Central Adiposity, Body Mass Index and Percent Body Fat among Bengalee Hindu Male Slum Dwellers of Dum Dum, West Bengal, India

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Abstract: The relationship between body mass index (BMI) and percent body fat (PBF) with central adiposity measures varies between ethnic groups and it has not been much studied in low socio-economic groups in India. Therefore, this study was undertaken to test the relative efficacy of waist circumference (WC), hip circumference (HC), waist hip ratio (WHR) and conicity index (CI) to predict BMI and PBF among Bengalee Hindu male slum dwellers. A total of 465 adult (aged 18-72 years) male slum dwellers of Bengalee Hindu ethnicity were included. Standard anthropometric techniques and formulae were used. WC showed the strongest significant ($p < 0.001$) partial correlation with BMI and PBF (0.82 and 0.77, respectively). Stepwise multiple linear regression analyses of BMI and PBF with the central adiposity measures revealed that WC had the strongest impact on BMI and PBF. On the other hand WHR, HC and CI had weaker effect. Moreover, WC alone accounted for about 67 and 60 per cent of the variations, respectively, of BMI and PBF. The models involving only WC and CI, explained almost similar proportions of variations ($adjR^2$ = 94.1, and 69.4, respectively). Furthermore, the WC was found to best predict BMI (R^2 Change = 0.666; F Change = 921.32, $p < 0.001$) and PBF (R^2 Change = 0.597; F Change = 686.66, $p < 0.001$). Even after controlling for each other, i.e., BMI and PBF (results not shown) WC had the strongest significant impact on these two measures. Therefore, in this population, WC may be preferred over other measures of central adiposity in studies dealing with obesity and cardio vascular disease risk factors.

Keywords: Bengalee, central adiposity, body mass index, percent body fat.

INTRODUCTION

Body mass index (BMI) is a measure of overall adiposity, whereas, waist circumference (WC), waist-hip ratio (WHR), and conicity index (CI) are reliable proxy measures of abdominal fat [1, 2]. Studies indicate that BMI, WC and WHR could be used independently to identify overweight and obesity [3]. These measures of adiposity have also been widely recommended for epidemiological surveys because of their independent association with major cardiovascular and metabolic risk factors. However, there is little consensus as to which of these measures is preferable in studies dealing with abdominal adiposity [4-6]. It is also not clear which of these measures best predicts total body fat [7]. Therefore, it seems important to understand the relationship of these central adiposity measures with generalized adiposity and body fat content because BMI and the total body fat as well as its distribution pattern are related to metabolic syndrome [8]. The interrelationship of WC with WHR and BMI is also required to be understood to identify not only those who have high BMI, but also those who have low BMI but high WHR by using the simple measure of WC [9]. Higher BMI has also been shown to be associated with both central adiposity and higher WHR along with the non-communicable diseases that appear at lower BMI ranges in Indian population [10]. It is also desirable to have a measurement simpler than BMI and PBF but at the same time being a good predictor of the later two. It is most important, especially, for the fast and effective implementation of public health development programmes in limited resource set ups.

Asian Indians, in common, were reported to have mean and median values of BMI lower than that observed in non-Asians, and also have higher PBF, waist-to-hip ratio (WHR) and abdominal fat at a lower level of BMI [11-13] and also a higher susceptibility to diabetes mellitus (DM) and insulin resistance compared with the Europeans [14, 15]. On the other hand, central adiposity has been linked to increased risk of cardiovascular disease, hypertension and diabetes by many studies [16-18]. There are many studies in Indian populations dealing with central adiposity and cardiovascular risk factors [19-22] and diabetes [23, 24]. But little attempts have been made [6,7,9,25] to identify the best abdominal measure to predict BMI and PBF. However, the terms Asian Indians and Indian represent vast and bio-culturally diverse populations at different degrees of urbanization, socio-economic and nutritional histories [26]. Therefore, it may be of particular interest to study the relationships between overall and regional adiposity in these different sub-groups.

The relationship between BMI and other adiposity measures were studied mostly in higher socio-economic groups [27-29]. But this is not well documented in lower socioeconomic groups [30]. Recent studies also documented that cardiovascular disease (CVD) was a major health problem among the Bengalee ethnic group [31, 32]. Therefore, in

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this study, an attempt has been made to test the relative efficacy of WC, hip circumference (HC), WHR and CI to predict BMI and PBF among Bengalee Hindu male slum dwellers of Kolkata, India.

MATERIALS AND METHODOLOGY

The Study Area and the Population

This study is based on a cross sectional survey carried out as part of a research project undertaken jointly by the authors. All the subjects were adult male individuals aged 18 years or above and residents of a slum named '*Bidhan Colony'*, situated approximately 15 kms from Kolkata (formerly Calcutta) town centre. Kolkata is the capital city of West Bengal province. Most of the subjects had migrated from Bangladesh as well as from other districts of the West Bengal province. The slum is situated at the right hand side of the railway tracks between Dum Dum Junction and The Dum Dum Cantonment Railway Stations. It is the terminal part of an urban settlement, called East Sinthee nearby to the Dum Dum Junction Rly. Station, and under The South Dum Dum Municipality, P.S.- Dum Dum, North 24 Parganas, West Bengal, India. At the other side of the said railway track is area under Kolkata Corporation.

All the participants had their origin in the state of West Bengal and spoke Bengali language as the mother tongue. They belonged to the Hindu religious group. A total of 474 reportedly healthy males, without having any known disease, not under any prolonged medication, not having undergone any recent surgery and able to do their normal day-to-day works at the time of examination, participated in the study. This sample size was enough to test all hypotheses at 5% level of significance with power 80% (beta = 0.8). Out of these, data on 465 individuals are presented in the present analysis, since nine individuals were aged more than 72 years and thus their body composition could not be estimated using available validated equation [33]. Most of the people were engaged in so called jobs of low socio-economic status, ranging from factory workers to rickshaw-pullers, or, day-labourers. There were landlords who are the first settlers of the locality, and also a huge number of families tenants to them. The general hygienic condition clearly seemed to be poor. The sanitation, sewerage systems and household structures were the silent but definite indications of their poverty and poor quality of life.

Data Collection

Ethical approval and prior permission was obtained from Vidyasagar University Ethics Committee and the institution of the first author, respectively. The municipal authorities and local community leaders were informed before commencement of the study. Most households were approached in the evening, because of the greater likelihood of adult males being present. Occasionally, prior appointments were made at the time with individuals for interviews to be carried out on a subsequent visit. Most of the subjects were interviewed and measured at their respective households. However, in some cases, where logistical issues made it difficult to carry out the survey in the respective households of some subjects, they were taken to a common place where a number of them were examined together. However, care was taken so that all the participants resided inside the boundary of the slum under study, i.e., Bidhan Colony. The overall response rate was around 80%. Informed consent was also obtained from each participant before starting interviews. The field investigation including anthropometric measurements was done by the first author (RC). Primary information on ethnicity, age, monthly family income (MFI), number of family members (FM), occupation, and education were collected from each subject with the help of a pre-tested questionnaire. Income was recorded in Indian rupee (UK £1 = 80 Indian Rupees, approx). Monthly per capita income (MPCI) was calculated as MFI divided by FM. Occupation was graded as manual and non-manual.

Anthropometric Measurements

All the measurements were taken following the standard techniques [34]. Height and weight were measured to the nearest 0.1 cm and 0.5 kg, respectively, using a local made Martin's type anthropometer, and standard weight scale, respectively. Minimum waist (WC) and maximum hip (HC) circumferences were measured to the nearest 0.1 cm using a tape measure (Triced, Sanghai, Chaina). Four skin folds namely, biceps (BSF), triceps (TSF), sub-scapular (SSF) and supra-iliac (SISF), were measured to the nearest 0.2 mm using a skin fold calliper (Holtain Ltd., UK). Technical errors of measurements were found to be within acceptable limits [35] and therefore, were not incorporated in the analyses. The BMI, WHR, and Conicity Index [36] were computed using the following standard equations:

$$\text{BMI (kg/m}^2) = \text{weight (kg) / height (m}^2).$$

$$\text{WHR} = \text{WC (cm)/HC (cm)}$$

$$\text{CI} = \text{MWC (cm) / (0.109) x} \sqrt{}\,[\text{weight (kg)/height (m)}$$

Per cent Body Fat (PBF) was calculated using four skin folds with the following standard equations [33] already validated in Indian population [37] and has been utilized to estimate body composition among the Bengalee ethnic group by recent studies [7, 38]. The equations used were:

$$\text{Density} = 1.1356\text{-}0.07 \text{ x } \log_{10} (\text{BSF+TSF+SSF+SISF}).$$

$$\text{PBF} = (4.95 / \text{density-}4.5) \text{ x } 100$$

The subjects were classified as underweight, overweight and obese if they have BMI <18.5, BMI $\geq$ 23 kg/m^2 and BMI $\geq$ 25 kg/m^2 (WHO, 2000) [39] abdominal adiposity by WC, as normal (WC $\leq$ 80 cm) and obese (WC >80 cm) [9]. Excess adiposity was determined as PBF > 25 % [40].

Analyses of Data

The distributions of the anthropometric variables were not significantly skewed. Age and anthropometric variables were described by their means and standard deviations. Multiple linear regression analysis was carried out to show the effect of central adiposity on BMI and PBF. Pearson correlation coefficients were calculated to see the relations of anthropometric parameters with MFI and MPCI. Partial correlation coefficients were computed, after controlling for age to show the relative associations of BMI with WC, WHR and CI. The subjects were further divided into the following age groups: 18-29.9 (n = 173, 37.2%), 30-39.9 (n = 113, 24.3%), 40-49.9 (n = 97, 20.9%), 50-59.9 (n = 52, 11.2%)

and 60-72.0 (n = 30, 6.5%) years to test whether these relationships vary across age groups. All statistical analyses were undertaken using the SPSS Statistical Package, version 10.0. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 65.2 % of the subjects had manual occupation, and the rest (34.8%) had non-manual jobs. Regarding educational status, 28.6 % of them were illiterate or only could sign their names and never went to school, 31.4 % did not pass eighth standard, 34% had secondary level education and 3.96% had passed twelfth standard. Only 1.9% had earned graduate degree or did not pass the undergraduate level. The means and standard deviations of age, anthropometric and socio-economic variables are presented in Table **1**. The mean (range) age of the subjects was 36.7 (18-72) years. Mean (sd) MFI and MPCI were Rs. 3654.4 (1971.0) and Rs. 885.3 (502.2), respectively.

Table 1. Characteristics of the Sample (n = 465)

Variables	Mean	SD
Age (years)	36.7	13.2
MFI (Rs)	3654.4	1971.0
MPCI (Rs)	885.3	502.2
Height (cm)	161.5	6.2
Weight (kg)	53.1	9.5
BSF (mm)	4.4	2.4
TSF (mm)	7.2	3.5
SSF (mm)	13.6	7.6
SISF (mm)	13.0	8.7
PBF (%)	15.8	7.0
BMI (kg/m^2)	20.3	3.3
WC (cm)	74.0	9.2
HC (cm)	84.1	7.7
WHR	0.89	.17
CI	1.19	.08

Overall, 31.8%, 11.6 % and 8.0 %of the subjects were underweight (BMI < 18.5 kg/m^2) overweight (BMI ≥ 23 kg/m^2) and obese (BMI ≥ 25 kg/m^2), 23% were found to be abdominally obese (WC > 80 cm), and only 9% were found to be obese by WHR (WHR > 0.95). 13.5% of the subjects were found to be obese by percent body fat (PBF>25.0%). Age was not significantly correlated with either BMI or PBF. Correlation studies revealed that (results not presented) both MFI and MPCI had significant associations with all the anthropometric variables except for height, WHR and CI. Table **2** shows Partial correlation coefficients of WC, WHR, and CI with BMI and PBF. WC showed the strongest significant ($p < 0.001$) partial correlation with BMI and PBF (0.82 and 0.77, respectively). HC was also found to be significantly correlated with BMI ($r = 0.67$; $p < 0.001$) and PBF ($r = 0.66$; $p < 0.001$). On the other hand, WHR and CI had much weaker partial correlations with BMI and PBF. It may be mentioned here that these values remained almost the same when age, MFI, and MPCI were controlled for. There were also no significant differences (results not presented) in these relationships across age groups.

Table 2. Partial Correlation Coefficients of Central Adiposity Measures with BMI and PBF after Controlling for Age, MFI and MPCI

Variables	BMI	PBF
WC	0.82*	0.77*
HC	0.68*	0.67*
CI	0.32*	0.41*
WHR	0.19*	0.15*

*p<0.001

Stepwise multiple linear regression analyses for BMI (Table **3**) and PBF (Table **4**), separately, on the central adiposity measures revealed that WC had the strongest impact on both BMI (Table **3**) as well as PBF (Table **4**). On the other hand, WHR, HC and CI had weaker effects on each. The regression equations, involving all the four central adiposity measures entered together, predicted around 94 % and 71% of the total variability of BMI and PBF, respectively. On the other hand, models involving only WC and CI (excluding HC and WHR), explained almost similar proportions of variations of BMI (*adj* R^2 = 94.1), and PBF (*adj* R^2 = 69.4), respectively. Furthermore, the WC was found to best account for the variability of BMI (R^2 Change = 0.666; *F* Change = 921.322, $p < 0.001$) and PBF (R^2 Change = 0.597; *F* Change = 2149.587, $p < 0.001$). Even after controlling for each other, i.e., BMI and PBF (results not shown), WC had strongest significant impact on these two measures compared with WHR and CI. It is also worth mentioning that these relationships did not differ across the age groups.

DISCUSSION

The BMI is widely used as a surrogate measure of overall adiposity because of its simplicity and high correlation with PBF [41, 42]. But the relationship of BMI with PBF and central adiposity depends upon age, sex and ethnic background [43-46]. However, the accumulation of body fat in the abdominal region is now established to be more predictive of health risks than in other regions of body or overall adiposity as measured by BMI [47, 48]. BMI, WHR, and WC all have been shown to have significant role in identification of obese and overweight individuals [3]. BMI is a measure of overall adiposity and the Asian Indians tend to have comparatively more body fat and its centralised deposition at a lower level of BMI [12]. It is also not clear which of the central adiposity measures best predict the overall adiposity [6,7]. Therefore, the objective of the present study was to find out the most effective and simple anthropometric measure of abdominal adiposity to predict BMI as well as PBF.

Table 3. Stepwise Multiple Linear Regressions of BMI and Central Adiposity Measures

Predictors	*B*	se*B*	Beta	*T**	F-Change	R^2Change
WC	0.586	0.016	1.654	37.77	921.32**	0.666
CI	-34.136	0.840	-0.893	-40.64	2149.59**	0.275
HC	-0.074	0.015	-0.174	-4.95	5.928*	0.001
WHR	-2.114	0.493	-0.111	-4.29	18.411**	0.002

**p < 0.001;
*p < 0.005;
Dependent variable: BMI.

Table 4. Stepwise Multiple Linear Regressions of PBF and Central Adiposity Measures

Predictors	*B*	se*B*	Beta	*T**	F-Change	R^2Change
WC	0.560	0.075	0.744	7.477	686.66**	0.597
CI	-27.859	4.054	-0.343	-6.872	146.92**	0.097
HC	-0.330	0.072	0.366	4.569	15.08**	0.010
WHR	-7.425	2.378	0.183	3.123	9.75*	0.006

**p < 0.001;
*p < 0.005;
Dependent variable: PBF.
(Values of *B*, se*B*, Beta and T are for the final model which includes WC, CI, HC and WHR as independent variables).

In our study WC explained the highest variability of both BMI and PBF compared with WHR and CI. In other studies also WC performed the best to assess intra abdominal fat in contrast to subcutaneous fat [49, 50]. WC has been also reported to predict most closely the total body fat [51]. In a study among adolescents [5] BMI and WC have been identified as diagnostic for fatness, while WHR has been less useful. In another recent study [6] among Bengalee Hindu elders (aged ≥ 55), WC has been found to be most correlated with BMI than WHR or CI, and BMI explain the highest variability of WC than of WHR and CI in both men and women. In the present study the contribution of WC, WHR and CI has been evaluated among the adult Bengalee males. WC had been found to be most strongly correlated with BMI and the later explained the largest variability of it. A study among groups of low socio-economic status from the southern part of India provided evidence that BMI, WHR and CI, all had significant inter-correlations and both the later measures were influenced by BMI [30].

A study from India [25] also concluded that WC correlated better with BMI than WHR. But they did not study CI. Another recent study [7] among adult females in the Bengalee population found that WC had the highest correlation with total body fat and explained the largest amount of variation in the same measure. In the same study, CI was a relatively better index compared to WHR to predict total body fat. There are other studies also in which WC had better efficacy in detecting overweight than WHR [52] and BMI [53]. The present study was also in conformity with this study in the same population but in adult males, showing the highest partial correlation between PBF and WC. As it is always more desirable to have the simplest and inexpensive measure for the use in the field situation and for emergency clinical diagnosis, WC seems to have the highest potential in this regard. Like the study mentioned above [6], we found that CI had better correlation with BMI as well as with PBF as compared to WHR. Our results perhaps, simply indicate that a great proportion of the body fat (which has its contribution to BMI) is located in the abdomen in these males. Therefore, most of the BMI variation is accounted for by the WC. Moreover, if it is assumed that WC reflects more of the fat mass than the muscle mass, then it can be proposed that BMI values of these males represent more fat than muscles. This has also support for many studies which earlier showed that the South Asians have more body fat at same BMI than the Europeans.

CONCLUSION

In conclusion, we propose that, WC, which has been already recommended for use in health promotion or primary care [54, 55] may be preferred over other measures of central adiposity in assessment of obesity, in this population, However, with this proposal, some of the obvious limitations of the study must be mentioned. Firstly, no so called gold standard measures of body fat, such as, DXA, BII, or CT were used because they are relatively costly and not easy or sometimes impossible to carry out in the field situations in epidemiological surveys. Therefore, the well recommended and population validated [33, 37] equations using simpler skinfold measures were utilized to assess PBF. Secondly, no measures of metabolic variables associated with CVD and DM were taken in this study. Further studies in this section of the population are needed to unravel the relative associations of these variables with central adiposity measures, especially, with WC.

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CONFLICT OF INTEREST

The authors solemnly confirm that there are no relevant associations that might cause any conflict of interest.

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