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New Anthropometric Adiposity Indices and Their Associations With Hypertension in Ex-criminal Tribe of Gonda District, Uttar Pradesh, India

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ABSTRACT

The best adiposity index for predicting hypertension is still being debated. Therefore, this study aimed to compare the performance of different adiposity indices as associates and potential predictors of risk of hypertension in the ex-criminal tribe of Gonda district, Uttar Pradesh, India. Also, in this paper, attempted to construct some new indices of adiposity, relative to obesity. The present study was undertaken among 310 rural adults (154 males; 156 females) aged 20-59 years. The ANOVA and Chi-square tests, correlation analysis was performed to test for significant differences and associations between variables. The odds ratio and receiver-operating characteristic curve (ROC) were used to identify the risk factors for hypertension. The sex combined prevalence of combined general obesity, combined central obesity, and overall combined obesity is 34.9%, 69.8%, and 75.6%, respectively. The frequency of all AAIs increased from the normal stage to the hypertension stage in all cases. The SBP, DBP, and MAP had highly significant positive correlations with all adiposity measures (p <0.01). Using the Odds Ratio, obese people with BMI, WHtR, and FM-FFM ratio were found to be more than four times more likely to be hypertensive than those in the non-obese category. Finally, ROC analysis tells us that in both sexes PBF and FM-FFM ratio was the most sensitive and specific indicator for determined the optimal adiposity indices for hypertension risk in the study population.

Key words: *adiposity indices, central obesity, denotified tribe, general obesity, hypertension, medical anthropolog*

Introduction

Hypertension (HTN)[a] is the third 'killer' disease, accounting for one in every eight deaths worldwide[1]. It has been predicted that the number of hypertensives may rise from 118 million in 2000 to 214 million in 2025[1]. High blood pressure may or may not have any symptoms. In fact, many people have reported having undiagnosed high blood pressure for years. That is the reason it is also called the "Silent Killer"[2]. Hypertension is directly responsible for 57% of all stroke deaths and 24% of all coronary heart disease deaths[3]. About 33% of urban and 25% of rural Indians are hypertensive[3]. The Global Burden of Hypertension study has highlighted that of the global burden of 212 million disability-adjusted life years (DALYs) related to hypertension, 18% occurred in India in 2015[4]. Hypertension poses a significant health and financial challenge too, contributing to 10% of the total health burden[5].

Obesity and hypertension, which are two major risk factors for non-communicable diseases (NCDs), contribute to global health and economic burdens[6]. Obesity is considered a major health problem in both developed and developing countries, and it is increasing substantially worldwide[7]. Overall, in the whole country, 135 million, 153 million, and 107 million individuals will have generalised obesity, abdominal obesity, and combined obesity, respectively[8]. Obesity is generally classified into two types: overall or generalised obesity and abdominal or central obesity. In this present study, body mass index (BMI), percentage of body fat (PBF), body adiposity index (BAI), fat mass and fat free mass ratio (FM-FFM ratio) were used to assess generalised fat distribution, and waist circumference (WC), waist-hip ratio (WHR), waist-height

[a] Abbreviations used: GO- General Obesity; CO- Central Obesity; CGO- Combined General Obesity; CCO- Combined Central Obesity; OCO= Overall Combined Obesity; CGOI= Combined General Obesity Index; CCOI= Combined Central Obesity Index; HTN- Hypertension; AAIs- Anthropometric Adiposity Indices.

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ratio (WHtR), and conicity index (CI) were used to assess central fat distribution. The present study attempted to construct some new indices of adiposity such as combined general obesity (CGO), combined central obesity (CCO), and overall combined obesity (CGO+CCO), these adiposities are more useful than the other single obesity parameters in assessing the overall magnitude of obesity and identifying communities with multiple obesity parameters. The combined general obesity index (CGOI) and the combined central obesity index (CCOI) tell us which obesity is more likely to promote obesity. These two new indices, the CGOI and the CCOI, provide information on the significance of the problems of general and central obesity with respect to and relative to total obesity. These values are interpreted as percentages. The higher the value, the greater the severity with respect to total obesity. Moreover, by excluding normal individuals, these indices are obesity-specific. So, these new indices also help the upcoming obesity-related study and represent the actual severity of the disease.

The present study conducted on Barwar tribe which is a denotified tribe whose name appears on the "Idate Commission report" (National Commission for Denotified, Nomadic, and Semi-Nomadic Tribes, List-1A, 2017). They are socially as well as economically very backward in the sense that they have little access to the resources they need for their development, a low literacy rate, and a relatively small population size. Field-based studies on the prevalence of hypertension in different regions of India are still scarce[9]. However, only a few studies have been done on the health condition of the denotified community in recent years[10-12]. To the best of my knowledge, no previous study has been reported to date on assessing the adiposity indices and the prevalence of hypertension, particularly in this community. For the first time, this study uses some new obesity-related indices and evaluates which obesity is more likely to promote obesity. The aim of the present study is to evaluate the relationship between different anthropometric adiposity indices (AAIs) and hypertension and also to identify which of the AAIs allows a highest risk of having hypertension in ex-criminal tribes of Gonda district, Uttar Pradesh, India.

Materials and Methods

Study area and people

The present cross-sectional study was undertaken among 315 rural adults (141 males and 174 females) aged between 20-59 years. The data were collected between September and October of 2019. The eleven places, or *Majra*, studied across the three tehsils (Gonda, Tarabganj, and Mankapur) of Gonda district in Uttar Pradesh state were selected for the study of the Barwar community. The participants were selected using the purposive sampling method. A well-structured schedule questionnaire was used for data collection through house-to-house interviews with each participant. The objectives and methods of the study were explained to each participant before the data collection. Each participant provided verbal consent prior to the start of the study. We include the participants because they were apparently free from any physical deformity and were not suffering from any diseases during the time of data collection. Only those individuals who were not taking medication for hypertension have been included in the present study. Physically challenged women, pregnant women, individuals taking antihypertensive medication, and those who failed to meet any of the inclusion criteria were excluded from the current study to avoid biases and to appropriately represent the study population.

Crooke described the Barwar community as a "criminal tribe" and described their profession as thieving[13]. In 1871, the Barwar community was declared a "criminal tribe" by the colonial administration. After independence, under the Habitual Offenders Act, 1952, they were declared "Denotified" (VimukthJati). However, the social stigma of criminality still exists. In 1954, the Barwar community was declared a scheduled caste in Uttar Pradesh state. This constitutional safeguard helps them improve their socio-economic condition. The Uttar Pradesh government also allotted agricultural lands to them. In spite of that, they were not interested in agriculture; they started the business of country liquor on the allotted lands. Awadhi is the spoken dialect within the community, while Hindi is used as a communication language.

Anthropometric measurements

All anthropometric measurements were taken using standard procedures[14]. Height (cm) was measured using Martin's anthropometric rod to the nearest 0.10 cm, with the participant standing in an erect position on a flat surface and the head oriented in the Frankfort horizontal plane. Weight (kg) was recorded with the subject standing motionless on a digital body composition monitor (Omron). Waist circumference (cm) was measured at the midpoint between the iliac crest and lower margin of the ribs with the participant remaining in the standing position with two feet together. Hip circumference (cm) was measured at the highest point of the buttocks while wearing the bare minimum of clothing[15]. The WC (cm) and HC (cm) were measured using a non-stretchable measuring tape without compression of skin. PBF is measured by a body composition monitor (Omron).

Assessment of general and central obesity using different anthropometric adiposity indices (AAIs)

All derived and body adiposity related parameters such as body mass index (BMI), waist-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index (CI), body adiposity index (BAI), FM, FFM, FM and FFM ratio were calculated using the following standard equations:

$$\text{BMI}=\frac{Weight}{Height}\left(\frac{kg}{m^2}\right)$$

WHR: waist circumference (cm)/hip circumference (cm);

WHtR: waist circumference (cm)/height (cm);

$$CI=\frac{WC(m)}{0.109*\sqrt{\frac{Weight}{Height}\left(\frac{kg}{m}\right)}} \quad [16]$$

Body adiposity index (BAI) = [hip circumference (cm)/(height ×√height)] – 18

$$\text{OR BAI}=\frac{Hip\,circumference(cm)}{Height(m)*1.5}-18 \quad [17]$$

$$\text{FM(kg)=FM(kg)}=\frac{PBF}{100}\times \text{body weight}(kg) \quad [18]$$

FFM (kg)= Body weight (kg)– FM(kg) [18]

FM and FFM ratio= FM/ FFM [19]

Propose the obesity related new indices or parameters used in the present study:

Prevalence of combined general obesity (CGO) = BMI+PBF+BAI+FM-FFM Ratio

Prevalence of combined central obesity (CCO) = WC+WHR+WHtR+CI

Prevalence of overall combined obesity (OCO) = CGO+CCO (both)

Single or One obesity= CGO/ CCO

Dual or both obesity= CGO & CCO

No Obesity= Individual without either CGO/ CCO.

Combined general obesity index (CGOI)=

$$\frac{Combined\,general\,Obesity}{Overall\,Combined\,Obesity(CGO+CCO)}\times 100$$

Combined central obesity index (CCOI)=

$$\frac{Combined\,Central\,Obesity}{Overall\,Combined\,Obesity(CGO+CCO)}\times 100$$

Assessment of health risk

The assessment of health risk was based on different anthropometric adiposity indices (AAIs) and using standard cut-off values:

Variables	Male	Female	Reference
BMI	≥24.9	≥ 24.9	(World Health Organization, 2000)[20]
PBF	≥ 25	≥ 35	(World Health Organization, 1995)[21]
BAI	≥21.0	≥21.0	(Bergman et al., 2011)[17]
FM and FFM ratio	≥0.40	≥0.40	(Prado et al., 2012)[19]
WC	≥90	≥80	(World Health Organization, 2000)[20]
WHR	>0.95	>0.85	(World Health Organization, 1989)[22]
WHtR	≥0.5	≥0.5	(Hsieh and Muto, 2004)[23]
CI	≥1.25	≥1.18	(Flora et al., 2009)[24]

Assessment of hypertension

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured on the left arm using an Omron (Japan) digital blood pressure monitor. The participants were seated in the chair for at least five minutes before measurement.The standard equation was used to calculate mean arterial pressure (MAP): Mean arterial pressure (MAP) = [SBP + (2 × DBP)]/3. [25]

The classification of blood pressure is followed as per the recommendation of JNC8 (Eighth Report of the Joint National Committee) given by World Health Organization (2015) for the assessment of hypertension among the adult population. SBP <120 and DBP <80 was considered normal, SBP 120-140 and DBP 80-90 were considered pre-hypertension, and SBP >140 and DBP >90 was considered hypertension[26].

Statistical analysis

All statistical analyses were undertaken using the SPSS Statistical Packages (version 16.0). Descriptive statistics of mean and standard deviation (SD) were computed for all anthropometric or obesity related parameters, followed by hypertension-wise differences through an F test (ANOVA). The Chi square ($\chi 2$) test analysis was performed to test for sex differences in the prevalence of obesity and also shows the association between different adiposity parameters and hypertension. Correlation analysis was employed to determine the relationship between the variables (anthropometric and derived). The odds ratio was calculated to identify the risk factors for hypertension. Receiver-operating characteristic (ROC) curve analysis determined the optimal adiposity indices for developing hypertension risk.

Results

Table 1 shows the details of anthropometric (both simple and derived) variables (mean ±SD) in studied participants ranging from normotensive to hypertensive. The present study observed that the mean values of all anthropometric adiposity indices (AAIs) increased from normal to hypertensive (except WHR and CI in females), and highly significant group differences existed in all variables in both sexes ($p<0.05$) except CI in females.

The prevalence of all anthropometric adiposity indices among the participants is presented in Table 2. The sex-combined prevalence of general and central obesity varies from 11.7% (BMI-based) to 60.0% (CI based). Males have a higher prevalence of pre-hypertensive and hypertensive conditions than females, with 76.6% and 70.7%, respectively. This study clearly indicates the high prevalence of general obesity and central obesity in females, with statistically significant sex differences found (except for BMI- and PBF-based general obesity). The sex combined prevalence of CGO, CCO, and overall combined obesity is 34.9%, 69.8%, and 75.6%, respectively. This table clearly indicates the prevalence of CGO, CCO, and

TABLE 1

DESCRIPTIVE STATISTICS ON NORMAL, PRE-HYPERTENSIVE AND HYPERTENSIVE SPECIFIC ANTHROPOMETRIC AND DERIVED VARIABLES (MEAN AND SD) AMONG THE STUDY PARTICIPANTS

Anthropometric adiposity indices (AAIs)	Sex	Normal (n= 84)	Pre-hypertension (n= 127)	Hypertension (n= 104)	F test (ANOVA)	p value
BMI	M	19.24 ±3.57	20.55 ±3.91	21.45 ± 4.01	3.237	p <0.05
	F	18.51 ±2.59	20.80 ± 3.69	22.05 ±4.08	13.431	p <0.001
PBF	M	14.99 ±7.46	18.98 ±6.94	20.78 ±5.92	7.464	p <0.001
	F	23.17 ±5.57	28.16 ±6.26	29.64 ±6.47	16.134	p <0.001
BAI	M	15.35 ±2.83	16.50 ±2.82	17.29 ±2.23	9.798	p <0.001
	F	17.94 ±3.30	20.03 ±3.38	21.02 ±3.90	5.376	p <0.01
FM-FFM Ratio	M	0.19 ±0.12	0.24 ±0.12	0.27 ±0.10	11.662	p <0.001
	F	0.31 ±0.10	0.40 ±0.12	0.43 ±0.13	5.619	p <0.01
WC	M	73.71 ±7.97	76.77 ±8.17	80.87 ±7.51	8.628	p <0.001
	F	68.84 ±6.76	75.07 ±8.80	76.38 ±9.73	11.638	p <0.001
WHR	M	0.91 ±0.04	0.92 ±0.05	0.94 ±0.04	5.777	p <0.01
	F	0.85 ±0.05	0.89 ±0.06	0.87 ±0.07	4.474	p <0.05
WHtR	M	0.46 ±0.05	0.48 ±0.05	0.50 ±0.04	8.303	p <0.001
	F	0.46 ±0.05	0.50 ±0.06	0.51 ±0.06	14.044	p <0.001
CI	M	1.22 ±0.08	1.23 ±0.09	1.27 ±0.06	4.584	p <0.05
	F	1.20 ±0.08	1.24 ±0.10	1.23 ±0.10	2.895	p > 0.05

TABLE 2

SEX WISE PREVALENCE OF TYPES OF OBESITY (GENERAL & CENTRAL) AND HYPERTENSION AMONG THE STUDY PARTICIPANTS

Anthropometric adiposity indices (AAIs)	Male (%) N=141	Female (%) N=174	Overall (%) N=315	Chi square (χ^2)	p value
General obesity (BMI based)	18 (12.8)	19 (10.9)	37 (11.7)	.278	p >0.05
General obesity (PBF based)	22 (15.6)	22 (12.6)	44 (14.0)	0.57	p >0.05
General obesity (BAI based)	10 (7.1)	57 (32.8)	67 (21.3)	30.64	p <0.001
General obesity (FM-FFM based)	12 (8.5)	75 (43.1)	87 (27.6)	46.62	p <0.001
Central obesity (WC based)	10 (7.1)	41 (23.6)	51 (16.2)	15.57	p <0.001
Central obesity (WHR based)	49 (34.8)	114 (65.5)	163 (51.7)	29.52	p <0.001
Central obesity (WHtR based)	44 (31.2)	75 (43.1)	119 (37.8)	4.69	p <0.05
Central obesity (CI based)	76 (53.9)	113 (64.9)	189 (60.0)	3.96	p <0.05
Combined general obesity	29 (20.6)	81 (46.6)	110 (34.9)	23.14	p <0.001
Combined central obesity	89 (63.1)	131 (75.3)	220 (69.8)	5.47	p <0.05
Overall combined obesity	94 (66.7)	144 (82.8)	238 (75.6)	10.92	p <0.001
No obesity	47 (33.3)	30 (17.2)	77 (24.4)	-	-
Combined general obesity index	30.85%	56.25%	46.22%	-	-
Combined central obesity index	94.68%	90.97%	92.44%	-	-
Pre-hypertensive & hypertensive	108 (76.6)	123 (70.7)	231 (73.3)	1.39	p >0.05

OCO and shows increases in female people and statistically significant sex differences were found. The sex combined prevalence's of single obesity, dual obesities, and no obesity are 46.4%, 29.2%, and 24.4%, respectively (Figure 1). The present study shows that 46.22% of combined general obesity and 92.44% of combined central obesity involvements to promote overall obesity. Similarly, 56.25% females have a higher involvement in combined general obesity and 94.68% males have more involvement in combined central obesity to promote overall obesity.

The results of correlation analyses among studied participants are presented in Table 3. Age had a significant association with all obesity measures, SBP, DBP, and MAP, among the studied peoples. The blood pressure variables (SBP, DBP, and MAP) had highly significant positive cor-

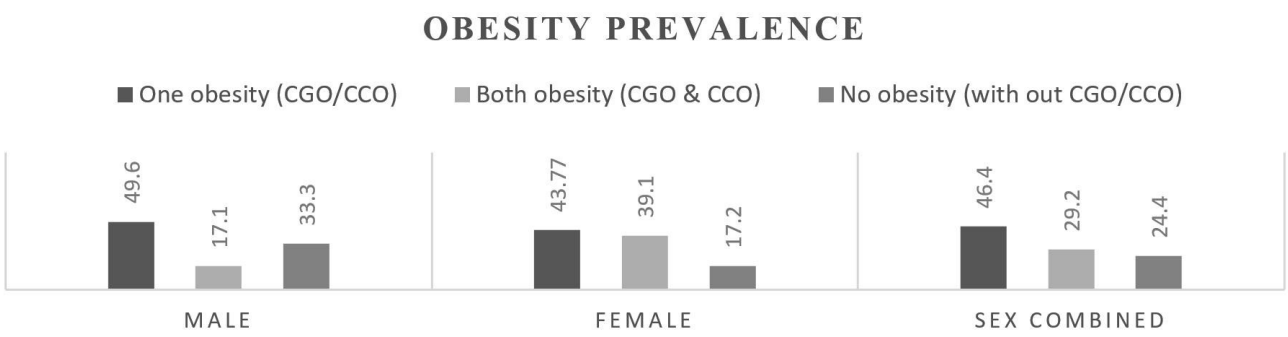

Fig. 1. Sex wise obesity prevalence (single obesity, both obesity) among the studied community.

TABLE 3

PEARSON CORRELATION BETWEEN ANTHROPOMETRIC ADIPOSITY INDICES AND BLOOD PRESSURE

AAIs	Age	BMI	PBF	WC	WHR	WHtR	CI	BAI	FM-FFM	SBP	DBP	MAP
Age	1	.118*	.319**	.243**	.218**	.332**	.319**	.230**	.312**	.297**	.208**	.266**
BMI		1	.626**	.708**	.148**	.729**	-.082^{NS}	.733**	.645**	.285**	.376**	.359**
PBF			1	.455**	-.063^{NS}	.638**	.078^{NS}	.776**	.992**	.256**	.350**	.330**
WC				1	.638**	.882**	.595**	.559**	.465**	.323**	.400**	.391**
WHR					1	.505**	.710**	-.136*	-.072^{NS}	.154**	.164**	.171**
WHtR						1	.566**	.783**	.642**	.331**	.388**	.389**
CI							1	.143*	.070^{NS}	.171**	.149**	.171**
BAI								1	.787**	.277**	.338**	.333**
FM-FFM									1	.260**	.353**	.334**
SBP										1	.737**	.918**
DBP											1	.945**
MAP												1

** means p <0.01 level (2-tailed). * p= <0.05 level. NS- statistically not significant.

relations with all adiposity measures and derived variables (P<0.01). WC had the strongest significant positive correlations with SBP (r = 0.323, p<0.01), DBP (r = 0.400, p<0.01) and MAP (r = 0.391, p<0.01). As expected, all obesity related measures were significantly positive inter correlated. There was no correlation between CI and BMI, PBF, FM-FFM, or WHR and the PBF or FM-FFM ratio.

The distribution of different adiposity parameters with hypertension among the studied participants is presented in Table 4. This table indicated that the prevalence of obesity was much higher in hypertensive individuals and that it varied between 76.4% (CCO-based) and 91.9% (BMI-based). The frequency of all AAIs increased from the normotensive to the hypertensive stage in all cases and it is significant association found (except WHR and CCO). Hypertension had the strongest association with BMI-based obesity, with an odds ratio (OR) of 4.66 (p <0.01), followed by WHtR-based obesity with an OR of 4.63 (p <0.001), FM-FFM ratio-based obesity with an OR of 4.24 (p <0.001), WC-based obesity with an OR of 3.93 (p <0.01), PBF-based obesity with an OR of 3.21 (p <0.05), CGO-based obesity with an OR of OR of 2.92 (p<0.001) and BAI based obesity with an OR of 2.42 (p<0.05), CI based obesity with an OR of 1.87 (p<0.05) and OCO based obesity with an OR of 1.86 (p<0.05).

Table 5 and the ROC curve determine the most effective anthropometric indices for predicting the incidence of developing hypertension risk. The PBF and FM-FFM ratios in both sexes have the highest AUC among the eight indices (BMI, PBF, BAI, FF-FFM, WC, WHR, WHtR, and CI) in the present study. Compared with males, the AUC of all the indices was higher in females (except CI). The AUC value in males varies from 62.6 (CI) to 72.1 (PBF and FM-FFM ratio), but in the case of females, it is 61.2 (CI) to 75.2 (PBF).

TABLE 4

RISK ESTIMATE BY USING ODDS RATIO AND ASSOCIATION BETWEEN OBESITY AND HYPERTENSION AMONG THE STUDY PARTICIPANTS

AAIs	n	Normotensive N (%)	Hypertensive N (%)	Odds Ratio	95% CI	χ^2 value	p value
GO (BMI)	37	3 (8.1)	34 (91.9)	4.660	1.392- 15.603	7.38	p <0.01
GO (PBF)	44	5 (11.4)	39 (88.6)	3.209	1.220- 8.442	6.13	p <0.05
GO (BAI)	67	10 (14.9)	57 (85.1)	2.424	1.174- 5.005	6.0	p <0.05
GO (FM-FFM)	87	9 (10.3)	78 (89.7)	4.248	2.020- 8.933	16.37	p <0.001
CO (WC)	51	5(9.8)	46 (90.2)	3.929	1.505- 10.258	8.85	p <0.01
CO (WHR)	163	36 (22.1)	127 (77.9)	1.628	0.984- 2.695	3.63	p >0.05
CO (WHtR)	119	13 (10.9)	106 (89.1)	4.631	2.429- 8.831	24.24	p <0.001
CO (CI)	189	41 (21.7)	148 (78.3)	1.870	1.128- 3.100	5.98	p <0.05
CGO	110	16 (14.5)	94 (85.5)	2.916	1.593- 5.338	12.70	p <0.001
CCO	220	52 (23.6)	168 (76.4)	1.641	0.969- 2.780	3.43	p >0.05
OCO	238	56 (23.5)	182 (76.5)	1.857	1.069- 3.227	4.90	p <0.05

TABLE 5

DIFFERENT ADIPOSITY PARAMETERS ASSESSING THE HYPERTENSION RISK THROUGH AREA UNDER THE CURVE

AAIs	Male			Female		
	AUC	95% CI	P value	AUC	95% CI	P value
BMI	.650	.541-.759	.009	.723	.644-.803	.000
PBF	.721	.613-.828	.000	.752	.677-.827	.000
BAI	.692	.584-.801	.001	.711	.624-.797	.000
FM-FFM	.721	.613-.829	.000	.751	.677-.826	.000
WC	.699	.592-.807	.001	.717	.639-.796	.000
WHR	.638	.537-.740	.016	.640	.555-.725	.004
WHtR	.709	.600-.818	.000	.745	.667-.823	.000
CI	.626	.517-.736	.028	.612	.523-.701	.020

Discussion

The present study observed that the mean values of all adiposity parameters were increased in both sexes from normal to hypertensive (except for WHR and CI in females). The current study found highly significant group differences ($p < 0.05$) in all variables for both sexes, with the exception of the CI for females. The present study study clearly indicates the high prevalence of general obesity and central obesity in females, with statistically significant sex differences found (except for BMI and PBF based general obesity). Similar results were found in another study conducted on rural adults in Paschim Medinipur, which observed that all central obesity was high in females, with a statistically highly significant ($p<0.001$) sex difference found[27]. Another study conducted in the Andaman Bhantus community found a high prevalence of GO and CO in females[28]. Recent NFHS-5 (2019–21) data revealed that the frequency of overweight or obesity (BMI and WHR-based) was much higher among adult females (21.3% and 56.8%) compared to males (18.5% and 52.1%, respectively) in Uttar Pradesh[29]. So, previous and present studies show females have higher general and central obesity than males.

The present study shows high prevalence of CGO (34.9%), CCO (69.8%), and overall combined obesity (75.6%) increases in female people, and statistically significant sex differences were found ($p= <0.05$). The present study reported that the sex-combined prevalence's of single obesity (46.4%) very high than the dual obesity (29.2%) and only 24.4% people shows no any obesity (Figure 1). The present study clearly demonstrates that 46.22% of combined general obesity and 92.44% of combined central obesity involvements to promote overall obesity. Similarly, females have a higher involvement in combined general obesity (56.25%) and males have more involvement in combined central obesity (94.68%) to contribute and promote the overall obesity. So, the present study clearly mentions the actual involvement of obesity through CGOI and CCOI.

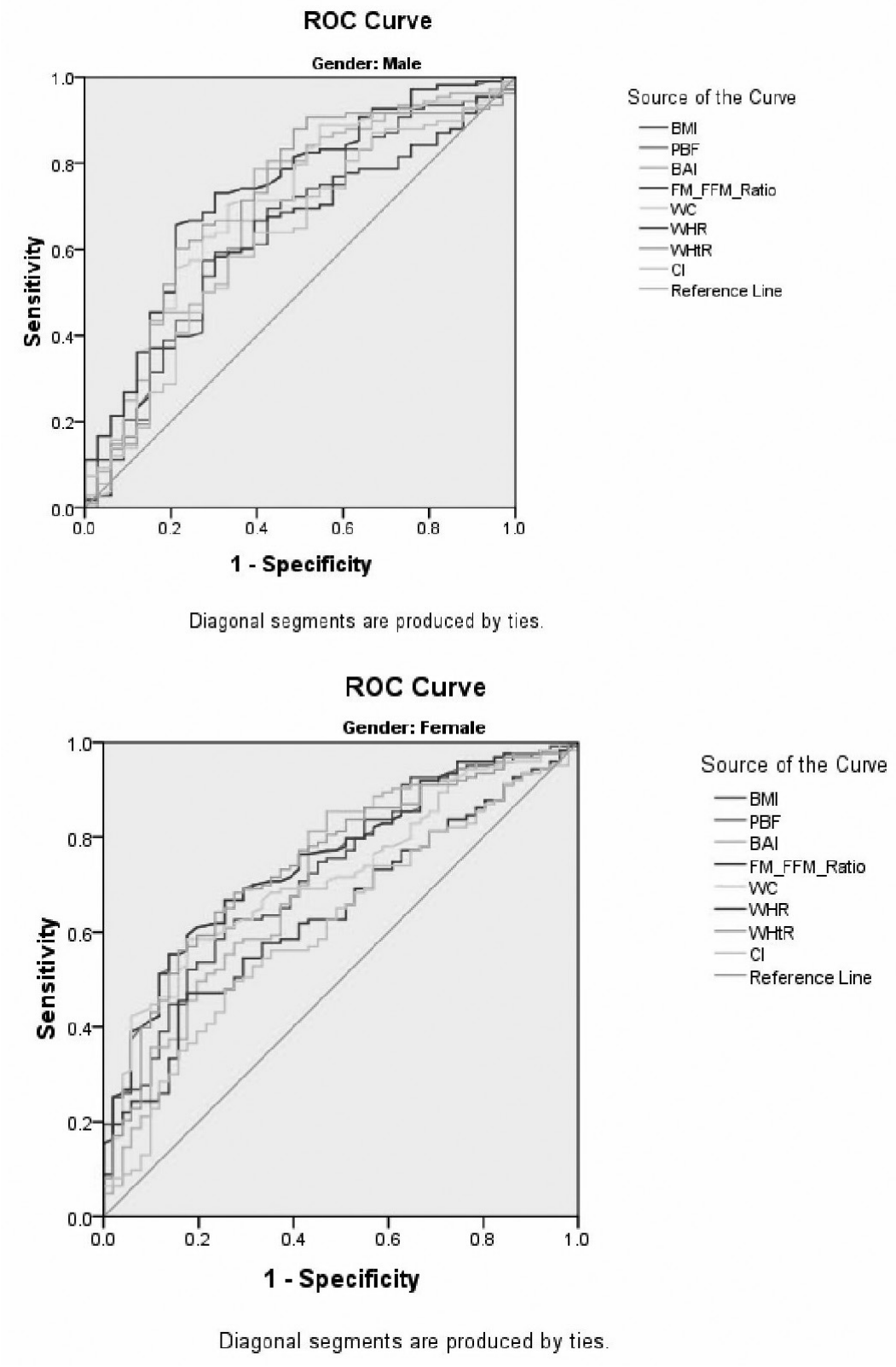

Fig. 2. ROC curve for different adiposity indices in relation to incidence of hypertension. ROC – receiver operating characteristic; BMI-Body mass index; PBF- Percentage of body fat; BAI- Body adiposity index; FM-FFM ratio- Fat mass and fat free mass ratio; WC – waist circumference; WHR – waist-hip ratio; WHtR – Waist-to-Height Ratio (WHtR), Conicity Index (CI).

It was observed that males were more hypertensive compared to females (76.6% and 70.7%), which was in accordance with some earlier studies in India[28,30]. Recent NFHS-5 (2019-21) data revealed that the frequency of elevated blood pressure (systolic ≥140 mmHg or diastolic ≥90 mmHg) was much higher among adult males (20.7%) compared to females (18.4%) in Uttar Pradesh[29]. In India, recent NFHS-5 (2019-21) data revealed that the prevalence of HTN among adult males and females was 24% and 21.3%, respectively[29].

Age had a significant positive association with all anthropometric adiposity indices (AAIs), SBP, DBP, and MAP among the studied people. The blood pressure variables (SBP, DBP, and MAP) had highly significant positive correlations with all AAIs (P<0.01). As expected, all obesity-related measures were significantly inter-correlated. Similar results were found in another study on the Bhantu community of Andaman, where the correlation analysis revealed a positively significant age effect on both the obesity and blood pressure variables, and similarly, blood pressure variables revealed significant correlations with all the obesity measures except for CI in the case of DBP ($r = 0.149$, $p>0.05$) among females[28]. The present study shows WC had the strongest significant positive correlations with SBP ($r = 0.323$, $p<0.01$), DBP ($r = 0.400$, $p<0.01$) and MAP ($r = 0.391$, $p<0.01$). Another study conducted on Bengali women in West Bengal found the strongest correlation of WC with both SBP ($r = 0.302$, p 0.01) and DBP ($r = 0.342$, p 0.01)[31]. Another study conducted on rural adults in Paschim Medinipur, West Bengal, found that both the blood pressure variables had significant positive correlations with all CO measures. All CO measures were significantly intercorrelated[27]. So, both the previous study and the present study conclude that blood pressure has a positive correlation with all anthropometric adiposity indices (AAIs).

In the present study, the prevalence of all AAIs increased from the normal stage to the hypertension stage in all cases (except WHR). Another study in Paschim Medinipur, West Bengal, discovered that the overall frequency of CO was much higher in hypertensive people[27]. So, previous and present study concluded that not obese people had less hypertension and obese people were mostly hypertensives.

The odds ratio was calculated to identify the risk factors for hypertension. The current study found that obese people with a BMI of 4.66, a WHtR of 4.63, and a FM-FFM ratio of 4.24 were more than four times more likely to be hypertensive than those in the normal/non-obese category. WC (3.93) and PBF (3.21)-based obese people were more than three times more likely to be hypertensive than non-obese people. CGO (2.92) and BAI (2.42) based obese people were more than two times more likely to be hypertensive than non-obese people. Another study conducted on Bengali women of West Bengal found that BMI-based obese women were three times (3.24) more likely to be hypertensive, and WC-based obesity was 1.48 times more likely to be hypertensive than non-obese women[31]. The stronger association between BMI and hypertension in the present study might be due to the fact that an increase in BMI was associated with increased peripheral resistance, body fluid volume, and cardiac output[28,31]. In the present study, PBF and the FM-FFM ratio in both sexes had the highest AUC among the eight indices. Compared with males, the AUC of all the indices was higher in females (except CI). Another study conducted on the rural adult population of Haryana found that the WHtR was the most sensitive and specific indicator for the study population[32].

There are several potential advantages to using these new anthropometric indices (CGOI and CCOI) from the obesity related public health burden. Effective health promotion and nutritional interventional programmes can be formulated based on these indices. For example, a higher value of CGOI and CCOI would indicate an enhanced level of chronic general and central obesity relative to overall obesity. These indices suggest that they provide additional information on the prevalence of different forms of obesity relative to the total level of obesity in a particular population. However, it must be pointed out that these two new indices cannot replace the general and central measures of obesity. Rather, they should supplement them in order to get a more comprehensive picture of the obesity stress being experienced by a population.

The present study also has some limitations. First, the study design was cross-sectional, so the causal explanation behind the association between obesity and hypertension was not explored. Second, the sample size was small and restricted only to the denotified tribes. As a result, no cut off value is provided. Third, the findings were obtained from a particular community, so selection bias should be considered and cannot be generalised to the whole population living in Uttar Pradesh.

Conclusion

The present study shows that high prevalence of all adiposity indexes (except two general obesity) was high in females and using AUC, females show most sensitive and specific indicator for determined the optimal adiposity indices for hypertension risk. It clearly demonstrates that 46.22% of combined general obesity and 92.44% of combined central obesity involvements to promote overall obesity. The current study found that obese people with a BMI, WHtR and FM-FFM ratio were more than four times more likely to be hypertensive than those in the normal/non-obese category. PBF and FM-FFM ratio was the most sensitive and specific indicator for determined the optimal adiposity indices for hypertension risk in the study population. Results of such investigations may be helpful in the formulation of appropriate ethnic and region-specific health promotion and intervention programmes. The simultaneous presence of obesity and hypertension in the community may make them vulnerable to several chronic diseases and other severe health consequences. More research with larger samples is required to determine cut-off values for obesity measures.

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ANTROPOMETRIJSKI INDEKSI ADIPOZNOSTI I NJIHOVA POVEZANOST S HIPERTENZIJOM U BIVŠEM KRIMINALNOM PLEMENU OKRUGA GONDA, UTTAR PRADESH, INDIJA

SAŽETAK

Kako se još uvijek raspravlja o najboljem indeksu adipoznosti za predviđanje hipertenzije, ovaj rad je imao za cilj usporediti učinak različitih indeksa adipoznosti kao potencijalnih prediktora rizika od hipertenzije u bivšem kriminalnom plemenu okruga Gonda, Uttar Pradesh, Indija. Također, u ovom radu pokušalo se konstruirati neke nove indekse adipoznosti u odnosu na pretilost. Ovo je istraživanje provedeno među 310 odraslih ruralnih stanovnika (154 muškarca; 156 žena) u dobi od 20 do 59 godina. Korelacijska analiza ANOVA i Hi-kvadrat testova provedena je za testiranje značajnih razlika i povezanosti između varijabli. Omjer izgleda i karakteristična ROC krivulja korišteni su za identifikaciju čimbenika rizika za hipertenziju. Korištenjem omjera izgleda, otkriveno je da pretile osobe s BMI, WHtR i FM-FFM omjerom imaju više od četiri puta veću vjerojatnost da će biti hipertenzivne od onih u kategoriji nepretilih. Konačno, ROC analiza nam govori da je u oba spola PBF i FM-FFM omjer bio najosjetljiviji i specifični pokazatelj za određivanje optimalnih indeksa adipoznosti za rizik od hipertenzije u ispitivanoj populaciji.