Bio-electrical Impedance Analysis versus Anthropometry as Predictor for Hypertension

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Abstract

Background: Several measures like Bio-electrical Impedance Analysis (BIA) and anthropometry are been proposed in literature to quantify obesity. As Obesity is an established harbinger of hypertension; the strength of association of these measures with hypertension may provide an evidence for their aptness in context specific setting.

Aims and Objective: To compare the performance of Bio-electrical Impedance Analysis with anthropometric indices (Body Mass Index and Waist Circumference) to predict hypertension among Indian population.

Method/study design: This hospital based cross sectional study was conducted for 6 months. BIA, anthropometry data and blood pressure were recorded from representative sample. Validity of these obesity measures for hypertension was analyzed through sensitivity, specificity and predictive values. Further the strength of association and overall accuracy of these measures were compared through area under Receiver Operator Characteristic (ROC) curves and non-parametric paired comparisons.

Result: Waist Circumference (WC) was overall more sensitive and specific tool than BIA and Body Mass Index (BMI), with higher predictive accuracy for hypertension. Area Under Curve (AUC) was maximum for WC in both male and female and this difference was detected statistically significant in contrast paired comparison.

Conclusion: BIA was not found to be superior over anthropometric measures in Central-Indian ethnicity to envisage Hypertension; However, more evidences need to be generated from a multi-centric study with diverse strata representation before making final remark.

Key words: Obesity, BMI, WC, BIA, Hypertension, ROC

Introduction

Hypertension is the leading single risk factor accounting for global disease burden. Approximately 9.4 million (95% UI 8·6 million to 10·1 million) deaths globally and 7·0% (6·2–7·7) of global Disability Adjusted Life Years (DALYs) in 2010 were attributed to it.[1]

Obesity is a strong and independent risk factor for hypertension.[2]The adipocytes behave as an endocrine cell and release numerous molecules including Angiotensinogen and Cytokines which in turn activate rennin-angiotensin-aldosterone axis and Sympathetic Nervous System.[3, 4]

The risk of hypertension is 5 times higher in the obese as compared to non-obese person. Obesity attributes >85% to all hypertension cases.[5]

Obesity can be measured indirectly by anthropometric indices like Body Mass Index (BMI) and Waist Circumference (WC), While Bio Electric Impedance Analysis (BIA) directly measures Body Fat Percentage(BF%).

Because of the intrinsic, constitutional and instrumental limitation of anthropometric tools, will it be more valid to assess the actual amount of fat? Bio electric impedance analysis is a relatively simple, quick & non-invasive technique to measure body composition. By measuring conductance of small current through body, BIA allows calculation of fat free mass & body fat %(BF%).[6]BIA has an advantage over BMI & WC that it can differentiate between fat & lean tissue. Erceg[7] showed that mean BF% calculated by BIA was not significantly different from Dual Energy X-ray Absorbtiometery (DEXA) & Hydrostatic Weighing. A good agreement was also detected between BIA and DEXA.[8]

Present study was conducted with the objective to compare the performance of BIA; a direct measure of percentage body fat to surrogate measure of body fat - BMI & WC in their ability to predict hypertension.

Methodology

The study was carried out in a tertiary care center in central India for a period of six months. The sample size was calculated 384≈400 assuming pre-test prevalence 0.20 and maximum allowable error 20%.[9]These 400 participants aged 20 years and above were equally taken from the general Out Patient Department (GOPD) from each week day through simple random sampling. Participants with known secondary hypertension, pregnancy, ascites and presenting with emergency were excluded from study. After the informed consent, anthropometric measurement (height, weight and waist circumference) were performed as per the standard protocol set by World Health Organization (WHO).[10, 11]The height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. The Body Mass Index (BMI) was calculated as weight (kg)/height^2 (m). The cut off value[12] for obesity was set as BMI > 25kg/m^2. Waist circumference was measured midway between iliac crest and lowermost margin of ribs. Discrimination value for obesity was defined as WC > 90 cm for men & > 80 cm for women.[10]

Body Fat Percentage (BF %) was measured with the help of body fat analyzer. The readings were recorded after entering the data about sex, age, height and weight of the subject. The males with BF% > 25 and females with BF %> 32 were considered to be obese.[13]

Blood pressure was recorded in sitting position after 5 minutes rest with a mercury sphygmomanometer according to Joint National Committee-VII guideline. Individuals were considered to have hypertension if their systolic blood pressure was > 140 mm Hg or diastolic blood pressure > 90 mm Hg or if they were under treatment for hypertension.[14]

Sensitivity, specificity, positive/negative predictive value and likelihood ratio for each measurement tools (BMI/WC/BF %) were separately calculated for male and female. Receiver Operating Curves (ROC) for each tool was drawn to check the discriminating capacity among diseased and non diseased assuming measures as continuous variable. This study examines the performance of tools over a range of decision levels through D'long-D'long non-parametric approach.[15]

Present study provided the appropriate interpretation of the tools and their hypertensive state and the treatment was made available to them.

Results

There were 240 males and 160 females in the study out of which 105 males and 70 females were hypertensive (sample prevalence=43.75%). The demographic and anthropometric characteristics of studied normotensive and hypertensive population are shown in Table 1.

Performance of the studied obesity measures to envisage hypertension is shown in Table 2.

Waist circumference was detected most sensitive and specific obesity measures tool allied with hypertension in males while in females it was identified as most specific but less sensitive than BF%. Positive predictive value (PPV) was highest for WC in both sexes and Negative Predictive Value (NPV) was highest for WC in male and equivalent to BF% in female.

The trade-off trend between sensitivity and specificity for alternative tests (WC/BMI/BF %) is shown by ROC curves (Figure 1 and Figure 2) for both sexes**.** The results of the paired comparisons for Area Under Curve for WC/BMI/BF% are as shown in (Table 3).

Waist circumference occupied the maximum Area Under Curve (AUC) in both sexes. The paired comparison difference was significantly higher for Waist circumference with other two studied variable in male and with BMI in female.

Discussion

Waist circumference overall secured higher place compared to BF% and BMI in present study performed on Central Indian Population. This index as continuous variable, also had a superior discriminatory capacity (true positive and false positive) for Hypertension, shown by ROC curve.

Asian Indians tend to have more visceral adipose tissue and higher abdominal adiposity as compared to white Caucasians which is associated with increased disease risk independent of overall obesity.[16-18]

The reasons behind these susceptibility are not fairly known, may be linked with regulatory molecules secretions by endocrine cell and differential lipolytic nature of adipocytes.[3, 19]Thus to discover an obesity measure in Indian population which is valid, accurate and acceptable for all ethnic sub group is a favorite issue for scientific discussion.

Theoretically BIA measures Total Body Water (TBW) through impedance and in turns estimates the BF% by pre-designed equations.[20] So BIA technically depends on hydration status and segmental ratios of body parts. The assumptions while devising equations for BIA takes parameters for these two variables mainly from Caucasian population. Hence, extrapolating these equations without the correction factor to other ethnic group might be a source of systematic deviation from reality. Some experts also endorse that BIA equations may not be easily transferred from one population to other; specific equations must be developed for various subgroups of such study populations.[21] With the above; the sub-optimum performance of BF% in present study may be explained by the fact that the ethnicity of studied population is of non-Caucasian origin for which correction factor is not calculated yet.

BMI, does not distinguish between fat mass and lean (non-fat) mass so the relation between BMI & body fatness may be different for non Caucasian (South Asians) compared to Caucasian population.[22]Another potential limitation of BMI is that the distribution of fat over the body is not captured.[23]

Though Waist circumference being a non-invasive procedure cannot discriminate between subcutaneous and visceral fat[24], still propensity of South East Asians to accumulate excess fat centrally may validate WC as a predictor for hypertension.

On an epidemiological plane, studies around the globe offer similar opinion- A study on measures of adiposity and cardiovascular disease risk factors from US found waist circumference to be a better predictor of hypertension compared to BIA.[25] Other studies also affirm supplanting of anthropometric indices (BMI & WC) over BIA as a predictor of hypertension.[26-28] A study on Japanese office workers reported BMI to be better than BF% measured by BIA as predictor of both systolic and diastolic blood pressure thus further confirming our findings.[29]

In contrast to finding of this study, some studies have also reported BIA to be superior predictor of hypertension compared to BMI. A study from a cohort of urban men in north India shows that coronary risk factors including hypertension were significantly associated with the level of body-fat percent determined by bioelectrical impedance analysis in population with low BMI. [30]

WC vis-à-vis BMI is found to be superior predictor of hypertension both in male and female in many studies which are in accordance with current study's findings.[31, 32] A study from the central India of association of anthropometric indices of obesity with diabetes, hypertension and dyslipidemia, also found Waist circumference to be the better predictor of hypertension in comparison to BMI.[33]

As demographic group selection process was not stringently scrutinized and the participants were taken from health-care seeking population so the prevalence spectrum for variables and disease might differ from general population. These limitations are countered by the fact that probably this is the first study from Central India which explores comparative utility of BF% as obesity marker to predict Hypertension in this ethnicity and thus generates some initial evidence in support of utilizing waist circumference compared to Bio-electrical Impedance as obesity measure for prediction of hypertension. An extensive community based multi-centric study may be planned to arrive on any explicit conclusion.

Conflict of Interest: None declared.

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Table 1: Demographic and Anthropometric Characteristics of Population under study

No.	Sex	Disease Status	Age(Years)	Mean BMI(kg/m2)	Mean Waist Circumference (c.m.)	Median BF%(Inter quartile range)
1	Male (240)	Hypertensive(105)	51.09(±10.12)	25.95(±2.96)	94.11(±7.96)	0.26(0.24-0.30)
		Normotensive(135)	45.67(±14.51)	24.32(±4.34)	85.75(±12.37)	025(0.22-0.29)
2	Female (160)	Hypertensive(70)	45.50(±8.42)	26.25(±4.36)	87.2(±10.99)	0.38(0.34-0.42)
		Normotensive(90)	46.22(±14.79)	27.04(±4.94)	82.41(±7.68)	0.37(0.33-0.39)

Table 2: validity and Predictive Accuracy of Body Mass Index, Waist Circumference and Body Fat% to predict Hypertension

Sex	Obesity Measurement Tool	Sensitivity	Specificity	Predictive Value		Likelihood Ratio	
				Positive	Negative	Positive	Negative
Male	Body Mass Index	0.52 (0.42-0.62)	0.63 (0.54-0.71)	0.26 (0.18-0.35)	0.84 (0.79-0.88)	1.41	0.76
	Waist Circumference	0.76 (0.67-0.84)	0.65 (0.56-0.73)	0.35 (0.28-0.44)	0.91 (0.87-0.94)	2.19	0.37
	Body Fat %	0.67 (0.57-	0.51 (0.43-	0.26 (0.20-	0.86 (0.80-	1.38	0.64

		0.76)	0.60)	0.32)	0.91)		
Female	Body Mass Index	0.64 (0.51-0.75)	0.38 (0.28-0.49)	0.20 (0.15-0.27)	0.81 (0.70-0.89)	1.05	0.92
	Waist Circumference	0.78 (0.67-0.87)	0.44 (0.34-0.55)	0.26 (0.20-0.33)	0.89 (0.80-0.94)	1.41	0.48
	Body Fat %	0.92 (0.84-0.97)	0.16 (0.09-0.26)	0.21 (0.19-0.24)	0.90 (0.70-0.97)	1.11	0.43

Table 3: Paired Comparisons of Area Under Curve (AUC) for Body Mass Index, Waist Circumference and Body Fat%

Sex	Obesity Measurement Tool	Area Under Curve(AUC)	D'long-D'long Paired Comparison		
			Contrast	Difference in curve area	p-value
Male	Body Mass Index	0.66±0.03(0.60-0.73)	WC Vs BMI	0.07±0.03(0.00-0.14)	0.04
	Waist Circumference	0.73±0.03(0.67-0.80)	WC vs BF%	0.13±0.04(0.06-0.21)	0.008
	Body Fat %	0.60±0.04(0.53-0.67)	BF% vs BMI	-0.06±0.03(-0.13-0.00)	0.06
Female	Body Mass Index	0.51±0.05(0.42-0.61)	WC Vs BMI	0.20±0.07(0.07-0.33)	0.003
	Waist Circumference	0.71±0.05(0.62-0.81)	WC vs BF%	0.11±0.07(0.03- -0.25)	0.127
	Body Fat %	0.61±0.05(0.51-0.70)	BF% vs BMI	0.09±0.07(-0.07-0.26)	0.279

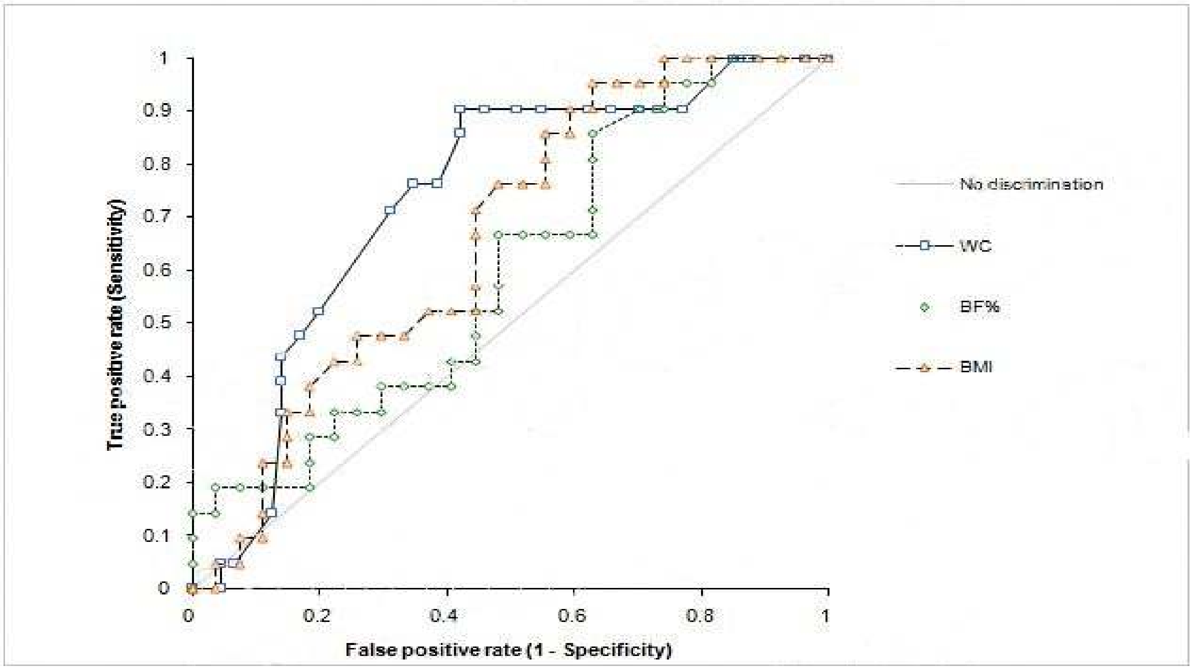

Figure 1: Receiver-operating characteristic (ROC) plots for Obesity Measures in Males

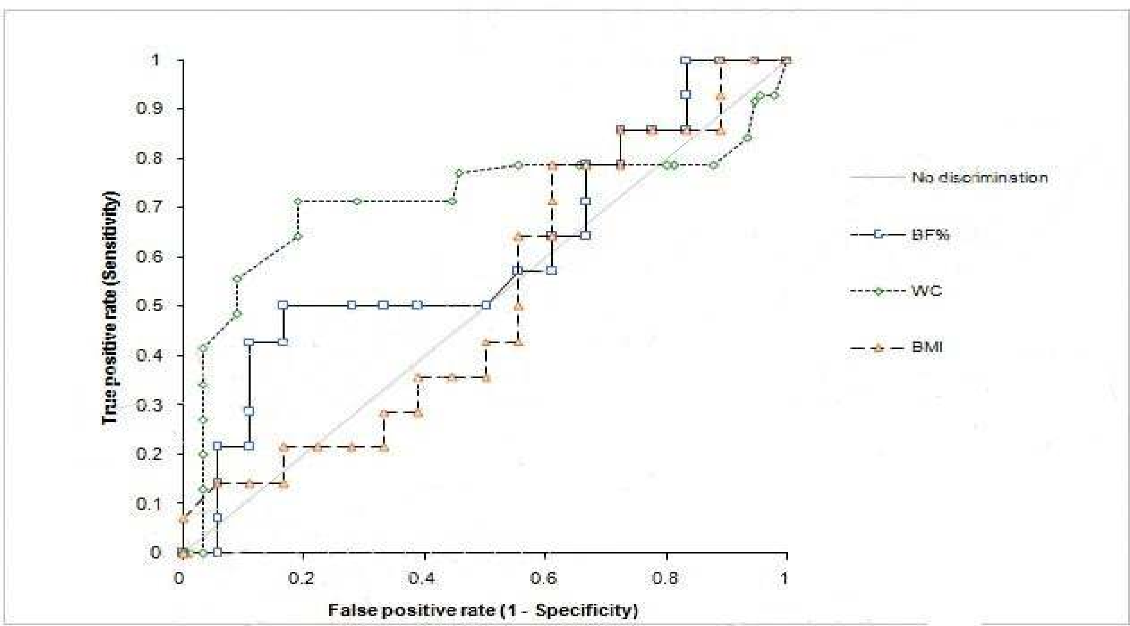

Figure 2: Receiver-operating characteristic (ROC) plots for Obesity Measures in Females