtR, BAI, AVI, and CI offer valuable complementary insights into obesity risk, especially when accounting for differences in gender and body fat distribution. Employing a combination of these measures may therefore enhance obesity screening efforts among university students and enable timely interventions to reduce the prevalence of non-communicable diseases.

Table 7: Anthropometric Indices for Screening Students

Index	Category	Class / Range	Frequency (N)	Percentage (%)
BMI Status	Underweight		51	23.3
	Normal		78	35.6
	Overweight		45	20.5
	Obesity	Class 1	27	12.3
		Class 2	9	4.1
		Class 3	9	4.1
Waist-to-Hip Ratio (WaHpR)	Female	Normal Range	158	90.8
		High Risk	16	9.2
	Male	Normal Range	35	77.8
		High Risk	10	22.2

Waist-to-Height Ratio (WaHtR)	Normal Range		199	90.9
	High Risk		20	9.1
Body Adiposity Index (BAI)	Female	Low	117	67.2
		Normal	36	19.0
		High	21	12.1
	Male	Low	34	75.6
		Normal	8	17.8
		High	3	6.7
Abdominal Volume Index (AVI)	Normal Range		207	94.5
	Abnormal (High Risk)		12	5.5
Conicity Index	Normal Range		177	80.8
	High Risk		42	19.2

Source: Field Data: June 2025.

4. Conclusion

This study examined the effectiveness of various anthropometric indices as support to BMI in screening for overweight and obesity among students at Radford University College. The findings provide valuable insights into the demographic and physiological characteristics of the student population, the interrelationships between different indices, and the reliability of each measure in detecting obesity-related risks. Firstly, the sociodemographic analysis showed that the majority of respondents were female, single, and within the 24–26-year age range. Most were in their third year of study and reported engaging in physical activity. However, some exhibited early signs of metabolic risk such as weight gain, fatigue, and increased thirst or urination, suggesting the potential onset of obesity or related conditions. Secondly, the correlation analysis revealed significant associations between BMI and other indices such as BAI and WaHtR, while measures like CI and WAWaI demonstrated weak or negative relationships with BMI. This highlighted the complexity of body composition and confirmed that not all indices are equally related, with some better suited for measuring central adiposity. Thirdly, the sensitivity and specificity assessment using the ROC curve established that BAI and WaHtR are the most reliable indices in predicting overweight and obesity. In contrast, indices such as WaHpR, CI, and WAWaI showed low diagnostic accuracy, making them less suitable for screening in this population. The analysis emphasized that no single index is sufficient in isolation; a combined approach is more effective in identifying students at risk for obesity.

Author Contributions

Richard Nkrumah conceptualized the study, designed the methodology, conducted the analysis, and organized the manuscript. Yennusom Maalug supervised the research. Angela Nkrumah, a registered midwife, assisted with the measurement of participants' anthropometric parameters. Derrick Nii Kwartei Quartey, Andrews Yeboah Murphy, and Jacob Apibilla Ayembilla contributed to data collection and organization.

Funding

This research did not receive any specific grant or financial support from funding agencies in the public, commercial, or not-for-profit sectors.

Institutional Review Board Statement

This study involved the collection of primary data from human participants through structured questionnaires and physical assessments using instruments such as a blood pressure apparatus, glucometer, calibrated digital scale, and stadiometer. Ethical approval for the study was obtained from Radford University College. Participation was entirely voluntary, and informed consent was obtained from all participants before data collection. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Ghana and the institutional guidelines for research involving human subjects.

Data Availability Statement

The dataset contains sensitive medical information about participants. To protect privacy and maintain ethical standards, the data are available from the corresponding author upon reasonable request.
Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this article.

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