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Use of waist circumference and its optimal value to identify obesity in relation to hypertension: a cross-sectional study among adult male slum dwellers of Eastern India

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Abstract

Background: Waist circumference (WC) is a useful surrogate marker of abdominal adiposity and a risk factor of cardiovascular disease and hypertension. Asians have higher abdominal fat at a lower level of body mass index (BMI). Previous studies showed that WC was the best measure and correlate of abdominal fat and general adiposity, respectively, among the Bengalee people of Eastern India including the present sample. This study aimed to evaluate the clinical usefulness of waist circumference and its appropriate cut-off in identifying obesity and hypertension.

Methods: Adult male slum dwellers aged between 18 and 60 years were included in the study. Height, weight, skinfolds, waist circumference, systolic- (SBP) and diastolic blood pressures (DBP) were measured. Body mass index (BMI) and percent body fat (PBF) were also calculated. Obesity was defined as >25% of body fat. Mean (+ SD) and range statistics were used to describe the variables. WC values were divided into four categories, viz. <72cm, 72-79.9cm, 80-84.9cm and ≥ 85.0cm. ANCOVA was performed to observe the differences in mean SBP and, DBP between the WC categories, with age, smoking and alcohol consumption status as covariates. Pearson correlation and multiple linear regressions were employed to examine the relationship of WC with SBP and DBP. Adjusted odds ratios for hypertension by WC categories were obtained through logistic regression analysis. Receiver operating characteristic (ROC) curve analysis revealed the optimal value of WC to identify obesity.

Results and conclusions: PBF increased significantly (F = 208.74, p<0.001) from the lowest WC category (10.6%) to the highest one (26.9%). Mean SBP and DBP also increased significantly from the lowest to the highest WC categories. Waist circumference had significant positive effect on both SBP (T=2.559, p<0.01) and DBP (T=3.256, p<0.05) irrespective of age and PBF. WC value >80.9cm could be accepted as the best cut-off point for WC to identify obesity. Participants with a WC of 80-84.9 cm were around three times more likely to have HT(p<0.005), however the likelihood increased to over 5 for those with a WC of > 85.0 cm when compared to lower WC categories. The odds ratio significantly increased for WCs at or above 80cm. Therefore the measurement of WC could be used to identify general obesity and be used as a screening tool for HT risk factors in Bengalee urban slum dwelling men. The WC cut off to define obesity and identifying hypertension was around 81cm.

Key words: waist circumference, obesity, hypertension, ROC, adult men, slum, India

Introduction

Abdominal obesity (AO) is defined by an increased amount of intra-abdominal fat (IAF) including visceral adipose tissue (VAT) and has been associated with a number of CVD risk factors [1], CVD [2] and all-cause mortality [3]. Waist circumference (WC) is a useful surrogate marker of IAF [4]. It has been demonstrated in prospective and case–control studies that subjects with an elevated WC or waist-hip ratio (WHR) had a two- to threefold increase in cardiovascular disease (CVD) risk and premature death even within a 'normal' body mass index (BMI) range [5, 6]. Asians have increased prevalence of AO compared to Caucasians [7]. South Asians also have increased abdominal adiposity at a given BMI [8, 9] and a higher percentage of body fat [10-12] compared to Europeans. Increased mortality was also found to be associated with lower WC in Asians compared with those in African-Americans and Europeans [13].

Although there was no consensus about the most appropriate measure of AO for the prediction of clinical risks, some studies have suggested that WC is a better predictor of CVD risk profiles [14, 15] and total body fat [16]. Studies from India [17] including the Bengalee population of the West Bengal State indicated that WC correlated better with BMI [18-20] and total body fat [21]. Studies also indicated that cardiovascular disease (CVD) was a major health problem among the Bengalee ethnic group [22, 23]. It has been shown in other studies, using the same data-set [19, 20], that WC was the strongest correlate of BMI and PBF and explained the largest variability of the later measures than hip circumference, WHR, and conicity index. It was, therefore, recommended that WC, being simpler, inexpensive, non-invasive, and easy to standardize, might be the best measure of adiposity and obesity in Bengalee adult males [20].

Among several recommendations for the appropriate cut off value of WC, the most commonly used cut offs among Caucasians are 102cm for men and 88cm for women [24, 25]. More recently, the International Diabetes Federation (IDF) has included WC as mandatory measure in its candidate definition of metabolic syndrome (MS) and recommended a cut off level of 90 cm for central obesity in Asian men [26]. A recent joint proposal by the international apex bodies maintained that WC might be a useful preliminary screening tool. More importantly, a single set of cut off points was recommended for all components of MS but the WC, for which regional cut offs were recommended for use until further consensus is reached [27]. Several studies among Asian populations have already indicated that the cut off points of WC in identifying metabolic syndrome might be lower than the western standard [28, 29]. Furthermore, studies relating to MS in Indian populations [30-34], have also indicated that the WC cut off points might be lower in terms of defining abdominal obesity. But while considering these findings, it has to be realized that the relationship of abdominal obesity may be different with various metabolic risk factors. In addition, predictive values for various levels of abdominal obesity for CVD and diabetes may differ [27]. Therefore, alternately, it may be of greater interest to find out the optimal level of WC to identify obesity by percent body fat (PBF), which, itself, is an established risk factor for both diabetes and CVD.

In India and other developing countries, slum dwellers are of particular interest. They are mainly poor people who have migrated from rural areas to settle down in towns and cities, thereby getting exposed to adverse urban lifestyles and obesogenic environments. Unfortunately, only a few studies have been carried out among the slum dwellers in India to explore the relationship between central adiposity and PBF [19, 20]. However, they did not go on to explore how their findings related to risk factors like hypertension. About 30% of the metropolitan population in India lives in slum clusters and resettlement colonies. The number of slum dwellers is estimated to be over 4 million in Kolkata (formerly, Calcutta), excluding those living in unregistered and unauthorized squatter settlements [35]. The purpose of the present study was to evaluate the clinical usefulness of waist circumference in relation to body fat and blood pressure. It also proposes a suitable cut off point to identify obesity (PBF>25%) in relation to blood pressure and hypertension among adult Bengalee male slum dwellers in West Bengal, India, since there is a paucity of information on central obesity and hypertension among this group.

Methods

The area and the subjects

The present cross-sectional study was based on a survey conducted under a research project granted to the first author (RC) in a slum called *Bidhan Colony*, situated approximately 15 kms from Kolkata (formerly Calcutta) town centre. Kolkata is the capital city of West Bengal province. The study population was comprised of adult males aged 18 years or above. Most of the subjects were migrants from Bangladesh as well as from other rural parts of the West Bengal province. The slum was located at the right hand side of the railway tracks between Dum Dum Junction and The Dum Dum Cantonment Railway Stations. It was the terminal part of an urban settlement, called East *Sinthee*, nearby to the *Dum Dum* Junction railway station, and was under the jurisdiction of South Dum Dum Municipality, North 24 Parganas, West Bengal, India. The other side of the said railway track was an area under the jurisdiction of the Kolkata Corporation.

All the participants originated from the West Bengal state in India, or Bangladesh and spoke the Bengali language as their mother tongue. They belonged to the Hindu religious group. A total of 474 reportedly healthy males, without any known disease, not under any prolonged medication, not having undergone any recent surgery and able to do their normal day-to-day work at the time of examination, were included in the study. Data on blood pressures were available for 470 subjects. On assumption that body composition may change significantly at higher age, data on individuals aged 60 years or below were utilized for the present analysis. Thus, a total of 433 males aged between 18 and 60 years were included in the present study. Most of the participants were engaged in so called jobs of low socio-economic status, ranging from factory workers to rickshaw-pullers, or day-labourers.

Collection of data

Ethical approval and prior permission was obtained from the institution of the first author. 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 presence of the adult male members. 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 there were logistic difficulties in carrying out the survey in some households, the subjects were taken to a common location where a number of them were examined together. However, care was taken to include only those participants residing inside the boundary of the slum under study, but, Bidhan Colony. The overall response rate was around 80%. Informed consent was also obtained from each participant before starting the interviews. Data including anthropometric measurements were collected by the first author (RC). Primary information on ethnicity, age, monthly family income (MFI), and occupation was collected from each subject with the help of a pre-tested questionnaire. Income was recorded in Indian rupee (UK £1 = 72.6 Indian Rupees, approx). Monthly per-capita income (MPCI) was calculated as MFI divided by number of family members.

Anthropometric measurements

All the measurements were taken following standard procedures [36]. Height and weight were measured to the nearest 1.0 mm and 500 g, respectively, using a standard anthropometer, and standardized weight scale, respectively. Minimum waist circumference (WC) was measured to the nearest 1.0 mm using a tape measure (Triced, China). 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 caliper (Holtain Ltd., UK). Technical errors of measurements were found to be within acceptable limits [37] and therefore, were not incorporated in the analyses.

Body density was calculated according to the Durnin and Womerseley equation [38] using the four skin fold measurements. PBF was computed following Siri's equation [39]. Both of these equations have previously been validated in Indian populations [40] and are generally followed to estimate body composition [21,41]. The equations used were:

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

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

The subjects were classified as obese if they have PBF > 25 % [42, 43].

Blood pressure was measured by RC in the left arm of each subject, using a standardized digital blood pressure monitor (Home Health, Switzerland) with adjustable calf size following the prescribed protocol. Resting systolic and diastolic blood pressures (in mmHg) was measured with the subject in a sitting position for at least 15 minutes prior to measurement and again at least 10 minutes before the second reading. The mean values of two measures were used in the analyses. Hypertension was defined as a systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg,

Statistical analyses

Age and anthropometric variables were described by their respective mean and standard deviation with the maximum and minimum values. Receiver operating Characteristic (ROC) curve analysis was performed along with the calculation of sensitivity, specificity, positive- and negative predictive values (PPV and NPV). Youden Index (YI) [44] was calculated as: (sensitivity + specificity – 1). PPV, NPV and YI values for different WC values were compared to find out the optimal cut off point for obesity (PBF>25%). WC values were categorized into four groups, viz. <72cm, 72-79.9cm, 80-84.9cm and ≥ 85.0cm. Mean (SD) values of age, PBF, SBP and DBP were calculated for each WC category and the differences were evaluated by ANCOVA with age, smoking and drinking status as the covariates. The mean values thus obtained were adjusted for those covariates. Smokers and drinkers were coded as '1' in contrast to '0' for non-smokers and non-drinkers, respectively. Scheffe's test was employed to observe the significance of differences between the WC categories. Multiple linear regression analyses of SBP and DBP on waist circumference after controlling for age, smoking and alcohol consumption status and PBF were undertaken. Since the entry of smoking and alcohol consumption did not improve the models significantly either independently, or with age, they were not entered in the final models where age and PBF were entered en-block before entering waist circumference as the predictor variable. The results of the regressions after controlling age and PBF in the said way were utilized. Binary logistic regression of HT (coded as 0=normal, 1=HT) was run on age and WC categories. Age-adjusted odds ratios of HT for each WC categories with reference to the lowest one were obtained. Contingency chi-square test was utilized to see the significance of difference in prevalence of HT between the WC categories. All statistical analyses were undertaken using the SPSS Statistical Package (version 10.0) and MedCalc Software (Mariakerke, Belgium). Statistical significance was set at $p< 0.05$.

Results

The mean (SD) per capita income of the families was RS. 893.0 (507.6). The prevalence of smoking and alcohol consumption was 67.4% and 23.8%, respectively. 53.1% undertook manual works as the primary occupation. The prevalence of obesity (PBF>25%) was 14.3%. The abdominal obesity using WC cut offs of 90 cm, 85 cm and 80 cm were 5.1%, 12.0% and 24.7% , respectively. 17.6 % of the subjects had hypertension (SBP/DBP ≥ 140/90 mmHg) (results not shown).

In Table 1, mean, standard deviations (SD), and ranges of age and anthropometric variables are presented to describe the data. The age of the subjects were between 18.0 and 60.0 years with a mean (SD) value of 34.7 (11.1). The mean (SD) height, weight, and WC were 161.7 (6.1) cm, 53.5 (9.2) kg and 74.1 (9.3) cm, respectively. The mean (SD) PBF was 16.0 (7.0). The mean (SD) SBP and DBP were 120.2 (13.4) and 79.4 (9.4) mmHg, respectively.

Mean age increased significantly ($p<0.05$) from the lowest WC category to the highest one (result not shown). The mean (SD) values of PBF, SBP and DBP, adjusted for age, smoking and alcohol consumption status, for each WC categories, are presented in Table 2. PBF increased significantly

Table 1. Mean and SD value of the age and anthropometric variables.

Variable	Mean	SD	Minimum	Maximum
Age (year)	34.7	11.1	18.0	60.0
Height (cm)	161.7	6.1	142.8	189.3
Weight (kg)	53.5	9.2	30.1	92.0
WC (cm)	74.1	9.3	25.8	103.6
BSF	4.4	2.1	1.8	16.2
TSF	7.2	3.5	3.0	22.0
SSF	13.8	7.6	3.6	43.8
SISF	13.2	8.8	3.5	42.0
SumSF	38.6	20.6	14.8	114.0
PBF	16.0	7.0	4.4	33.7
SBP	120.2	13.4	68.5	181.0
DBP	79.4	9.4	49.0	113.5

(F = 208.74, p<0.001) from the lowest WC category (10.6%) to the highest one (26.9%). In respective Scheffe's tests, all the four categories showed significant differences (p<0.001) among themselves in mean PBF. Mean SBP also increased significantly from the lowest WC category to the highest one. Scheffe tests revealed significant difference in mean SBP of the first and the second categories, respectively, with the third WC category (p<0.001) and also with the highest category (Figure 1). Sheffe test revealed that the mean DBP increased significantly (p<0.01) from

Table 2. Mean and 95% CI values of PBF, SBP and DBP according to WC categories.

WC (cm)	PBF [a]	95%CI	SBP [a]	95%CI	DBP [a]	95% CI
< 72	10.6 (6.2)	10.06 - 11.24	117.9 (19.4)	114.07 - 121.70	78.7 (13.1)	76.09 - 81.31
72 – 79.9	16.8 (7.5)	16.17 - 17.58	120.1 (17.8)	116.60 - 123.62	80.6 (12.2)	78.22 - 83.01
80-84.9	22.2 (11.4)	21.12 - 23.31	125.1 (34.1)	118.26 - 131.68	82.8 (23.3)	78.24 - 87.41
≥ 85.0	26.9 (11.8)	25.75 - 28.02	128.2 (21.3)	124.05 - 132.45	86.4 (14.6)	83.51- 89.26
F	208.74*		13.72*		16.82*	

*a = adjusted for age, smoking and alcohol consumption status; *p<0.001.*
Standard deviations of mean values are presented in parentheses.

Table 3. Results of multiple linear regression analyses of SBP and DBP on waist circumference after controlling for age and PBF.

Dependent Variable	B	SeB	Beta	T	p
SBP	0.261	0.102	.181	2.559	<0.01
DBP	0.228	0.070	.226	3.256	<0.05

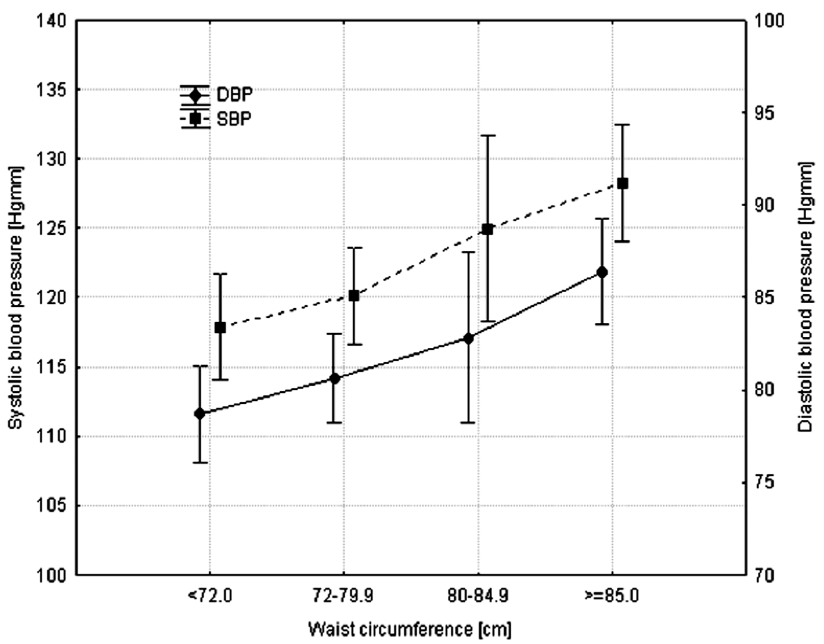
the first to second WC category and then, to the third one. There was significant difference in mean DBP of the highest WC category with all the lower ones.

WC was significantly correlated with age (r= 0.26, p<0.001). The age controlled partial correlation of WC with PBF, SBP and DBP, respectively, were 0.76, 0.29 and 0.32 (for all, p<0.001). Age was also significantly correlated with SBP (r=0.24, p<0.001) and DBP (r=0.28, p<0.001) (results not shown). Multiple linear regression analyses of SBP and DBP (separately) on waist circumference, after controlling for age and PBF, were undertaken. Waist circumference had significant positive effect on both SBP (T=2.559, p<0.01) and DBP (T=3.256, p<0.05) irrespective of age and PBF (Table 3). Age had significant independent positive impact on both the BP measures. PBF also showed a significant effect on SBP independent of age and WC, but not on DBP (results not shown).

The results of ROC curve analysis of WC with respect to obesity (PBF>25%) are presented in Table 4 with sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for various WC values. Although WC values between 80.0 and 80.9cm had the highest sensitivity of 85.48%, the value 80.9cm was identified as the best cut off to identify obesity (PBF>25%) with the highest specificity of 88.59%. Again, the values little above 81.0 cm had the same specificity, but the sensitivity decreased to 83.87%. The sum of sensitivity and specificity was the highest (1.74) for the value 80.9cm. The Youden index as well as the sensitivity, on the other hand, were the same and the highest (0.73 and 85.48, respectively) for WC values between 80.7cm and 80.9cm. But the specificity and the PPV were slightly higher for 80.9cm of WC. Therefore, a WC value >80.9cm could be accepted as the best cut of WC to identify obesity. The ROC curve is presented in Figure 2. The area under curve was 0.94.

Table 5 presents the results of binary logistic regression analysis of hypertension (HT) on age and WC (coded in four categories and the lowest one as the reference group). It also shows the prevalence (%) and the odds ratios (adjusted for age, smoking and alcohol status) of HT according to WC categories. Both age and WC had significant independent effect on the HT status as indicated by the significant Wald statistics. WC had a large Wald value (28.19, p<0.001) after allowing for age. The prevalence of HT was similar in the two lower WC categories (10.9 and 10.6%, respectively). It increased significantly (30.9%) at and above the level of 80cm and again rose up to 45.3% at the highest WC category (X^2 = 45.28, p<0.001). Age-adjusted odds ratios for HT also increased significantly at above WC level of 80.0 cm. The individuals having WC 80-84.9 cm were about three times (p<0.005), and WC > 85.0 cm, were more than 5 times (p<0.001) more likely to

Figure 1. The increment of blood pressures with waist circumference.



DBP: Diastolic-, and SBP: systolic blood pressure.

have HT compared to the lower categories. The odds ratio had significant increase only at and above the WC level of 80.0 cm.

Finally, when WC cut off of 90cm was employed to define central obesity, 32% of the obese (PBF≥25) was rightly identified and 67.7% of the obese was misclassified as non-obese. But on application of the cut off of 80cm for central obesity, misclassification was reduced to 14.5% and 85.5% of the obese (PBF≥25) was rightly included. In case of hypertension, when the cut off value of 90cm was utilized, only 10.5% hypertensive could be identified with central obesity and the extent of misclassification was as high as 89.5%. Using 80cm as the cut off improved the screening ability to a considerable extent and 43.4% more hypertensive could be identified by this later cut off for central obesity.

Discussion

Central obesity is a key component in the definition of MS, but the cut-off values proposed to define abnormal values vary among different guidelines. WC being a convenient proxy measure of abdominal adipose tissue is itself a CVD and diabetes-risk factor and strongly linked to other CVD risk factors. There are several proposed cut offs of WC for determination of central obesity. There is possible evidence that Asians have lower WC cutoffs, and a value of 85 cm for men, was supposed the most appropriate [45, 46]. More recently, in a joint declaration, the apex bodies recommended WC as a useful screening tool for MS and ethnic or region specific cut off points were recommended for this purpose [27]. The IDF not only recommended a lower WC cut off of 90 cm to define adiposity in Asian men but placed

Table 4. Results of ROC curve analysis of WC for PBF criterion of >25%.

WC (cm)	Sensitivity (95%CI)	Specificity (95%CI)	PPV	NPV	Youden Index
> 80.6	85.48 (74.2 – 93.1)	87.34 (83.7 – 90.4)	51.0	97.5	0.72
>80.7	85.48 (74.2 – 93.1)	88.09 (84.5 – 91.1)	52.5	97.5	0.73
>80.8	85.48 (74.2 – 93.1)	88.34 (84.8 – 91.3)	53.0	97.5	0.73
>80.9*	85.48 (74.2 – 93.1)	88.59 (85.1 – 91.5)	53.5	97.5	0.73
>81.1	83.87 (72.3 – 92.0)	88.59 (85.1 – 91.5)	53.1	97.3	0.71
>81.3	82.26 (70.5 – 90.8)	89.33 (85.9 – 92.2)	54.3	97.3	0.71
>81.4	80.65 (68.6 – 89.6)	89.58 (86.2 – 92.4)	54.3	96.8	0.69

** proposed cut-off value.*

ITALIAN JOURNAL OF PUBLIC HEALTH

Figure 2. ROC curve of WC for PBF criterion of >25%.

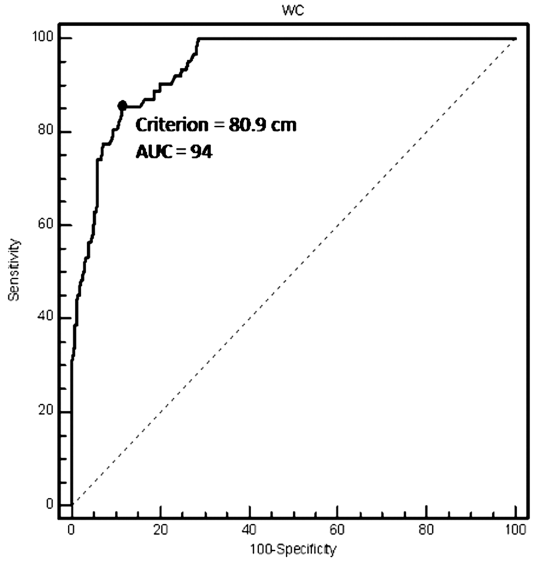


Table 5. Logistic regression analysis of hypertension on age and WC grades.

DV	Wald	Odds Ratio [a] (95% CI)	HT (%)**	p
Age (years)	10.53	1.042 (1.016 – 1.068)	---	< 0.005
WC	28.19	---	---	<0.001
WC categories:				
< 72*	---	---	10.9	---
72-79.9	0.12	0.88 (0.43 – 1.80)	10.6	0.734
80-84.9	8.10	2.96 (1.40 – 6.26)	30.9	<0.005
≥ 85.0	19.17	5.08 (2.45 – 10.51)	45.3	<0.001

** WC < 72 cm was set as reference category in the regression; a adjusted for age, smoking and alcohol consumption status; **X2 = 45.28, p<0.001.*

emphasis on the attempts to identify ethnic or local standards of the measure. However, owing to different relationship of central obesity with different components of MS, there may be different cut off points for WC for each component [27].

Several studies indicated better efficacy of WC, among other measures of central adiposity, to predict overall adiposity in India [17] and abroad [16,47], including the Bengalee population [18,21]. The WC had been already shown to have the strongest correlation with BMI and PBF among the slum men under study with the same dataset [19, 20]. Within this context the present study was undertaken to identify the optimal cut off point for WC in determination of obesity (PBF>25%) in relation to blood pressure and hypertension among the slum dwelling Bengalee men in West Bengal, India.

The present study demonstrated that a WC ≥ 80.9 corresponded well with excess adiposity (PBF>25%) in slum dwelling Bengalee men. This value was lower than the European as well as the IDF-recommended Asian standard (90 cm) of AO. In Northern Indian men a WC cut off point of 90 cm was appropriate for identifying overweight (BMI≥25 kg/m^2) individuals [48]. It has previously been established from a number of studies that the optimal level of WC to identify AO in relation to MS or any of its components is lower in Asian people. The waist circumference cut-off was ≥ 85 cm for Chinese men [49], whereas, in another recent study it was 89 cm [50]. WC value for predicting metabolic risk factors in Koreans was about 85 cm for men [51]. While the optimal point of waist circumference to predict the accumulation of the components of MS was estimated as being approximately 84 cm for Japanese men [29].

A study among urban adults from six cities in India [31] reported a WC of 85 cm for men as the optimal cut point value. The optimal WC cut point for identifying any two cardio-metabolic risk factors was 87 cm for north-Indian men [30]. Another study on north Indian people also reported a lower cut point for WC [32]. A study among adults, again from the northern part of India [33], found that a 10.5% of abdominally non-obese subjects (WC<90 cm) had at least 3 risk variables of MS. By making waist circumference mandatory in identifying MS led to non-inclusion of nearly 11% cases which would be otherwise diagnosed as metabolic syndrome as per modified NCEP, ATP III definition. Setting the WC cut off at a level lower than the recommended value (90 cm) would have solved the problem of misclassification. However, most of these studies except a few [48] found out the optimal WC value to identify MS but not obesity (excess BMI or PBF). Interestingly, only one previous study [34] among Bengalee adult males in Kolkata, proposed a WC cut off > 80 cm to identify overweight (BMI ≥ 25 kg/m^2). Since the study was conducted in the OPD of Calcutta Medical College Hospital, the lower and lower-middle class groups of people were mainly expected to be visitors. Therefore, the present study showed similar finding with regard to the WC cut off point.

Although the present study did not concern with any of the components of metabolic syndrome, the findings were analyzed in relation to blood pressure and HT. The results demonstrated a significant increase in the prevalence (%) as well as risk (OR) of HT at a WC level of 80cm or higher. We also demonstrated that WC had significant positive effect on both SBP and DBP independent of age and PBF. In case of DBP, higher PBF is effective only with higher WC. The SBP and DBP also increased significantly at and above WC value of 80cm. In adult males of northern India (Wardha) a lower cut off value of 72.5cm for WC was established in relation to hypertension risk [52].

It seems that in Bengalee men, most of the body fat is located in the abdominal region. Even in an abdomen of relatively low girth, the relative proportion of fat was high. This abdominal fat increases their PBF count, and when above critical level, exposes them to higher likelihood of having metabolic or CVD risk factors such as hypertension. It might also be assumed that the adult slum dwellers, having witnessed chronic nutritional deprivation during the prenatal period or their early years, had a higher proportion of body fat relative to their total body volume compared to their economically well-off counterparts [53]. This might be the reason for the WC cut off point to be even lower than reported in other Indian studies, none of which dealt with poor people from slums.

However, it can be concluded from the present findings that the WC cut off point to define obesity and identifying HT is around 81cm. WC is the simplest and the most efficient measure of central adiposity and obesity (BMI and PBF) in Bengalee populations [18-21] including the slum dwelling men who took part in this study [20]. It requires minimal equipment and standardization of only one measurement [5, 54]. Therefore, it may be used as a standalone measurement to identify general obesity and should be used as a screening tool for HT in Bengalee urban slum dwelling men.

Recent studies from Kolkata have indicated that HT is a major problem among Bengalee people [55] and the present study demonstrated its association with increased WC. Metabolic syndrome was often seen to be more prevalent in lower socioeconomic classes [56] and in Kolkata, the incidence of stroke was greater among slum dwellers than the non-slum dwellers [57]. In a study among the slum dwelling men of the present study, it was shown that improvement in financial status may encourage the higher consumption of energy rich drinks which may lead to the higher incidence of obesity [58]. Therefore, it may be recommended that along with the economic improvements among these poor people, awareness and intervention programmes, like those carried out among the children [59] should be undertaken for abdominal obesity utilizing simple screening techniques for self-assessment of cardiovascular health. Lastly, it must be mentioned here that our results may not applicable to all Indian populations as they are vast and diverse in terms of ethnicity, culture, degrees of urbanization, socio-economic status and nutrition transition. Similar studies in India are needed among various ethnic groups of diverse socio-economic backgrounds to arrive at a more pan-Indian consensus.

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References

1) Johnson S, Martin D, Sarin C. Diabetes Mellitus in the First Nations population of British Columbia, Canada. Int J Circumpolar Health 2002;61:260–3.
2) Nicklas BJ, Penninx BW, Cesari M et al. Association of visceral adipose tissue with incident myocardial infarction in older men and women: the Health, Aging and Body Composition Study. Am J Epidemiol 2004;160,741–9.
3) Kuk JL, Katzmarzyk PT, Nichaman MZ, Church TS, Blair SN, Ross R. Visceral fat is an independent predictor of all-cause mortality in men. Obesity (Silver Spring) 2006;14,336–41.
4) Day C. Metabolic syndrome, or What you will: definitions and epidemiology. Diab Vasc Dis Res 2007;4;32.
5) Yusuf S, Hawken S, Ounpuu S, et al. Obesity and the risk of myocardial infarction in 27000 participants from 52 countries: a case-control study. The Lancet 2005;366:1640-9.
6) Pischon T, Boeing H, Hoffmann K et al. General and abdominal adiposity and risk of death in Europe. N Engl J Med 2008;359:2105–20.
7) Tanaka S, Horimai C, Katsukawa F. Ethnic differences in abdominal visceral fat accumulation
between Japanese, African-Americans, and Caucasians: a meta-analysis. Acta Diabetol 2003;40(Suppl 1):S302–4.
8) Lean ME, Han TS, Bush H, Anderson AS, Bradby H, Williams R. Ethnic differences in anthropometric and lifestyle measures related to coronary heart disease risk between South Asian, Italian and general-population British women living in the west of Scotland. Int J Obes Relat Metab Disord 2001;25:1800–05.
9) Orr-Walker B, Evans MC, Reid IR, Cundy T. Increased abdominal fat in young women of Indian origin. Asia Pac J Clin Nutr 2005;14:69–73.
10) Banerji MA, Faridi N, Atluri R, Chaiken RL, Lebovitz HE. Body composition, visceral fat, leptin, and insulin resistance in Asian Indian men. J Clin Endocrinol Metab 1999;84,137–44.
11) Deurenberg-Yap M, Schmidt G, Wvan Staveren A, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obes Relat Metab Disord 2000;24:1011–7.
12) Rush EC, Goedecke JH, Jennings C, et al. BMI, fat and muscle differences in urban women of five ethnicities from two countries. Int J Obes (Lond) 2007;31:1232–9.
13) Koster A, Leitzmann MF, Schatzkin A, et al.. Waist circumference and mortality. Am J Epidemiol 2008;167:1465–75.
14) Venkataramana P, Reddy PC. Association of overall and abdominal adiposity with coronary heart disease factors: comparison between urban and rural men. Asia Pac J Clin Nutr 2002;11:68-71.
15) Esmailzadeh A, Miriram P, Aziz F. Waist to hip ratio is a better screening measure for cardiovascular risk factors than other anthropometric indicators in Teheranian adult men. Int J Obes Relat Metab Disord 2004; 28:1325-32.
16) Lean MEJ, Han TS, Deurenberg P. Predicting body composition by densitometry from simple anthropometric measurements. Am J Clin Nutr 1996; 63:4-14.
17) Kurpad SS, Tandon H, Srinivasan K. Waist circumference correlates better with body mass index than waist hip ratio in Asian Indians. Natl Med J India 2003;16:189-92. Comment in: Natl Med J India 2004;17:115-6.
18) Bose K. Which measure of abdominal adiposity best relates with body mass index among older Bengalee Hindus of Kolkata, India? A comparison of three measures. Int J Anthropol 2006;21:247-52.
19) Chakraborty R, Bose K. Central adiposity measures of Bengalee male slum dwellers. Int J Body Comp Res 2008;6(3):122–6.

20) Chakraborty R, Bose K. Central Adiposity, Body Mass Index and Percent Body Fat among Bengalee Hindu Male Slum Dwellers of Dum Dum, West Bengal, India. The Open Obesity J 2009;1:32-7.
21) Ghosh JR, Bandyopadhyay AR. Waist circumference as a measure of total body fat in Asian Indians. Int J Body Comp Res 2007;5(3):89-93.
22) Ghosh A, Bose K, Das Chaudhuri AB. Association of food patterns, central obesity measures and metabolic risk factors for coronary heart disease (CHD) in middle-aged Bengalee Hindu men, Calcutta, India. Asia Pac J Clin Nutr 2003;12(2):166-71.
23) Ghosh A, Bose K, Chakravarti S, et al. Relationship of waist circumference and waist-hip ratio with coronary heart disease risk factors among Bengalee Hindu men of Kolkata, India. J Royal Soc Health 2004;124(2):86-91.
24) Lean ME, Han TS, Morrison C. Waist circumference as a measure of indicating need for weight management. Br Med J 1995;311:158-61.
25) NECP. Executive summary of the third report of the National Cholesterol Education Program (NCEP): Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486-97.
26) Alberti KG, Zimmet P, Shaw J. Metabolic syndrome – a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med 2006;23:469–80.
27) Alberti KGMM, Eckel RH, Grundy SM, et al. Harmonizing the Metabolic Syndrome: A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International association for the Study of Obesity. Circulation 2009;120:1640-5.
28) Wang JW, Hu DY, Sun YH, et al. Obesity criteria for identifying metabolic risks. Asia Pac J Clin Nutr 2009;18(1):105-13.
29) Ogawa D, Kahara K, Shigematsu T, et al. Optimal cut-off point of waist circumference for the diagnosis of metabolic syndrome in Japanese subjects. J Diabetes Invest 2010;1:117-20.
30) Mohan V, Deepa M, Farooq S, Venkat Narayan KM, Datta M, Deepa R. Anthropometric cut points for identification of cardio-metabolic risk factors in urban Asian Indian population. Metabolism 2007;56:961-8.
31) Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes Care 2003;26:1380-4.
32) Gupta R, Rastogi P, Sarna, M, et al. Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subjects. J Assoc Physicians India 2007;55:621-7.
33) Wasir JS, Misra A, Vikram NK, Pandey RM, Gupta R. Comparison of definitions of the metabolic syndrome in adult Asian Indians. J Assoc Physicians India 2008;56:158-64.
34. Dasgupta S, Hazra SC. The utility of waist circumference in assessment of obesity. Ind J Pub Health 1999;43:132-5.
35) Mallick R. Urban poor in Calcutta. Available from: http://www.achr.net/sup_india_c.htm [accessed December 9, 2008].
36) Lohman TG, Roche A.F, Martorell R. Anthropometric standardization reference manual. Chicago: Human Kinetics Books,1998.
37) Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Br J Nutr 1999;82:165-77.
38) Durnin JVGA, Womerseley J. Body fat assessed from total body density and its estimation from skin fold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr 1974;32:77-97.
39) Siri WE. Body composition from fluid spaces and density: analysis of methods. In Brozek J, Hensche A (eds). Techniques for measuring body composition. Washington DC: National Academy of Sciences, 1961:223-44.
40) Kuriyan R, Petracchi C, Ferro-Luzzi A, et al. Validation of expedient methods for measuring body composition in Indian adults. Indian J Med Res 1998;107:37-45.
41) Khongsdier R. BMI and morbidity in relation to body composition: a cross-sectional study of a rural community in North-East India. Br J Nutr 2005; 93:101-7.
42) World Health Organization. The Asia Pacific Perspective: Redefining obesity and its treatment. Geneva: WHO, 2000.
43) Deurenberg P, Yap MD, Wang J, et al. The impact of body build on the relationship between body mass index and percent body fat. Int J Obes 1999;23:537-42.
44) Youden WJ. Index for rating diagnostic tests. Cancer 1950;3,32-35.
45) Huxley R, Barzi F, Lee CM, et al. Waist circumference thresholds provide an accurate and widely applicable method for the discrimination of diabetes. Diabetes Care 2007;30:3116–8.
46) Obesity in Asia Collaboration. Is central obesity a better discriminator of the risk of hypertension than body mass index in ethnically diverse populations? J Hypertens 2008;26:169–77.
47) Moy FM, Atiya AS. Waist circumference as a screening tool for weight management
evaluation using receiver operating characteristic curves for Malay subjects. Asia Pac J Pub Health 2003;15:99-104.
48) Misra A, Vikram NK, Gupta R, Pandey RM, Wasir JS, Gupta VP. Waist circumference cut-off points and action levels for Asian Indians for identification of abdominal obesity. Int J Obes 2006;30:106-11.
49) Zhou BF, Wu YF, Li Y, Zhang LF. The cut-off point of waist circumference for identifying metabolic syndrome in Chinese adults. Zhonghua Xin Xue Guan Bing Za Zhi 2005;33:81-5.
50) Wang Y, Rimm FB, Stampfer MJ, Willet WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type-2 diabetes among men. Am J Clin Nutr 2005;81:555-63.
51) Lee SY, Park HS, Kim DJ, et al. Appropriate waist circumference cutoff points for central obesity in Korean adults. Diabetes Res Clin Pract 2007;75:72–80.
52) Deshmukh PR, Gupta SS, Dongre AR, Bharambe MS, Maliya C, Kaur S, Garg BS. Relationship of anthropometric indicators with blood pressure levels in rural Wardha. Ind J Med Res 2006;123:657-64.
53) Koziel S., Jankowska EA. Birth weight and stature, body mass index and fat distribution of 14-year-old Polish adolescents. J Pediatr Child Helath 2002;38:55-8.
54) Deepa M, Farooq S, Deepa R, Manjula D, Mohan V. Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India [CURES– 47]. Eur J Clin Nutr 2009;63(2):259-67.
55) Chakraborty R, Bose K, Bisai S. Body mass index and blood pressure among adult Bengalee male slum dwellers of

Kolkata, India. J Pub Health 2009;17:301-8.
56) Riva MA, Facchetti R, Ferrario MM, et al. Biological and social values of metabolic syndrome in predicting cardiovascular disease. Ital J Public Health 2009;6(4):330-7.
57) Das K, Banerjee TK, Biswas A, et al. A prospective community based study of stroke in Kolkata, India. Stroke 2007;38:906–10.
58) Chakraborty R, Bose K, Ulijaszek SJ. Income Level and Food Intake Patterns among Male Bengalee Slum Dwellers in Kolkata, India. Mal J Nutr 2009;15(1):19-25.
59) Dietrich S, Pietrobelli A, Dämon S, Widhalm K. Obesity intervention on the healthy lifestyle in childhood: results of the PRESTO (PrEvention STudy of Obesity) Study. Ital J Public Health 2008;5(1):22-7.