Body Roundness index, biochemical and Clinical indices in Undergraduate students of a Public University in Edo State, Nigeria: A Pilot Study

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ABSTRACT

Background: *Anthropometric indices are useful in determining the types of obesity. In spite of studies done, there is paucity of information on the association of new anthropometric indices with clinical and biochemical indices in adolescents.*

Objective: *This study was aimed at investigating the association of Body Roundness Index (BRI) with biochemical and clinical indices in undergraduate students of Edo State University Uzairue, Edo State, Nigeria.*

Methods: Eighty-seven (87) undergraduate students; 38 males and 49 females aged 15 to 24 years old participated in this cross-sectional study. Socio-demographic data, anthropometric indices, biochemical and clinical measurements were made using appropriate methods. Data analyzed using SPSS were considered significant at $p<0.05$.

Results: *BRI had sensitivity of 100%, specificity of 80.5% and model quality of 0.87 at BMI> 30 kg/m^2. Age, weight, height, waist circumference, middle-upper arm circumference, systolic blood pressure, lean body mass, muscle, water and metabolism were significantly higher in male compared with female participants ($p<0.05$). Whereas, percentage body fat and body age were significantly higher in female than male participants ($p< 0.05$). BRI positively correlated with body age, weight, BMI, waist circumference, hip circumference, middle-upper arm circumference, systolic blood pressure, diastolic blood pressure, fat, visceral fat, metabolism, obesity and lean body mass ($p< 0.05$). BRI inversely correlated with water and protein ($p< 0.05$).*

Conclusion: *BRI appears more useful in identifying obesity. The association of BRI with anthropometric indices and blood pressure suggests its utility in predicting obesity and its associated diseases.*

Keywords: Undergraduates, Body Roundness Index, Anthropometric indices, Biochemical indices, Clinical indices

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INTRODUCTION

The nutrition and dietary habits of undergraduate students constitute major public health concerns in several parts of the world, particularly in Nigeria, where malnutrition and nutrition-related diseases are widespread (1). Anthropometric indices and dietary habits of Nigerian undergraduate students demand attention to gain a better understanding of their nutritional health and develop strategies to improve and prevent future nutritional health challenges.

The Body Roundness Index (BRI) is an anthropometric index that determines Visceral Adipose Tissue (VAT) and body fat percentage by combining height and waist circumference to predict the total and regional fat distribution in the body (2). The BRI has a potential of predicting the risk of many nutrition-related diseases and disorders such as obesity, diabetes mellitus, metabolic syndrome, and other cardiovascular diseases (CVDs) (3). However, only a few studies have used the BRI to predict

diseases and indicated the utility of BRI in identifying both cardiovascular disease (CVD) and CVD risk factors. Currently, information is sparse on the utility of BRI in adolescents and young adults.

A report showed a perfect non-linear relationship between BRI and Waist to Height Ratio (WHtR) (4). It was also reported that BRI has the advantage over the WHtR in that it can assess body fat percentage and so provides a more comprehensive picture of physical health condition (4). In a study conducted to determine the association of certain anthropometric indices with cardio-metabolic risk in a Chinese population, BRI showed a higher superiority than Waist Circumference (WC), Waist Hip Ratio (WHR), Body Mass Index (BMI) and WHtR in predicting accrued cardio-metabolic risk (3). Yang et al (5) reported an association between higher BRI trajectory and higher risk of CVDs. Rico-Martin et al (6) reported that BRI is a good predictor of metabolic syndrome in both genders irrespective of ethnicity and nationality.

Currently, there is paucity of information on the relationship between new anthropometric indices and other indices including biochemical and clinical indices. This study was designed to elucidate the association between BRI and biochemical and clinical indices in undergraduate students of Edo State University Uzairue, Edo State.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study involved 87 apparently healthy undergraduate students of Edo State University Uzairue., Edo State, Nigeria recruited using random sampling method. The respondents comprised 38 males and 49 females aged between 15 and 24 years old. Written consent was obtained from the study participants after the study's aims and objectives were discussed with them. A semi-structured, interviewer-administered and pre-tested questionnaire was used to collect information on socio-demographic characteristics. Anthropometric and biochemical parameters were assessed using standard methods.

Sample Size Determination

The sample size was determined using the formula;

$n=Z\alpha^2 P(1-P)/d^2$

Where n=sample size, Zα=Standard normal value at confidence level at 100=1.96, d=margin of error=0.05 and p=prevalence of hypertension in Nigerian adolescents estimated at 5% (7)

$N= (1.96)^2 0.05(1-0.05)/(0.05)^2=72.99=73$

Anthropometric measurements

Body Weight was measured using two scales: a manual and an electronic weighing scale. The manual scale used was adjusted to zero before each use. Respondents' weights were assessed with, light outdoor clothing, without head covering and barefooted. Weight was measured in kilogrammes based on the average of two sets of readings. The electronic weighing scale was used alongside a Bluetooth-connected android phone app (OKOK) that records weight, fat, muscle, water, visceral fat, bone mass, metabolism, protein, obesity, body age, lean body mass (LBM), and BMI after prior input of height data.

Height

The height of participants was determined as described by Ajayi *et al* (8)

Waist circumference

The waist circumference of participants was measured using an inelastic tape rule. The tape rule was wrapped around the participant's waist i.e. minimum circumference between the iliac crest and the rib cage while standing (9). Measurement was taken in centimetres and recorded to two decimal places.

Hip circumference

Hip circumference was determined at the minimum circumference at the level of the greater trochanters using an inelastic tape rule (9). Measurement was taken in centimeters and to two decimal places

Middle upper arm circumference

The middle upper arm circumference of participants was measured using a tape rule in centimetres. The tape rule was wrapped around the participant's left middle upper arm between the tip of acromion and olecranon (10). The tape was firmly placed on respondent's arm to avert compression of the soft tissue. Measurement was taken and recorded to two decimal places. MUAC values were determined directly in participants above 19 years old, whereas z-scores of MUAC were computed in adolescents in the study

Body Mass Index (BMI)

The body mass index was calculated using the formula Wt/H^2 manually and automatically calculated by the automatic scale after prior input of height. BMI values were determined directly in participants above 19 years old, while z-scores of BMI were computed in adolescent participants.

Body Roundness Index

The body roundness index was calculated by the formula $BRI = 365.2 - 365.5 \times \sqrt{1 - [(WC2\pi)^2 / (0.5 \times height)^2]}$.

Clinical data

Clinical information was taken from each participant as described below:

Pulse rate and Saturation of Peripheral Oxygen (SpO_2)

An oximeter was used to determine the pulse rate and SpO_2. The oximeter was switched on and placed

on the participant's middle or index finger while seated and rested for about 2 minutes before when readings were taken. Readings were taken according to manufacturer's instruction

Blood pressure and Pulse pressure

Systolic, diastolic blood pressure and pulse pressure were determined by an automatic sphygmomanometer. Each participant was seated and asked to rest for 5 minutes before the test, the cuff was placed on the bare left upper arm of the participant one inch above the bend of the elbow and wrapped around it until it was evenly tight around the upper arm that only two fingers can slip under the top edge of the cuff. The participant was asked not to move or talk, the machine was then turned on and readings were taken.

Body composition

Data on the following body composition were obtained using the electronic weighing scale (OKOK Home use intelligent Bluetooth body fat scale, QB/T2065-1994, China); fat, visceral fat, muscle, water, protein, bone mass, metabolism, lean body mass, obesity and body age according to the manufacturer's instruction.

Biochemical data

Biochemical information was taken from each participant as described below:

Plasma glucose

Plasma glucose was estimated by the use of an Accu-chek glucose meter. A test strip was loaded into the blood glucose meter. The fingertip of the participant was cleaned with cotton wool containing ethanol and pricked with a sterile lancet. Pressure was added to squeeze out a drop of blood that was placed on the test area of the test strip and the reading was displayed on the screen of the glucose meter Accu-chek. Both fasting and random plasma glucose test was carried out.

Total cholesterol

The total cholesterol was estimated by a lipid estimation meter (SpeedGUC Multifunctional Analyzer, Changasha Zealson Biotech, China). A test strip was loaded into the cholesterol meter and the right code was inputted into the meter. A fingertip of the participant was cleaned with cotton wool containing ethanol and pricked with a sterile lancet. Pressure was added to squeeze out a drop of blood that was placed on the test area of the test strip and the reading was displayed on the cholesterol meter and was recorded. Both fasting and random total cholesterol test were carried out.

Ethical Considerations

The Ethics committee of Edo State University, Uzairue, Edo State, Nigeria approved this study. (ERC/FBM/007/2021).

Data analysis

Data were analyzed using statistical package for social sciences (SPSS 18.0). The frequencies and percentages of participant's socio-demographic data were also determined. Student's t-test was used for the comparison of mean (mean±SD) of the quantitative variable, while the association among the variables was determined by Pearson correlation coefficient. Data were considered statistically significant at $P < 0.05$.

RESULTS

Gender, Age, Faculty, BMI and Blood Pressure Distribution of Study Participants

Table 1 shows the gender, students' faculty and age distribution of study participants. Female population was higher than male population. Furthermore, students in the faculties of Applied Health Sciences and Law accounted for the highest and least population of the study participants, respectively. Students aged 18-20 years and 24-26 years accounted for the highest and least population of the study. Normal weight and obese participants were 54.02% (highest) and 10.35% (least), respectively. Individuals with normal blood pressure accounted for 81.61% of the study participants.

Comparison of Age, Body composition, Anthropometric, Clinical and Biochemical Indices in Male and Female Participants

As shown in Table 2, significant difference was found in the comparison of male and female participants in their age, body age, weight, height, waist circumference, middle upper arm circumference, systolic blood pressure, fat, lean body mass, muscle, water and metabolism ($p<0.05$) while there wasn't significant difference found in BMI, hip circumference, body roundness index, diastolic blood pressure, pulse rate, pulse pressure, SpO_2, visceral fat, obesity, bone mass, protein, random glucose and random cholesterol level.

Correlation of BRI with Age, Body Composition, Anthropometric, Clinical and Biochemical Indices

Table 3 shows the association of BRI with age, body composition, anthropometric, clinical and biochemical indices. Association was found between BRI and body age, weight, BMI, waist circumference, hip circumference, middle upper arm circumference, systolic blood pressure, diastolic blood pressure, fat, visceral fat, metabolism, obesity and lean body mass all had a positive relationship with BRI while protein and water had a negative relationship with BRI ($p<0.05$). No significant association was found between BRI and height, pulse rate, SpO_2, pulse pressure, muscle, bone mass,

Table 1: Gender, Age, Faculty, BMI and Blood Pressure Distribution of Study Participants

Parameter	Frequency (87)	Percentage(%)
Gender		
Male	38	43.68
Female	49	56.32
Age (years)		
15-17	18	20.69
18-20	44	50.57
21-23	23	26.44
24-26	2	2.30
Faculty		
Science	5	5.75
Applied Health Science	25	28.74
Engineering	22	25.29
Clinical Science	4	4.59
Basic Medical Science	6	6.89
Law	3	3.45
Arts, Management and Social Sciences	22	25.29
BMI (Kg/m^2)		
<18.5 (Underweight)	12	13.79
18.5-24.9 (Normal weight)	47	54.02
25-29.9 (Overweight)	19	21.84
>30 (Obese)	9	10.35
Blood Pressure (mmHg)		
<120/80 (Normal)	71	81.61
120-129/<80 (Elevated)	7	8.04
>130-139/80-89 (High Blood Pressure)	9	10.35

N=Number of participants, %=Percentage

random glucose and random total cholesterol level.

Specificity, sensitivity and model quality of BRI for detecting different classes of body mass index

Table 4 shows the sensitivity, specificity and model quality of BRI for underweight, normal weight, overweight and obesity. Highest sensitivity (100%), specificity (80.5%) and model quality (0.87) were observed for obesity (BMI > 30 kg/m^2).

Receiving operating characteristic curves of BRI based on underweight, normal weight, overweight and obesity are shown in Figures 1, 2, 3 and 4, respectively.

DISCUSSION

In this study, males were observed to be significantly older than females. This observation is similar to a report from another study (11). The reason for this is not clear, it could be that females were admitted into this institution at a younger age in comparison with male participants. It is of note also that females accounted for over 50% of the study participants. This observation suggests the increase in female enrolment in our tertiary institution.

Metabolic age is a function of body metabolism. In this study, female participants had a higher body age than male participants. This is physiological and could be due to differences in energy metabolism in the genders. Males are assumed to consume more food than females which enhances their muscle mass building (12). Contrariwise, women generally have more fat depots than men, with young women showing appreciably higher level of body fat as well as less of lean body mass than their male counterparts (13, 14).

Anthropometric indices are non-invasive techniques used in assessing health status and future risks of having any disease condition (15). Body weight was significantly higher in males than females in this study. This could be attributed to the role of androgens in metabolism. Testosterone enhances cell growth and maintains bone mineral density (16,17,18). Bone and muscular changes in adolescent males are significantly influenced by

Table 2: Comparison of Age, Body composition, Anthropometric, Clinical and Biochemical Indices in Male and Female Participants

Variable	Male (n=38)	Female (n=49)	t	P
Age and Anthropometric Indices				
Age (years)	19.68±1.99	18.65±1.96	2.460	0.016*
Body age (years)	22.13±6.21	25.22±4.57	-2.312	0.024*
Weight (Kg)	75.03±16.62	62.86±13.23	3.910	0.000*
Height (m)	1.76±0.07	1.63±0.06	9.210	0.000*
BMI (kg/m^2)	25.157±4.853 (n=22)	23.782±4.486 (n=17)	0.247	0.932
ZBMI	-0.008±0.965 (n=18)	0.004±1.031 (n=35)	-0.040	0.968
Waist circumference (cm)	79.65±10.09	70.71±8.69	4.558	0.000*
Hip circumference (cm)	95.44±10.46	90.57±14.49	1.796	0.076
MUAC (cm)	28.859±4.340 (n=22)	25.612±3.251 (n=17)	2.574	0.475
ZMUAC	0.284±1.479 (n=18)	-0.146±0.609 (n=30)	1.499	0.140
BRI	2.69±1.01	2.33±0.98	1.734	0.086
Clinical Parameters				
SBP (mmHg)	115.70±17.28	106.11±12.09	3.128	0.002*
DBP (mmHg)	75.18±12.92	70.94±8.47	1.892	0.062
Pulse rate	84.00±27.44	82.52±12.75	0.344	0.732
Pulse Pressure	84.90±31.38	84.94±12.11	-0.009	0.993
SpO_2	95.65±4.50	96.08±8.42	-0.290	0.773
Body Composition				
Fat (%)	19.91±8.58	29.58±8.37	-5.431	0.000*
Visceral Fat	6.65±5.61	4.72±3.12	1.762	0.083
Obesity (%)	9.68±21.23	12.40±21.73	-0.602	0.548
LBM (kg)	58.43±8.31	43.34±4.44	11.104	0.000*
Muscle (kg)	56.67±8.70	44.16±11.44	5.667	0.000*
Water (%)	55.44±3.89	49.04±3.41	7.077	0.000*
Bone mass (kg)	3.39±4.62	2.61±0.73	1.210	0.230
Metabolism	1701.93±259.61	1353.97±154.33	8.006	0.000*
Protein (%)	24.71±13.54	19.08±13.71	1.691	0.096
Biochemical Parameters				
Random Glucose (mg/dl)	102.74±13.75	108.38±18.84	-1.304	0.198
Random Total Cholesterol (mg/dl)	264.18±52.36	254.25±45.92	0.334	0.744

Values are mean±SD, LBM: Lean Body Mass. SBP: Systolic Blood Pressure. DBP: Diastolic Blood Pressure. MUAC: Middle upper arm circumference. SpO_2: Saturation of Peripheral Oxygen. *Significant at $p<0.05$. Z=Z-score

elevated testosterone and IGF-1, hence resulting in elevated muscular mass (19).

Height was significantly higher in males than females in this study. Our observation is similar to a report by Tang et al (20). Environmental, endocrine and genetic factors could be responsible for this observation (21). Genetic variation in CYP19 gene on the Y chromosome in men influences a man's height (22). The faster rate of growth in boys than girls at the peak of puberty could also be enhanced by higher testosterone levels (20).

Waist circumference (WC) is a pointer to intra-abdominal adipose tissue mass, elevated level of which raises the risk of cardio-metabolic diseases (23). In this study, it was observed that males had significantly higher WC compared to females. This was similar to the reports by Jacobsen and Aars (24) and Stevens *et al*. (25). The reason for this observation could be due to factors outside the scope of this study

Table 3: Correlation of BRI with Age, Body Composition, Anthropometric, Clinical and Biochemical Indices

Index	Index	r	P
BRI	Body age	0.533	0.000*
	Weight	0.700	0.000*
	Height	0.100	0.343
	BMI	0.779	0.000*
	Waist circumference	0.848	0.000*
	Hip circumference	0.597	0.000*
	MUAC	0.372	0.000*
	Pulse rate	-0.187	0.074
	SBP	0.481	0.000*
	DBP	0.307	0.003*
	SpO_2	0.092	0.383
	Pulse pressure	-0.175	0.095
	Fat	0.562	0.000*
	Muscle	0.205	0.055
	Water	-0.425	0.000*
	Visceral fat	0.808	0.000*
	Bone mass	0.156	0.139
	Metabolism	0.531	0.000*
	Protein	-0.331	0.006*
	Obesity	0.785	0.000*
	LBM	0.459	0.000*
	Random Glucose	-0.043	0.750
	Random Total cholesterol	-0.041	0.883

*Significant at $p<0.05$. r=Pearson correlation coefficient.

Table 4 shows the sensitivity, specificity and model quality of BRI for underweight, normal weight, overweight and obesity. Highest sensitivity (100%), specificity (80.5%) and model quality (0.87) were observed for obesity (BMI > 30 kg/m^2).

Table 4: Specificity, sensitivity and model quality of BRI for detecting different classes of body mass index

BMIs	Sensitivity	Specificity	Model Quality
< 18.5 kg/m^2	91.7%	0%	0.01
18.5 – 24.9 kg/m^2	100%	19.5%	0.30
25 – 29.9 kg/m^2	94.7%	49.3%	0.58
> 30 kg/m^2	100%	80.5%	0.87

A good model has a value above 0.5. A value less than 0.5 indicates the model is no better than random prediction.

The Mid Upper Arm Circumference gives an indication of the extent of wasting. It is an indicator of nutritional status in adults (10). In this study, there was no difference in the MUAC and ZMUAC of participants in this study. Mid Upper Arm Circumference is a measure of the aggregate of both muscular and subcutaneous fat in the upper arm and males are usually more muscular than females (26).

Human body composition assessment enhances the

understanding of the functional capability and nutritional status of the human body (27). Percentage body fat indicates the total stored fat excluding lean body mass and muscle mass in the body (28). In this study, females were observed to have significantly higher percentage body fat compared to males. This was similar to some reports (29, 30). Women have the ability of accumulating fat right from the pubertal to menopausal phases of life (31)

It was observed in this study that males had significantly higher lean body mass, muscle mass, body water concentration and rate of metabolism compared to the females. Observations in this study

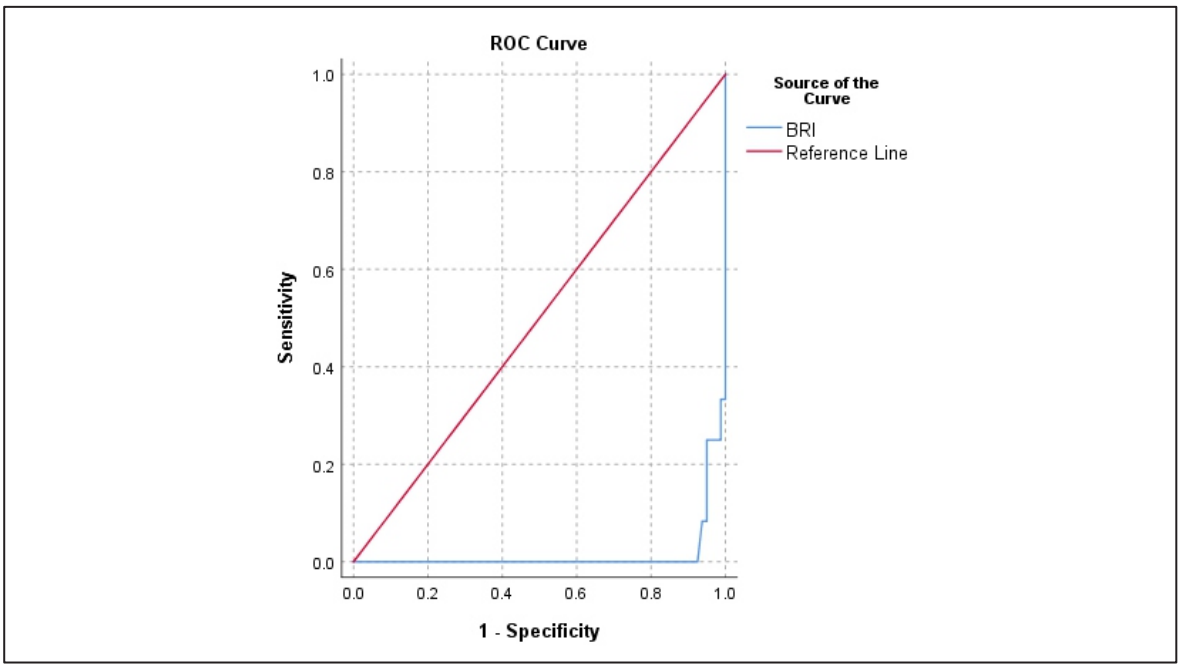

Fig. 1: ROC curves of BRI based on BMI < 18.5 kg/m^2

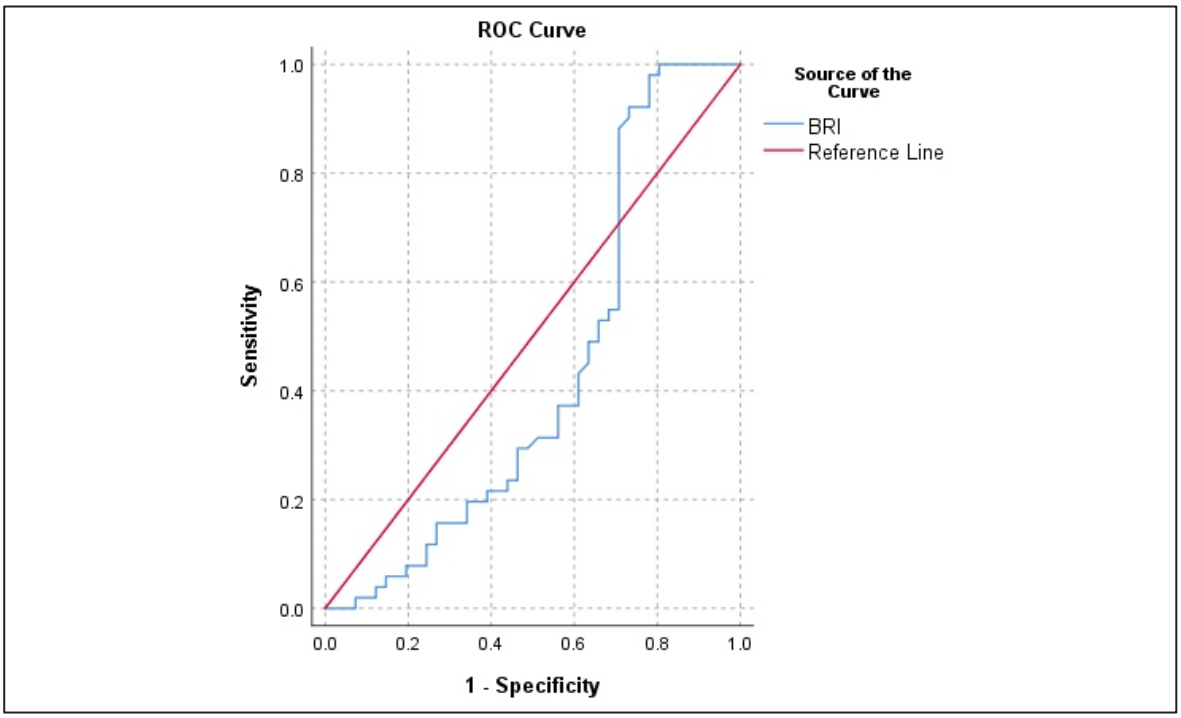

Fig. 2: ROC curves of BRI based on BMI 18.5kg/m^2-24.9 kg/m^2

were in tandem with other reports (2, 11, 32. 33). These observations are physiological and have been attributed to the sex hormones (30)

It has been reported that men usually have elevated blood pressure and develop cardiovascular diseases earlier than women (34). It was observed in this study that systolic blood pressure was significantly higher in males in comparison with females. A similar finding was published by Reckelhoff (35). Androgens, particularly, testosterone is critical in

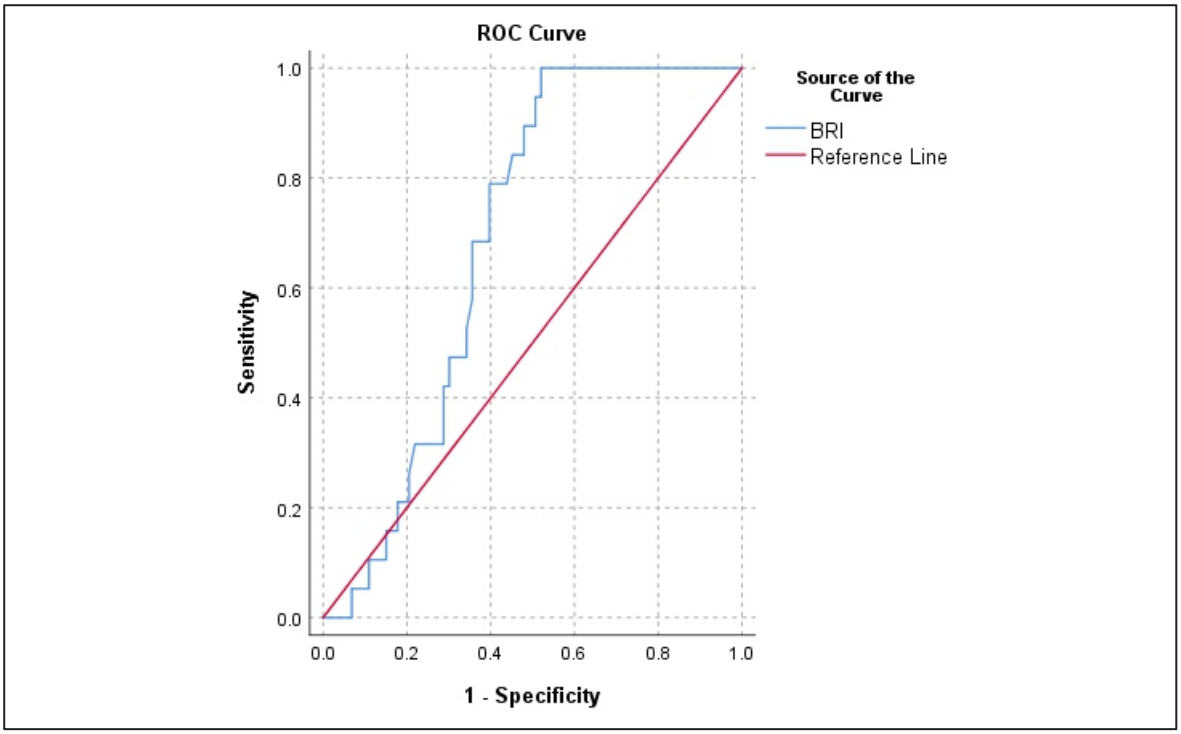

Fig. 3: ROC curves of BRI based on BMI 25.0kg/m^2-29.9kg/m^2 kg/m^2

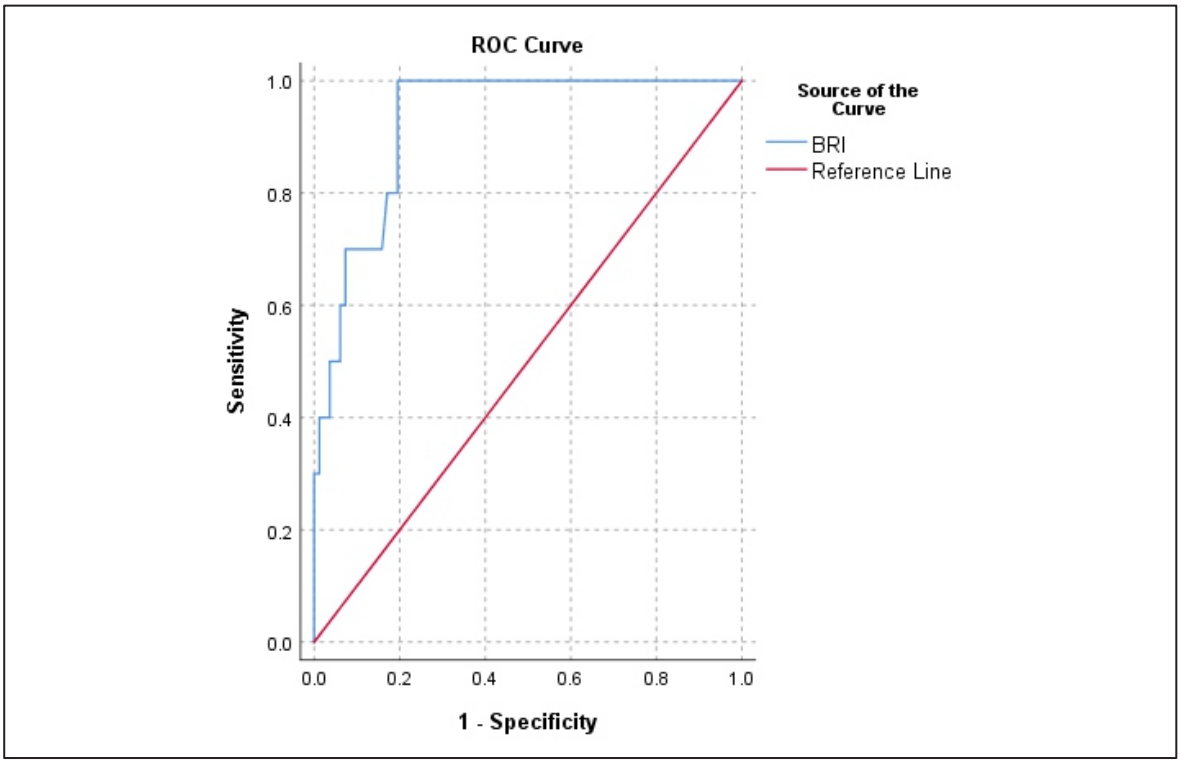

Fig. 4: ROC curves of BRI based on BMI > 30 kg/m^2

gender-associated disparity in blood pressure control. After the onset of puberty, boys have an elevated blood pressure than age-matched girls. In a report of participants aged 13 and 15 years, boys had 4 mmHg systolic blood pressure higher than girls, while an increase of between 10 and 14 mmHg was observed in boys than girls aged 16-18 years. In post-pubescent boys, the rate blood pressure plummeting is less than girls'. Decrease in night blood pressure plummeting indicates dysfunctional control of blood pressure (35)

The performance of BRI with BMI in this study was sub-optimal in assessing under and normal weights. Its sensitivity is highest in determining obese individuals. BRI therefore offers a better alternative to BMI in distinguishing individuals with overweight and obese in the population. It is known that BMI assesses general obesity and cannot distinguish between lean body from fat mass which BRI can (3, 10)

In this study, BRI was observed to have both positive and inverse relationships with certain anthropometric, clinical and biochemical parameters. A positive relationship was observed between BRI and body age. Furthermore, BRI was observed to have a positive relationship with weight in this study. This was similar to the findings of Li *et al* (36). BRI was observed to have a positive relationship with BMI in this study. A similar report was made by another author (37). BRI was observed to have a positive relationship with waist circumference in this study. It was similar to the findings of another Xu *et al* (3). In this study, a positive relationship was observed between BRI and hip circumference. Middle upper arm circumference was discovered to have a positive relationship with BRI in this study.

A positive relationship of BRI with blood pressure was observed in this study. This was similar to a report by another author where a positive relationship was also found between BRI and systolic as well as diastolic blood pressure in adolescents (37). In this study, BRI positively correlated with body fat, visceral fat, obesity and lean body mass. Thomas *et al*.(2) reported a similar observation between BRI and body fat. Nkwana *et al* (38) also reported a positive relationship of BRI with obesity. Some reports showed an association of BRI with cardiovascular diseases (39,40). It therefore shows that observations made in this study suggest the use of BRI in determining the risk of cardiovascular diseases.

BRI and water were found to have a negative relationship in this study, the reason might be because the more fat depots present in the body, the less water reserves and a higher BRI indicates high body fat. A positive relationship between BRI and metabolism was observed. A negative relationship between BRI and protein was observed.

In this study, there was no difference in the levels of random glucose and total cholesterol between the two genders. This observation was similar to the report of Kamalaja and Rajeswari (41) that found no difference in random blood levels between the two genders in a study of rural population. Similarly, (42) reported no difference in the blood glucose levels between male and female undergraduate students. The observation of no significant difference in random total cholesterol levels between the two genders in this study however contrasted with the report of Dharmapriya and Bandara (43) that found a significantly higher fasting total cholesterol level in male than female apparently undergraduate students. The disparity between our findings and theirs could be in the nature of samples used for the analysis.

CONCLUSION AND RECOMMENDATION

In conclusion, observation in this study suggests the utility of BRI in determining obesity better than BMI. Furthermore, the association of BRI with BMI, waist circumference, hip circumference, middle upper arm circumference, systolic blood pressure, diastolic blood pressure, fat, visceral fat, metabolism, obesity and lean body mass suggests its utility as a good indicator for predicting some metabolic disorders and diseases such as obesity, hypertension, metabolic syndrome and cardiovascular diseases.

LIMITATIONS

The small study sample size was a limitation. Furthermore, the limited number of respondents is another limitation in the type of analysis conducted in this study. This was due to the fact that the study was a pilot study as earlier stated. It is hoped that the eventual findings of the main study upon completion can validate the observations made in this pilot study.

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CONFLICT OF INTEREST

None

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