*Annals of Human Biology*, 2011; Early Online: 1–7

ISSN 0301-4460 print/ISSN 1464-5033 online
DOI: 10.3109/03014460.2011.605396

informa
healthcare

RESEARCH PAPER

# Waist circumference in determining obesity and hypertension among 18–60 years old Bengalee Hindu male slum dwellers in Eastern India

Raja Chakraborty[1], Kaushik Bose[2] & Slawomir Kozieł[3]

*[1]Department of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal, India, [2]Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India, and [3]Institute of Anthropology, Polish Academy of Sciences, Wroclaw, Kuźnicza, Poland*



***Background*: Waist circumference (WC) has been previously shown to be the most efficient measure to explain variability in body mass index (BMI) and percentage body fat (PBF) in Bengalee males, including those under study.**
***Aim*: The objective was to evaluate the relative usefulness of WC and its single suitable value, if any, to identify both generalized obesity and hypertension in Bengalee men.**
***Subjects and methods*: This cross-sectional study included 433 adult (18–60 years) Bengalee Hindu slum dwelling men. Height, weight, waist circumference, systolic (SBP) and diastolic (DBP) blood pressures were measured. BMI was computed as weight (in kg) divided by height (in metres) squared. Hypertension (HT) was defined as SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg. A BMI $\geq$ 23 kg/m$^2$ and $\geq$ 25 kg/m$^2$ were considered overweight and obesity, respectively. Receiver operating characteristic (ROC) curve analyses were employed to determine the best cut-off points to define HT and overweight.**
***Results*: Prevalence of HT, overweight and obesity were 17.6% and 20.1% and 8.3%, respectively. Prevalence of central obesity using the cut-offs of 102 cm, 90 cm and 80 cm were 0.46%, 5.08% and 24.7%, respectively. Both in obese and non-obese, WC $\geq$ 80 cm was significantly associated with higher SBP and DBP than WC $<$ 80 cm. WC $>$ 79.4 cm and $>$ 80.3 cm were the most appropriate for detecting HT and overweight status.**
***Conclusion*: WC value of $\sim$80 cm could efficiently discriminate both obesity and hypertension among the Bengalee Hindu slum dwelling men aged between 18–60 years. Central obesity, determined by WC $\geq$ 80 cm, was associated with increased blood pressure and higher risk of HT, independent of age and general obesity.**

**Keywords:** Central obesity, waist circumference, BMI, hypertension, Bengalee, male, slum, ROC curve

## INTRODUCTION

Central obesity is defined by an excess amount of fat in the abdominal region. It is an established risk factor for metabolic syndrome (MS) (Wang et al. 2005; Lear et al. 2010), cardiovascular disease (CVD) (Fujimoto et al. 1999; Nicklas et al. 2004) and other cardiovascular risk factors, e.g. hypertension (HT) (Lemieux et al. 2001; Johnson et al. 2002; Grievink et al. 2004). Waist circumference (WC) is a convenient proxy measure of central obesity and has been suggested to be the best anthropometric indicator of both total body fat and intra-abdominal fat mass (Seidell et al. 1997; Li et al. 2008). The International Diabetes Association (IDF) has recently recommended WC as a mandatory measure in its candidate definition of MS. It has recommended a single cut-off point for each component, except for WC, for identification of MS. Use of region-specific cut-offs of WC was recommended until a universal agreement is achieved (Alberti et al. 2009). Regional studies among local ethnic groups are, therefore, needed to find out appropriate cut-offs.

Asian Indians have more total (Deurenberg-Yap et al. 2000) and abdominal fat (WHO 2000) compared to Europeans with a similar level of BMI. Several cut-off values of WC were proposed for identification of obesity, MS and its different components. The most accepted and widely used international cut-off point was 102 cm for males, corresponding to BMI $\geq$ 30 kg/m$^2$ in Europeans (Lean et al. 1998). However, several recent studies demonstrated that those cut-off values might not be appropriate for Asians (Zhou et al. 2005; Lee et al. 2007; Wang et al. 2009; Ogawa et al. 2010). In view of the Asian-Indian phenotype of higher body fat at lower BMI levels, the IDF has recommended an interim cut-off point of 90 cm for Asian men, while emphasizing upon further studies to find out regional cut-off points (Alberti et al. 2009).

Correspondence: Dr Kaushik Bose, Associate Professor, Department of Anthropology, Vidyasagar University, Midnapore 721 102, West Bengal, India. E-mail banda@vsnl.net or kaushikbose@cantab.net.

(*Received 3 January 2011; accepted 6 July 2011*)

Studies among different Asian populations, e.g. Koreans (Kim et al. 2009), Japanese (Ogawa et al. 2010) and Chinese (Zhou et al. 2005), indicated that WC cut-offs were lower than those among Europeans. Most of these studies were in relation to diabetes and other metabolic parameters. WC was shown to be strongly associated with increased risk of HT (Guagnano et al. 2001). There were, however, limited studies to establish the appropriate WC cut-off value to identify obesity (BMI or PBF) in relation to HT (Kim et al. 2009). In India also, a number of studies searched for the best WC level to screen MS and related components (Snehalatha et al. 2003), but very few were in relation to obesity (Dasgupta and Hazra 1999; Misra et al. 2006).

Recent studies among the Bengalee population of West Bengal in Eastern India indicated that WC was the best predictor of obesity measured either by BMI (Bose 2006) or total body fat (Ghosh and Bandyopadhyay 2007a). WC also remained the best of all the central obesity measures among the same slum dwelling male participants of the present study (Chakraborty and Bose 2008; 2009). Among them, a BMI of 23 $kg/m^2$ was also found to be the most appropriate in defining obesity (BF $>$ 25%) in relation to HT (Chakraborty et al. 2009). The same BMI level was also recommended as the cut-off for overweight among the Asian population (WHO 2000). Therefore, the objective of the present study was to evaluate the effect of increased WC on blood pressure as well as the risk of HT in centrally obese Bengalee men, relative to generalized obesity determined by BMI. It also proposed the most suitable cut-off values of WC to identify both HT and general obesity. For the present purpose, the same database which was used in the previous studies (Chakraborty and Bose 2008; 2009; Chakraborty et al. 2009) was utilized. This study was conducted considering the rising number of slum populations (30%) in the metropolitan cities of India, more particularly, in Kolkata (nearly 4 million) (Mallick 2008). It is also worth mentioning that high rates of obesity including central obesity, CVD and MS have also been reported in the poor slum dwellers in different parts of India (Misra et al. 2001a, Misra et al. 2001b; Gopi Chand and Sambasiva Rao 2007).

## MATERIALS AND METHODS

### Study area and the subjects

The study was cross-sectional. The slum under study is known as *Bidhan Colony* situated at *Dum Dum*, ~15 km from the centre of Kolkata (formerly known as Calcutta), the capital city of the Indian state of West Bengal (WB). *Dum Dum* is an urban centre of the greater-Kolkata and one of the starting points from which Kolkata started to expand into the adjacent districts. The slum was a typical one situated at the borderline between Kolkata and the district of North 24 Parganas, WB. The participants of the study were adult males belonging to the Bengalee Hindu caste groups. All households within two thirds of the slum area were considered eligible for inclusion in the study. No strict statistical sampling of individuals could be applied to collect data due to operational difficulties in the field (Khongsdier 2002). Each household was approached and the available adult male member(s) were recruited with their informed consent. More than 95% of the field visits were made in the evening when most of the male members were expected to return home from work. No household was visited twice for new enrolment of subjects. Almost all subjects were interviewed and measured in their respective households. In some cases ($<$10%), due to technical problems, they were taken to a common place where a number of them were examined. Overall response rate was ~80%. Apparently healthy men, free from any acute illness and on their normal regular work-schedule, were enrolled. Most participants belonged to low socio-economic background with a mean ± SD per capita income of RS 893.86 ± 507.6 (UK £1 = 73 Indian Rupees approx.). They were mostly factory workers, rickshaw-pullers and day-labourers. Ethical approval and prior permission was obtained from the institution of the first author and the project sanctioning authority. The municipal authority and local community leaders were informed in writing before the commencement of the study. A total of 474 adult men aged 18–84 years were included in the original survey. As the relationship of BMI with body fat may change significantly in the elder group, data on males aged 18–60 years were included in the present study.

### Measurements

One of the authors (RC) obtained all anthropometric measurements. Primary information on ethnicity, age and some socioeconomic aspects were collected from each participant. Standard procedure (Lohman et al. 1988) was followed for anthropometric measurements. Height and weight were recorded to the nearest 0.1 cm and 0.1 kg, respectively, using an anthropometer and weight-scale, respectively. Waist circumference was measured with a non-stretchable plastic tape (Cow Head, China) to the nearest 0.1 cm, at the level of the normal waist, which was the narrowest part of the torso, as seen from the anterior aspect (Lohman et al. 1988). Technical errors of measurements were found to be within acceptable limits (Ulijaszek and Kerr 1999) and thus not incorporated in the analyses. Blood pressure was measured in the right arm of each subject, using a digital blood pressure monitor with adjustable calf size, following the prescribed protocol of the manufacturer (Home Health, Switzerland). The accuracy of the device was routinely checked during the entire study period. Resting systolic (SBP) and diastolic (DBP) blood pressures (in mmHg) were recorded with the subject in a sitting position after at least 15 minutes of rest prior to measurement and again, for a second time, at least 5 minutes after the first reading. The mean value of two readings was finally recorded. The BMI was computed as weight (kg) divided by height (metre)-squared. HT was defined as a systolic BP $\geq$ 140 mmHg and/or diastolic BP $\geq$ 90 mmHg (JNC-VII 2003) or being under anti-hypertensive medication. WC was measured to the nearest 0.1 cm with a standard measuring tape. Having a BMI $\geq$ 23 $kg/m^2$ was considered as overweight and BMI $\geq$ 25 $kg/m^2$ as obese (WHO 2000).

### Analyses of data

Data were analysed using SPSS (version 10) for Windows (SPSS Inc., Chicago, IL) and MedCalc software. Mean and standard deviation (SD) values of age, anthropometric variables and blood pressures were computed. Students' *T*-tests were employed to evaluate the significance of differences in mean age and anthropometric measures between hypertensive and normal men. The distributions of the anthropometric variables were not significantly skewed. Subjects were graded into three age-groups, viz. $\leq 30$, 31–50 and $> 50$ years. One-way analyses of variance (ANOVA) with Scheffe's post-hoc test were carried out for BMI, WC, SBP and DBP to see significance of differences between their mean values between the age groups. Chi-square ($\chi^2$) tests were also performed to test for significance of differences in prevalence of overweight and HT, respectively, between the age-groups. Receiver operating characteristics (ROC) curve analysis was employed to determine the best WC cut-off points against two categories of BMI viz., normal (coded as 0) and overweight/obesity (coded as 1) and also for HT (HT = 1 vs Normal = 0). Youden Index (YI) (Youden 1950) was calculated as: (sensitivity + specificity − 1). YI for different WC values were compared to find out the optimal cut-off points for obesity (BMI $\geq 23\,kg/m^2$) and HT. Two-way analyses of covariance of SBP and DBP were undertaken, with general obesity (BMI $\geq 23\,kg/m^2$) and central obesity (WC $\geq$ 80 cm) as factors and age as covariate, to evaluate the independent effects of the factors on blood pressure after allowing for age. The $25^{th}$, $50^{th}$ and $75^{th}$ and $85^{th}$ percentile values of WC were 67.5, 72.7, 80.0 and 83.8 cm, respectively. Logistic regression analyses were carried out to calculate the age- and BMI-adjusted odds ratios of HT. In a test analysis we saw that a minimum of 2 cm increase of WC, between its $50^{th}$ and $85^{th}$ percentile values, caused significant increase of HT risk. Hence, in model 1 of logistic regression, WC values between 72 cm (median value rounded) and 84 cm ($85^{th}$ percentile rounded) were categorized into six groups in 2 cm intervals. A WC $<$ 72 cm was used as reference and WC $>$ 84 cm as the highest group. Again, in a second model, WC was used as a variable categorized differently into four groups based on the $25^{th}$, $50^{th}$ and $75^{th}$ percentile values. Interestingly, the $75^{th}$ percentile value of WC exactly matched with our proposed cut-off value obtained through ROC curve analyses. Therefore, in model 2 logistic regression, such WC grouping was used to test whether WC values above that cut-off (80 cm) had significantly higher risk of HT, relative to the lower groups, irrespective of age and BMI (both used as independent variables). Analysis of co-variance (ANCOVA) was performed to test for significance of difference in SBP and DBP between the WC categories (as in the second LR model) adjusting for the effect of age groups.

### Results

Table I presents mean and SD values of age and anthropometric and blood pressure variables in general and according to hypertensive status. Hypertensive men had significantly ($p < 0.001$) higher means of age, WC, BMI and blood pressures than their normal counterparts. The more pronounced differences in WC compared to BMI between the two groups were reflected by the greater *t*-value for the difference in WC ($t = 5.40$) compared to that in BMI ($t = 4.51$). The prevalence of HT, overweight and obesity were 17.6%, 20.1% and 8.3%, respectively. The prevalence of central obesity using the cut-offs of 102 cm (Lean et al. 1998), 90 cm (Misra et al. 2006) and 80 cm (Dasgupta and Hazra 1999) were 0.5%, 5.1% and 24.7%, respectively (results not shown).

Table II demonstrates the mean (SD) values of age, BMI, WC, SBP and DBP according to the age groups. The significance of the inter-group differences of each variable was evaluated by Scheffe's procedure. The BMI increased significantly ($p < 0.05$) from the youngest to the next elder group and then decreased in the eldest one. The difference between the two elder groups was not significant. The mean values of WC in the two elder groups were significantly ($p < 0.01$) higher than the youngest group. The mean WC values of two elder groups did not differ significantly. The mean SBP increased significantly ($p < 0.01$) only in the eldest group. The difference in mean SBP was not significant between the two younger groups. The mean DBP increased significantly ($p < 0.05$) from the youngest to the next elder group and after that the increase was not significant. Therefore, SBP rose significantly only after age 50 and the increase in DBP was significant even above age 30. The prevalence of overweight/obesity (BMI $\geq 23\,kg/m^2$) increased (4.8 to 11.7%) after age 30, but again decreased to 8.3% above the age of 50 years. However, the prevalence of

Table I. Mean (SD) value of the age, anthropometric and blood pressure variables.

| Variable | All subjects ($n = 433$) | HT ($n = 76$) | N ($n = 375$) | $t$ |
|---|---|---|---|---|
| Age (year) | 34.7 (11.1) | 40.2 (10.9) | 33.6 (10.8) | 4.81* |
| Height (cm) | 161.7 (6.1) | 161.7 (7.0) | 161.7 (5.9) | 0.07 |
| Weight (kg) | 53.5 (9.2) | 57.9 (10.7) | 52.6 (8.6) | 4.05* |
| BMI ($kg/m^2$) | 20.4 (3.2) | 22.1 (3.7) | 20.1 (3.0) | 4.51* |
| WC (cm) | 74.1 (9.3) | 79.3 (9.2) | 73.0 (8.9) | 5.47* |
| SBP (mmHg) | 120.2 (13.4) | 138.1 (13.0) | 116.4 (9.9) | 13.75* |
| DBP (mmHg) | 79.4 (9.4) | 93.3 (6.3) | 76.5 (6.9) | 20.74* |

HT = hypertensive, N = normal; * $p < 0.001$.
Figures in the parentheses below the mean values are standard deviations.

Table II. Mean (SD) of BMI, WC, SBP and DBP and percentages of overweight/obese and HT according to the age groups.

| Variables | Age groups (years) $\leq 30$ | $31-50$ | $>50$ | $F$ | $\chi^2$ |
|---|---|---|---|---|---|
| Age (years) | 24.5 (5.5) | 39.4 (5.1) | 55.0 (2.3) | 838.6** | – |
| BMI ($Kg/m^2$) | 20.0 (2.9) | 20.9 (3.3) | 20.3 (3.2) | 4.4* | – |
| WC (cm) | 71.4 (7.3) | 76.1 (10.0) | 76.0 (10.2) | 14.5** | – |
| SBP (mmHg) | 118.3 (12.8) | 120.3 (13.5) | 127.4 (13.4) | 9.2** | – |
| DBP (mmHg) | 77.0 (8.7) | 80.9 (9.5) | 83.0 (9.2) | 13.0** | – |
| OWT/OB (%) | 15.4 | 23.9 | 22.9 | – | 4.53 |
| HT (%) | 10.6 | 20.8 | 31.3 | – | 13.88* |

Figures in the parentheses below the mean values are standard deviations.
* $p < 0.05$, ** $p < 0.001$.

Table III. Results of ROC curve analyses of WC for Hypertension (SBP/DBP ≥ 140/90) and overweight/obesity (BMI ≥ 23 kg/m$^2$).

| | Hypertension | | | | Overweight and obese (BMI ≥ 23 kg/m$^2$) | | |
|---|---|---|---|---|---|---|---|
| WC (cm) | Sensitivity (95% CI) | Specificity (95% CI) | YI | WC (cm) | Sensitivity (95% CI) | Specificity (95% CI) | YI |
| >70.0 | 75.00 (63.7 − 84.2) | 38.38 (33.3 − 43.6) | 0.13 | >70.0 | 98.85 (93.8 − 100.0) | 44.51 (39.2 − 49.9) | 0.42 |
| >75.0 | 65.79 (54.0 − 76.3) | 64.70 (59.5 − 69.7) | 0.29 | >75.0 | 96.55 (90.3 − 99.3) | 73.41 (69.3 − 82.7) | 0.69 |
| >79.4* | 59.58 (44.4 − 67.9) | 80.11 (75.6 − 84.1) | 0.39 | >80.3* | 88.51 (79.9 − 94.3) | 91.91 (88.5 − 94.6) | 0.79 |
| >85.5 | 30.26 (20.2 − 41.9) | 91.88 (88.5 − 94.5) | 0.21 | >85.5 | 55.17 (44.1 − 65.9) | 98.84 (97.1 − 99.7) | 0.53 |
| >90.0 | 9.21 (3.8 − 18.1) | 96.08 (93.5 − 97.8) | 0.05 | >90.0 | 24.14 (15.6 − 34.5) | 100.00 (98.9 − 100) | 0.24 |

WC = waist circumference, YI = Youden Index; * optimal cut-off value of WC.

HT rose up steadily and significantly ($\chi^2 = 13.9$, $p < 0.05$) through the age groups by an increase of 10% in each group on average.

Table III shows the results of ROC curve analysis of WC for hypertension. Sensitivity (SN) and specificity (SP) values (as percentage) according to selected threshold values of WC against hypertension status are presented. The results revealed that a WC > 79.4 cm was the most appropriate for detecting HT among the subjects. The value has SN and SP of ~59.6% and 80%, respectively, and the highest YI of 0.39. The IDF-recommended WC cut-off point of > 90.0 cm had a very low sensitivity of 6.21% (95% Cl: 3.8–18.1) and 96.08% specificity (95% Cl: 93.5–97.8). However, if the proposed cut-off for screening central obesity is lowered to WC > 79.4 cm, the SN increased substantially to ~60% (95% Cl: 44.4–67.9), while that of SP decreased to ~80% (95% CI: 75.6–84.1). Similarly, the positive predictive value (PPV) increased from ~29% to 39% and the negative predictive value (NPV) increased from 84.5% to 92.5% (result not shown). The area under curve (AUC) was 0.690 (95% CI = 0.644–0.733; $p < 0.0005$).

The result of ROC curve analysis of WC for generalized overweight and obesity (BMI ≥ 23 kg/m$^2$) is also shown in Table III. A WC cut-off value of 80.3 cm was found to be the best one to identify overweight status. The SN of the value was 88.51% (95% CI: 79.9–94.3) with a considerably high SP of 91.91% (95% CI: 88.5–94.6) and the highest YI of 0.79. At a value of 90 cm, the SP rose up to 100% but the SP dropped to 24%, with the YI being 0.24. The area under curve (AUC) was 0.961 (95% CI: 0.938–0.977; $p < 0.0005$). Another ROC curve analyses was undertaken also for WC criteria to identify general obesity (BMI ≥ 25 kg/m$^2$). The most efficient cut-off point to identify obesity was 83.4 cm (SN 91.7 and SP 91.5). The AUC was 0.959 (95% CI = 0.936–0.976; $p < 0.0005$) (results not shown).

Table IV presents the results of two-way analyses of covariance of SBP and DBP, where general obesity (BMI ≥ 23 kg/m$^2$) and central obesity (WC ≥ 80 cm) were two factors with age as covariate. General obesity had no significant impact on SBP ($F = 2.9$, $p > 0.05$) after controlling for age and central obesity status. There was no significant interaction between general obesity and central obesity in determining SBP ($F = 0.1$, $p > 0.05$). A WC ≥ 80 cm had a significant impact on SBP, irrespective of age and general obesity ($F = 4.8$, $p < 0.05$). On the other hand, both general and central obesity had a significant impact ($F = 4.6$ and 4.4, respectively, both $p < 0.05$) on DBP after allowing for age. As in the case of SBP, there was no significant interaction ($F = 0.06$, $p > 0.05$) between general obesity and central obesity in determining SBP.

Table V shows the results of two multiple logistic regression analyses of HT on age, BMI and WC categories. Since smoking and alcohol consumption status (yes or no, for each) did not show any significant impact on HT, when all the independent variables were entered, they were not included in the final models run. In the first model, WC was used as a separate variable categorized into seven intervals of 2 cm each between the values of 72–84 cm. WC ≤ 72 cm was the reference category and WC ≥ 84 cm the highest category (see materials and methods section). In this model, the odds ratio for each WC interval was 1.26 and for the whole range of WC was 5.04 (2.59–9.82). Therefore, for a single interval (2 cm) change, the risk of HT significantly ($p < 0.001$) increased ~26% and changed from the lowest (<72 cm) to the highest (>84 cm) WC interval increased the risk by up to 5-times. In the second model, age, general obesity status (based on BMI cut-off of 23 kg/m$^2$) and WC (categorized into four groups based on its 25$^{th}$, 50$^{th}$, 75$^{th}$ percentiles) were independent variables. The result showed that increasing WC-grades had significant positive impact on the incidence of HTN (Wald = 3.83, $p < 0.05$). Men having WC ≥ 80 cm had a 2.65-times greater risk of being hypertensive, irrespective of their age and general obesity status ( < or ≥ 23 kg/m$^2$ of BMI). Age had a significant impact on HT (Wald = 11.65, $p < 0.005$), independent of BMI and WC. However, BMI had no significant impact after controlling for age and WC.

## DISCUSSION

Mean SBP and DBP were slightly higher among the present slum-men (120.2 and 79.4 mmHg, respectively) than those among previously studied (Ghosh and Bandyopadhyay 2007b) non-slum Bengalee men (118.8 and 78.1 mmHg, respectively). Prevalence of HT was also higher among the

Table IV. Results of two-way analyses of covariance of SBP and DBP.

| | SBP | | DBP | |
|---|---|---|---|---|
| | Sum of square | F | Sum of square | F |
| Age | 2385.68 | 15.2** | 1696.12 | 22.9** |
| Overweight and obesity^ | 447.46 | 2.9 | 338.71 | 4.57* |
| Central obesity^ | 753.24 | 4.8* | 323.06 | 4.36* |
| Interaction | 8.11 | 0.1 | 4.46 | 0.06 |

* $p < 0.05$; ** $p < 0.001$. ^ Categorized as Yes = 1 and No = 0.

Table V. Multiple logistic regression analyses of hypertension on age and WC grades (two models) and mean (SD) blood pressures according to WC categories.

| | Wald (95% CI) | Odds ratios of HT | HT (%)[@] | SBP[a] (mmHg) | DBP[a] (mmHg) |
|---|---|---|---|---|---|
| *Model 1* | | | | | |
| Age | 10.795*** | 1.04 (1.02 − 1.07) | | | |
| WC^ | 22.775*** | 1.26 (1.14 − 1.39) | | | |
| *Model 2* | | | | | |
| Age | 11.64** | 1.044 (1.02 − 1.07) | – | – | – |
| BMI ≥ 23 kg/m$^2$ | 1.84 | 1.74 (0.78 − 4.04) | – | – | – |
| WC categories: | | | | | |
| <67.5[#] | – | – | 10.1 | 115.1 (1.23) | 75.3 (0.80) |
| 67.5 − 72.7 | 0.00 | 0.99 (0.41 − 2.39) | 11.1 | 118.6 (1.19) | 78.4 (0.82) |
| 72.8 − 79.9 | 0.05 | 0.90 (0.37 − 2.19) | 11.1 | 120.3 (1.21) | 79.6 (0.83) |
| ≥80.0 | 3.83* | 2.65 (1.00 − 7.03) | 38.0 | 126.8 (1.20) | 84.4 (0.84) |

Dependent variable = hypertension (normal vs hypertensive).
* $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$; [@] $\chi^2 = 41.48$, $p < 0.001$; [a] Mean (SD) values are adjusted for age groups. $F_{SBP} = 15.73$, $p < 0.001$; $F_{DBP} = 21.75$, $p < 0.001$; ^ In model 1, WC was categorized into eight grades (see materials and methods section); [#] Reference category.



present sample (17.6%) than among those non-slum Bengalee men (11.7%). Again, the mean height, weight and BMI of our subjects were also lower than those among adult semi-urban Bengalee men from another district of West Bengal (162.2 cm, 54.7 kg, 20.7 kg/m$^2$, respectively) as reported by Bose et al. (2009).

In the present sample of slum-dwelling men, WC was previously reported to explain BMI and percentage body fat (PBF) better than WHR and conicity index (Chakraborty and Bose 2009). Among these men, BMI had a significant impact on SBP and DBP. A BMI of 23 kg/m$^2$ was the best cut-off to identify excess adiposity (PBF > 25%) and the risk of HT increased to a significant extent (>3-fold) only at and above that level (Chakraborty et al. 2009). With those background studies, the present attempt was made to assess the effect of increased WC on blood pressure, independent of generalized obesity. It also proposed the best cut-off values of WC to identify HT as well as overweight and obesity determined by BMI. The overall objective was to evaluate the relative efficacy of WC and its single suitable value, if any, in identification of generalized obesity as well as HT in Bengalee men.

The present study demonstrated that both WC and DBP increased significantly above the age of 30 years, whereas SBP rose above 50 years. The overall prevalence of HT was 17.6% and it increased significantly from the youngest (10.6%) through to the eldest group (31.3%). On the other hand, when WC value ≥ 90 cm was set as the criterion, the rate of central obesity was 5.08%, with inclusion of only 3.46% HT (15 out of 433), who were, again, only 19.7% of all HT subjects (15 out of 76). Therefore, the sensitivity (SN) of the WC criterion (≥90 cm) was low (9.21%), even with a very high specificity (SP) of 96% (Table II). Our findings also suggested that a WC value of 79.4 cm was the best to identify HT. This value, when used as the criterion of central obesity, included 9.9% HT (43 out of 433) and 56.6% of all hypertensive (43 out of 76). Using the value as the criterion, the SN also rose up to ~60% with a corresponding SP above 80%. The value was much lower than the value (90 cm) recently proposed by IDF for defining central obesity in the Asian populations and was also identified as appropriate among the Northern Indian men (Misra et al. 2006). Studies among various Asian populations also proposed lower WC cut-offs. For example, the waist circumference cut-offs for MS were 85 cm (Zhou et al. 2005) and 89 cm (Wang et al. 2009) among the Chinese men. The cut-off for discrimination of hypertension was 84 cm for Korean men (Kim et al. 2009). Among Japanese men, the optimal point of waist circumference to predict MS was ~84 cm (Ogawa et al. 2010). Among urban adults from six cities in India a WC of 85 cm for men was the optimal value (Snehalatha et al. 2003). The WC cut-off point for identifying men with any two cardio-metabolic risk factors was 87 cm in northern India (Mohan et al. 2007).

In the present study, the best WC cut-off to identify overweight/obesity was 80.3 cm. The value was also lower than the internationally proposed values mentioned above. Several studies also reported lower WC values to identify overweight and obesity in different populations. Among the rural Thais, the cut-off points of WC were proposed to be lower (93 cm) than the conventional recommendations (102 cm) for western men (Pongchaiyakul et al. 2006). A WC of 83 cm was suggested as the defining criteria for overweight and obesity among Malaysian men (Zaki Morad et al. 2009). Notably, the WC cut-off values identified in this study to identify overweight (80.3 cm) and hypertension (79.4 cm) were very close to each other. Therefore, we could propose an average WC value of ~80 cm (79.85 cm) to efficiently discriminate both obesity and hypertension. One representative study among the Chinese suggested a WC value of 80 cm to discriminate increased CVD risk including hypertension (Wildman et al. 2004). Mention may be made that the only previous study in a Bengalee population to find a WC cut-off for central obesity had proposed a value of 80 cm (Dasgupta and Hazra 1999). This value was also shown to discriminate well between hypertensive and non-hypertensive and WC above 80 cm was a risk factor for HT, irrespective of age and BMI among male Bengalee Jute mill workers (Bose et al. 2003). Both the studies, the first one in the outdoor clinic of a public city hospital and the second one among the factory workers, were supposed to have greater representation from the low socio-economic Bengalee urban men. The participants of the present study were also poor men of the same ethnic group. It, therefore, seemed that WC of 80 cm might be the approximate optimal value for screening of central obesity among the adult (18–60 years) Bengalee slum dwelling males. There was another indication that the Bengalee males did not actually demonstrate high WC at a low BMI, as was proposed for Asian Indian males (Yajnik 2001). Instead, the risk of HT (if not other CVD and/or MS risk factors, too) seemed to appear at both low BMI ($>23$ kg/m$^2$) and low WC ($\sim 80$ cm) conditions. It might also be assumed that the adult slum people, having suffered from chronic nutritional deprivation in the pre-natal period or at early ages, had a higher proportion of body fat relative to the total body volume compared to their economically well-off counterparts (Koziel and Jankowska 2002). Similar studies are required among higher socioeconomic counterparts of this ethnic group to test this hypothesis.

Our findings demonstrated that both among non-obese and obese (by BMI) men, a WC $\geq 80$ cm was significantly associated with higher SBP and DBP than WC $< 80$ cm. Overall, the results suggested that having WC $\geq 80$ cm had a significant positive impact on BP both in non-obese and obese (by BMI). Each 2 cm increase in WC above 72 cm had $\sim$26% greater risk of being hypertensive. However, men with BMI values of 23 kg/m$^2$ and over, too, had significantly higher BP, irrespective of age and central obesity status (WC $\geq 80$ cm). This implied that general obesity was an independent predictor of BP apart from higher waist values. However, keeping in view its simplicity and demonstrated clinical efficacy, WC may be recommended as an efficient screening tool for high BP, with its values $\geq 80$ cm as a safe cut-off point, in Bengalee males. The men having WC above this value also demonstrated $\sim$3-times greater risk of being hypertensive, independent of age and BMI. Therefore, evaluation of this value is also urgently needed with respect to other metabolic risk variables in this population. In the Bengalee jute mill workers, WC $\geq 80$ cm had a similar positive effect on SBP and DBP after controlling for age and BMI (Bose et al. 2003). In US adults, increased blood pressure was also reported in centrally obese in all the BMI categories; normal, overweight and grade-I obese (Janssen et al. 2002). Therefore, WC may be used as a reliable screening parameter for obesity and HT in Bengalee men, more particularly belonging to a low socioeconomic group. However, one limitation of the study is that it may not be applicable to elderly men ($>60$ years) of the population. Further studies on elderly people might reveal the relationship of WC with general obesity and blood pressure at higher ages.

A WC $\geq 80$ cm could identify 88.5% subjects with BMI $\geq 23$ kg/m$^2$ and 97.2% with BMI $\geq 25$ kg/m$^2$. Nevertheless, using the proposed WC criterion of 80 cm (or $> 79.4$ cm), more than 43% of the hypertensive men still remained unidentified. This indicated the need for inclusion of other causal factors (e.g. metabolic) of HT for more efficient screening. However, it was possible to screen out more than 56% of all hypertensive and more than 88% of overweight and obese men in resource-constrained situations of a third World country like India with a very simple measurement of WC, using very cheap equipment requiring little training to measure.

## CONCLUSION

Taken together, the present findings were in accordance with the view that increased WC and central obesity, determined by WC $\geq 80$ cm, was associated with increased blood pressure and higher risk of HT, independent of age and general obesity. A WC value of $\sim 80$ cm could efficiently identify both overweight/obesity and hypertension among the Bengalee Hindu slum dwelling adult men aged between 18–60 years.

## ACKNOWLEDGEMENTS

All subjects who participated in the study are gratefully acknowledged.

***Declaration of interest***: This work was partly funded by the University Grants Commission (India) through a Minor Research Project Grant (No. PSW-054/03-04 ERO) awarded to RC. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

## REFERENCES

Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart J, James WPT, Loria CM, Smith SC, Jr. 2009. 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 120:1640–1645.

Bose K. 2006. 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 21:247–252.

Bose K, Bisai S, Sadhukhan S, Mukhopadhyay A, Bhadra M. 2009. Undernutrition among adult Bengalees of Dearah, Hooghly District, West Bengal, India: relationships with educational status and food habit. Anthrop Anz 67:121–128.

Bose K, Ghosh A, Roy S, Gangyopadhyay S. 2003. Blood pressure and waist circumference: an empirical study of the effects of waist circumference on blood pressure among Bengalee male jute mill workers of Belur, West Bengal, India. J Physiol Anthropol Appl Human Sci 22:169–173.

Chakraborty R, Bose K. 2008. Central adiposity measures of Bengalee male slum dwellers. Int J Body Comp Res 6:122–126.

Chakraborty R, Bose K. 2009. Central adiposity, body mass index and percent body fat among Bengalee Hindu male slum dwellers of Dum Dum, West Bengal, India. Open Obesity J 1:32–37.

Chakraborty R, Bose K, Bisai S, Khongsdier R. 2009. Body mass index and body fat among adult Bengalee male slum dwellers in West Bengal, India. Obes Res Clin Pract 3:141–148.

Dasgupta S, Hazra SC. 1999. The utility of waist circumference in assessment of obesity. Ind J Pub Health 43:132–135.

Deurenberg-Yap M, Schmidt G, Wvan Staveren A, Deurenberg P. 2000. 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 24:1011–1017.

Fujimoto WY, Bergstrom RW, Boyko EJ, Chen KW, Leonetti DL, Newell-Morris L, Shofer JB, Wahl PW. 1999. Visceral adiposity and incident coronary heart disease in Japanese-American men. The 10-year follow-up results of the Seattle Japanese-American Community Diabetes Study. Diabetes Care 22:1808–1812.

Ghosh JR, Bandyopadhyay AR. 2007a. Waist circumference as a measure of total body fat in Asian Indians. Int J Body Comp Res 5: 89–93.

Ghosh JR, Bandyopadhyay AR. 2007b. Comparative evaluation of obesity measures: relationship with blood pressures and hypertension. Singapore Med J 48:232–235.

Gopi Chand M, Sambasiva Rao R. 2007. Appraisal of cardiovascular disease risk factors in a coastal environment fishermen's urban slum of Visakhapatnam. J Hum Ecol 21:53–58.

Grievink L, Alberts JF, O'Niel J, Gerstenbluth I. 2004. Waist circumference as a measurement of obesity in the Netherlands Antilles; associations with hypertension and diabetes mellitus. Eu J Clin Nutr 58:1159–1165.

Guagnano MT, Ballone E, Colagrande V, Vecchia RD, Manigrasso MR, Merlitti D, Riccioni1 G, Sensi S. 2001. Large waist circumference and risk of hypertension. Int J Obes 25:1360–1364.

Janssen I, Katzmarzyk PT, Ross R. 2002. Body mass index, waist circumference and health risk. Arch Intern Med 162:2074–2079.

JNC-VII. 2003. The seventh report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure. US Department of Health and Human Services. NIH Publication No. 03-5233.

Johnson S, Martin D, Sarin C. 2002. Diabetes mellitus in the First Nations population of British Columbia, Canada. Int J Circumpolar Health 61:260–263.

Kim HK, Kim CH, Park JY, Lee KU. 2009. Lower waist-circumference cutoff point for the assessment of cardiometabolic risk in Koreans. Diabetes Res Clin Pract 85:35–39.

Khongsdier R. 2002. Body mass index and morbidity in adult males of the War Khasi in Northeast India. Eur J Clin Nutr 56:484–489.

Koziel S, Jankowska EA. 2002. Birth weight and stature, body mass index and fat distribution of 14-year-old Polish adolescents. J Pediatr Child Helath 38:55–58.

Lean ME, Han TS, Seidell JC. 1998. Impairment of health and quality of life in people with large waist circumference. Lancet 351: 853–856.

Lear SA, James PT, Ko GT, Kumanyika S. 2010. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. Eur J Clin Nutr 64:42–61.

Lee SY, Park HS, Kim DJ, Han JH, Kim SM, Cho GJ, Kim DY, Kwon HS, Kim SR, Lee CB, Oh SJ, Park CY, Yoo HJ. 2007. Appropriate waist circumference cutoff points for central obesity in Korean adults. Diabetes Res Clin Pract 75:72–80.

Lemieux I, Pascot A, Prud'homme D, Almeras N, Bogaty P, Nadeau A, Bergeron J, Després JP. 2001. Elevated C-reactive protein: another component of the atherothrombotic profile of abdominal obesity. Arterioscler Thromb Vasc Biol 21:961–967.

Li L, Lei S, Chen X, Deng F, Tan L, Zhu X, Deng H. 2008. Anthropometric indices as predictors of trunk obesity in Chinese young adults: receiver operating characteristic analyses. Ann Hum Biol 35:342–348.

Lohman TG, Roche AF, Martorell R. 1988. Anthropometric standardization reference manual. Chicago, IL: Human Kinetics Books.

Mallick R. 2008. Urban poor in Calcutta. Available online at: http://www.achr.net/sup_india_c.htm, accessed 9 December 2008

Misra A, Pandey RM, Rama Devi J, Sharma R, Vikram NK, Khanna N. 2001a. High prevalence of diabetes, obesity and dyslipidemia in urban slum population in Northern India. Int J Obes 25:1722–1729.

Misra A, Sharma R, Pandey RM, Khanna N. 2001b. Adverse profile of dietary nutrients, anthropometry and lipids in urban slum dwellers of northern India. Eur J Clin Nutr 55:727–734.

Misra A, Vikram NK, Gupta R, Pandey RM, Wasir JS, Gupta VP. 2006. Waist circumference cutoff points and action levels for Asian Indians for identification of abdominal obesity. Int J Obes (Lond) 30:106–111.

Mohan V, Deepa M, Farooq S, Venkat Narayan KM, Datta M, Deepa R. 2007. Anthropometric cut points for identification of cardiometabolic risk factors in urban Asian Indian population. Metabolism 56:961–968.

Nicklas BJ, Penninx BW, Cesari M, Kritchevsky SB, Newman AB, Kanaya AM, Pahor M, Jingzhong D, Harris TB. 2004. Association of visceral adipose tissue with incident myocardial infarction in older men and women: the Health, Aging and Body Composition Study. Am J Epidemiol 160:741–749.

Ogawa D, Kahara K, Shigematsu T, Fujii S, Hayakawa N, Okazaki M, Makino H. 2010. Optimal cut-off point of waist circumference for the diagnosis of metabolic syndrome in Japanese subjects J Diabetes Invest 1:117–120

Pongchaiyakul C, Pongchaiyakul C, Wanothayaroj E, Nguyen TV, Rajatanavin R. 2006. Association between waist circumference and percentage body fat among rural Thais. J Med Assoc Thai 89: 1592–1600.

Seidell JC, Han TS, Feskens EJM, Lean MEJ. 1997. Narrow hips and broad waist circumferences independently contribute to increased risk of NIDDM. J Intern Med 42:401–406.

Snehalatha C, Viswanathan V, Ramachandran A. 2003. Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes Care 26:1380–1384.

Ulijaszek SJ, Kerr DA. 1999. Anthropometric measurement error and the assessment of nutritional status. Br J Nutr 82:165–177.

Wang JW, Hu DY, Sun YH, Wang JH, Wang GL, Xie J, Zhou ZQ. 2009. Obesity criteria for identifying metabolic risks. Asia Pac J Clin Nutr 18:105–113.

Wang Y, Rimm FB, Stampfer MJ, Willet WC, Hu FB. 2005. Comparison of abdominal adiposity and overall obesity in predicting risk of type-2 diabetes among men. Am J Clin Nutr 81:555–563.

Wildman RP, Gu D, Reynolds K, Duan X, He J. 2004. Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. Am J Clin Nutr 80:1129–1136.

World Health Organization. 2000. The Asia Pacific Perspective: redefining obesity and its treatment. Geneva, Switzerland: World Health Organization.

Yajnik CS. 2001. Commentary: fetal origins of cardiovascular risk—nutritional and non-nutritional. Int J Epidemiol 30:57–59.

Youden WJ. 1950. Index for rating diagnostic tests. Cancer 3:32–35.

Zaki Morad MZ, Robayaah Z, Chan SP, Vadivale M, Bernard NG, Geeta A, Teck Onn L. 2009. Optimal cut off level to define obesity: body mass index and waist circumference, and their relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes in Malaysia. Asia Pac J Clin Nutr 18:209–216.

Zhou BF, Wu YF, Li Y, Zhang LF. 2005. The cut-off point of waist circumference for identifying metabolic syndrome in Chinese adults. Zhonghua Xin Xue Guan Bing Za Zhi 33:81–85.