Comparison of Body Adiposity Indices in Predicting Blood Pressure and Hypertension among Slum-Dwelling Men in Kolkata, India

Chakraborty R[*1] & Bose K[2]

[1] *Department of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal, India*
[2] *Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India*

ABSTRACT

Introduction: Recent findings show a high incidence of stroke among slum dwellers in Kolkata, India. This cross-sectional study aimed to compare the association of different adiposity indices to blood pressure (BP) and hypertension (HT) among slum-dwelling Bengalee men in Kolkata. **Methods:** Measurements of height, weight, waist and hip-circumferences, biceps, triceps, subscapular and suprailiac skinfolds, systolic (SBP) and diastolic (DBP) of 470 men aged 18-60 years were taken.   Body mass index (BMI), body adiposity index (BAI), percent body fat, waist-height (WHtR) and waist-hip ratios (WHR) were computed. The effect of adiposity values on HT was estimated by logistic regressions, while partial correlations and linear regressions analyses of SBP and DBP with each index were performed. **Results:** BMI had the strongest correlation with blood pressure. The newly proposed index, BAI, had significant but considerably lower correlations with both BP compared to BMI and central adiposity. Both BMI and WHtR explained DBP with equal efficacy. Abdominal obesity, measured by WC, showed the strongest association with risk of HT, independent of age and BMI. The predictive effect of abdominal adiposity on blood pressure (SBP and DBP) appeared to be modified by age-BMI interaction. **Conclusion:** BAI showed no advantage over other adiposity measures in the prediction of hypertension among the men in this study. Waist circumference was the best obesity measure to predict hypertension and may be preferred to BMI considering its simplicity of measurement. The simple measure of WC might help in easy screening of hypertension among the poor people in resource constrained settings such as those in urban slums.

Keywords: Central obesity, blood pressure, hypertension, India

INTRODUCTION

About 25% of Indians who live in urban areas are reported to be hypertensive (Yadav *et al.*, 2008) and 57% of all stroke deaths and 24 % of all cardiovascular deaths in Eastern Asia are associated with hypertension (HT) (Rodgers, Lawes & MacMahon, 2000). India shows a steadily increasing trend of HT (Gupta, 2004) with the potential of becoming the 'hypertension capital of the world' (Joshi & Parikh, 2007).

Obesity, as a form of malnutrition is a major independent risk factor for HT. It

---

* Correspondence author: Raja Chakraborty; Email: *rajanth2003@yahoo.co.uk*

exposes an individual to 2-6 times higher risk of HT compared to the non-obese (WHO, 1996). Central obesity, as measured by waist circumference (WC), waist hip ratio (WHR), conicity index (CI) and/or waist-to-height ratio (WHtR), has been shown to be a stronger risk factor for cardiovascular diseases (CVD) (Fujimoto *et al.*, 2009), metabolic syndrome (Wang *et al.*, 2005) and HT (Sayeed *et al.*, 2003), compared to general obesity (assessed by BMI). However, there is little consensus upon the best obesity measure associated with HT (Sakurai *et al.*, 2006). Association of both general and central obesity with higher systolic (SBP) and diastolic blood (DBP) pressure has been reported in Pakistani (Khan *et al.*, 2008) and urban Western Indian men (Gupta *et al.*, 2007). Among the Bengalee men from the Eastern part of India, the WC, but not WHR or CI, was found to be the best correlate or predictor of BMI (Bose, 2006) and total body fat (Ghosh & Bandyopadhyay, 2007a). Among the same slum dwelling participants of the present study, the percent body fat (PBF) was best predicted by WC (Chakraborty & Bose, 2009). In another study among the adult men in the same district as the present study, the WHtR and BMI explained the relatively larger amount of variation in SBP and DBP, respectively, and a greater risk of HT was associated with increased BMI (Ghosh & Bandyopadhyay, 2007b).

The most recently proposed index, the body adiposity index (BAI), is proposed to be a reliable proxy indicator of body fat and better than BMI in clinical settings (Bergman *et al.*, 2011). Among the white and black adults, BMI and BAI performed similarly in predicting body fat (Barreira *et al.*, 2011). Nevertheless, BAI includes the hip-circumference, which is not a proxy measure of centralised fat which has been an established major risk factor across the world. Moreover, despite its high correlation with percentage body fat, the clinical significance of BAI is yet to be tested as a potential predictor of CVD and/or metabolic

risk factors, compared to other adiposity indices including those of central obesity.

In consideration of the above, the present study aimed to compare the associations of different adiposity indices with blood pressure and HT status. It also included the newly proposed index, the BAI, to test its relative efficacy to predict blood pressure and hypertension compared to other existent adiposity measures.

MEHODS

Setting and selection of participants

This cross-sectional study was carried out in an urban slum settlement, namely, Bidhan Colony, located approximately 15 km from the centre of Kolkata (formerly Calcutta) city of the West Bengal State in Eastern India. The participants were Bengali speaking Hindus. A total of 474 reportedly healthy men aged 18 years and above, without any known disease or not under regular medication, not having undergone any recent surgery and carrying on their normal daily activities at the time of examination, were included. Data on blood pressure were available for 470 subjects. Most were engaged in jobs of low socio-economic status, e.g., factory workers, rickshaw-pullers or day-laborers, with a mean $\pm$ SD monthly per capita income of Rs.883.5 $\pm$ Rs. 501.9.

Collection of data

The municipal authorities and local community leaders were informed before commencement of the study. The work was not experimental and did not involve any invasive methods. However, necessary ethical requirements as laid down by the Indian Council of Medical research (ICMR) were taken care of. The names and address of the individual subjects were recorded initially in the printed questionnaire in order to serve them with necessary health information and advice after analysing their individual data and to direct them for

clarification of information, if necessary. However, the confidentiality of information was strictly maintained by the first author and personal information was not entered in the main database and never used for any further purpose. The field visits were made mostly in the evenings when most of the male members were expected to return home from work. No household was visited twice in order to enroll new subjects. No strict statistical sampling of individuals could be applied to collect data due to operational difficulties in the field, also mentioned by other researchers (Khongsdier 2002). One of the objectives of the research project was to include as many subjects as possible within the stipulated time-frame. Therefore, we did not restrict the number of recruits within a statistically calculated minimum sample size. Sometimes there was high expectation among the men belonging to neighbouring households to be recruited in the study. Therefore, we could not include only those houses which would have been statistically sampled, leaving out the adjacent ones. All households within a two-third area of the slum were considered eligible for sampling. Each household was approached and the available adult male member(s) were recruited with their informed consent. That the participants resided inside the boundary of the slum under study was ensured. The overall response rate was around 80%.

Information and measurements

Information on age, ethnicity, smoking habit, tobacco-chewing and alcohol consumption was collected through a personal interview of the subjects by employing a pretested questionnaire. Height and weight were measured to the nearest 1.0 mm and 500g, respectively, using a standard anthropometer and weighing scale, respectively. In order to record the height, the subject stood straight and barefoot on a plain surface keeping his spine straight and the head held on eye-ear plane. Weight was measured with a very light

and minimum garment and with the subject not wearing shoes. Waist circumference (WC) was measured to the nearest 1.0 mm using a non-stretchable plastic tape (Triced, China) following the standard technique of Lohman, Roche & Martorell (1988). BMI, BAI (Bergman *et al.*, 2011), WHR, WHtR and CI (Valdez *et al.,* 1991) were computed using the following standard equations:

BMI (kg/m²) = weight (kg) / height (m²)
BAI = {hip circumference/ (height)$^{1.5}$}–18
WHR = WC (mm)/HC (mm)
WHtR = WC (mm)/height (mm)
CI = WC (mm) / (0.109) x √ [weight (kg)/ height (mm)]

Body density was calculated using four skin folds (Durnin & Womerseley, 1974). PBF was computed following Siri's equation (Siri, 1961). Both these equations have already been validated in the Indian population (Kuriyan *et al.*, 1998) and generally accepted for estimation of body composition among the Indian populations (Khongsdier, 2005). The equations used were:

Density = 1.1356-0.07 x $\log_{10}$ (BSF+TSF+ SSF+SISF).
PBF = (4.95 / density-4.5) x 100

Blood pressure was measured with a standardised digital blood pressure monitor (Home Health, Switzerland) with adjustable calf size following the prescribed protocol. Resting systolic and diastolic blood pressure (in mmHg) were 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 (Chakraborty *et al.*, 2009). The average value of the two measures was recorded. HT was defined as SBP $\geq$140 mmHg and/or DBP $\geq$90 mmHg following the JNC VII guidelines (Chobanian *et al.*, 2003).

Statistical analyses

The variables were described by their means, standard deviations (SD), maximum and minimum values. Partial correlation

analyses were performed to measure the association between adiposity indicators and blood pressure (separately for SBP and DBP) after controlling for age. Multiple linear regression analyses of SBP and DBP on adiposity indicators after controlling for age were used. The effect of adiposity (WHtR, WC, WHR and CI) on HT, after allowing for age, smoking habits (yes, no) alcohol consumption (yes, no), were assessed through binary multiple logistic regression analyses. The HT status (normal = 0, and HT = 1) was binary dependent variable, whereas, age (continuous), smoking (yes/1 vs. no/0), alcohol consumption (yes/1 vs. no/0) and indices of adiposity were the independent predictors. The adiposity indices were transformed into categorical variables. Each was coded as a binary variable (above the 85th percentile value was coded as '1' and below that as '0'). All the analyses were performed by SPSS software (version 11.5). The statistical significance was $p<0.05$.

RESULTS

The mean values and ranges of the anthropometric measurements are shown in Table 1. The 85th percentile values of WC, WHtR, WHR, CI, BMI and BAI were 83.8 cm, 0.52, 0.94 and 1.25, 23.5 kg/m² and 26.5, respectively (results not shown). Table 2 presents the age-controlled partial correlation coefficients (r) of adiposity measures with blood pressure. BMI had the strongest significant correlations with SBP ($r = 0.32$, $p<0.001$) and DBP ($r = 0.33$, $p<0.001$). WC and WHtR had similar significant correlations with SBP (both $r =$

Table 1. Mean and SD value of 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
BMI (kg/m²)	20.4	3.2	11.6	33.5
WC (cm)	74.1	9.3	25.8	103.6
WHtR	.46	0.06	.18	.66
WHR	.89	0.18	.32	3.75
CI	1.18	0.08	.43	1.49
BAI	22.97	3.90	10.0	36.00
SBP (mmHg)	120.2	13.4	68.5	181.0
DBP (mmHg)	79.4	9.4	49.0	113.5

SD = standard deviation of mean

Table 2. Age-controlled partial correlation coefficients of central adiposity measures with blood pressure

		WC	WHtR	WHR	CI	BMI	PBF	BAI
SBP		0.25	0.25	0.09	0.08	0.27	0.26	0.17
	p	<0.001	<0.001	<0.05	n.s.	<0.001	<0.001	<0.001
DBP		0.34	0.34	0.10	0.09	0.36	0.32	0.22
	p	<0.001	<0.001	<0.05	n.s.	<0.001	<0.001	<0.001

n.s.= not significant

0.30, *p*<0.001) and with DBP (both *r* = 0.31, *p*<0.001), but were slightly lower than those for BMI. Although BAI had a significant correlation with both SBP and DBP (r = 0.17 and 0.22, *p*<0.001), the coefficients were much lower than those of other adiposity measures including BMI. The WHR had relatively smaller and weakly significant coefficients for both SBP and DBP (both *r* = 0.10, *p*<0.05). The correlations of CI with SBP and DBP were not significant.

It was noted that when BMI was controlled, no adiposity measures, except for WC and WHtR, showed significant correlations with either SBP or DBP (results not shown). Interestingly, both SBP and DBP showed significant partial correlations with WC (SBP: *r*= 0.14, *p*<0.01; DBP: *r*= 0.15, *p*<0.01) and WHtR (SBP: *r*= 0.19, *p*<0.001; DBP: *r*= 0.185, *p*<0.001), independent of BMI, but not irrespective of age and BMI together. However, at the same time, BMI held its significant association with blood pressure even after controlling for age and other adiposity measures, e.g., PBF (SBP: *r*= 0.12, p<0.01; DBP: *r*= 0.19, *p*<0.001), WC (SBP: *r*= 0.13, *p*<0.01; DBP: *r*= 0.14, *p*<0.01), WHtR (SBP: *r*= 0.11, p<0.05; DBP: *r*= 0.13, *p*<0.01) and BAI (SBP: *r*= 0.22, *p*<0.001; DBP: *r*= 0.30, *p*<0.001) (results not shown).

Table 3 demonstrates the results of multiple linear regression analyses of SBP and DBP on adiposity indicators (separately done for each), after allowing for the effect of age. The BMI, WC, WHtR and WHR, but not CI, had significant positive impact on SBP and DBP. However, for both measures of pressure, BMI showed the strongest effect (SBP: T = 6.99 and DBP: T = 7.37, both *p*<0.001). However, more or less similar predictive powers were also noticed for WHtR and WC. Besides, BAI showed the next strongest effect (SBP: T = 3.73 and DBP: T = 5.10, both *p*<0.001) followed by WHR with a feebler value (SBP: T = 1.66 and DBP: T = 2.10, both *p*<0.05). Nevertheless, the greatest significant variation of SBP was explained by BMI (10%) followed by WHtR and WC (9% and 8%, respectively), whereas BAI and WHR explained only 2% and 1%, respectively, having an impact at a relatively weaker significance level. On the other hand, both BMI and WHtR explained the greatest variation (10%) of DBP, followed by WC (9%), PBF (8%) and BAI (5%). Both measures had a similar strength of impact (T = 7.18 and 7.01, respectively at *p*<0.001). The variation explained by WHR was very minute, although significant (0.9%, T = 2.10, *p*<0.05). The CI had no significant impact on DBP. All the impacts, nonetheless, were independent of age. It is also interesting and worth mentioning that none of the adiposity measures had a significant impact on any of the BP measures when both age and BMI was controlled for (results not shown).

The results of multiple logistic regressions of hypertension (yes=1, no=0)

Table 3. Regression analyses of SBP and DBP on central adiposity measures, controlling for age

DV	Regression parameters	BMI	PBF	WC	WHtR	WHR	CI	BAI
SBP	R²-change	0.10	0.07	0.08	0.09	0.01	0.006	0.02
	T	6.99	6.14	6.32	6.70	2.40	1.66	3.73
	p	>0.001	<0.001	<0.001	<0.001	<0.05	n.s.	<0.001
DBP	R²-change	0.10	0.08	0.09	0.10	0.009	0.008	0.05
	T	7.37	6.40	7.01	7.18	2.10	1.90	5.10
	p	<0.001	<0.001	<0.001	<0.001	<0.05	n.s.	<0.001

n.s. = not significant

on the central adiposity measures (separately on each measure categorised into below and equal or above value of 85th percentile, respectively) are shown in Table 4. After controlling for age, smoking habits and alcohol consumption, only BMI, WC, WHtR and BAI had a significant positive association with HT. WC had the strongest positive impact (Wald=22.425, $p<0.001$) followed by WHtR (Wald=20.760, $p<0.001$), BMI (Wald=15.58, $p<0.001$), PBF (Wald=9.389, $p<0.005$) and BAI (Wald=7.755, $p<0.005$). Men having values above the 85th percentiles of both WC and WHtR, demonstrated more than 4 times and of BMI about 3.3 times risk of hypertension, followed by PBF and BAI (2.6 and 2.3 times, respectively). On the other hand, WHR and CI did not qualify to show a significant risk. WC had significant positive impact even after controlling for age and BMI (Wald=4.23, $p<0.05$; odds 2.56, 95% CI=1.045-6.245). The WHtR narrowly missed attaining required level of significance($p<0.05$) (Wald=3.68, $p=0.055$; odds 2.30, 95%CI=0.982-5.408). On the other hand, BMI did not show a significant effect after controlling for age and waist circumference (results not shown).

DISCUSSION

Among the present adult slum men, 20.2% (95 out of 470) had HT. In a non-slum sample of Bengalee adults aged 20-60 years from the same district of the present study, the prevalence of HT was 11.7% (Ghosh & Bandyopadhyay, 2007b). High blood pressure, therefore, seemed to be a significant health concern among the Bengalee slum-men. The present study observed that BMI had the strongest correlations with both the measures of blood pressure (SBP and DBP) compared to the other indicators including those of central adiposity. The PBF had the second strongest correlation with SBP. BMI, however, had the strongest association with DBP followed jointly by WC and WHtR and then, PBF. The newly proposed index, BAI, had significant but considerably lower correlations with both measures of BP compared to BMI and central adiposity. WHR too had significant but very low correlation with BP. CI did not have a significant association. BMI also predicted the highest variation of BP followed by WHtR. Nevertheless, both these measures explained DBP with equal efficacy. PBF performed almost similar to WC and WHtR. Interestingly, BAI could explain BP variations less effectively than all the other measures but was a little better than WHR.

Among the central Indian adults, BMI and WC were important predictors of hypertension (Deshmukh *et al.*, 2006). Greater BMI, WC and WHtR have been associated with higher SBP and DBP in Pakistani males (Gupta, 2004). Central

Table 4. Results of multiple logistic regression analyses of hypertension on adiposity measures

Predictors	Wald	p	OR	95% CI
WC>83.8cm*	22.425	<0.001	4.22	2.32-7.65
WHtR>0.52*	20.760	<0.001	4.02	2.21-7.32
BMI>23.5* kg/m²	15.582	<0.001	3.30	1.82-5.97
PBF>24.8%*	9.389	<0.005	2.60	1.41-4.78
BAI>26.5*	7.755	<0.01	2.30	1.33-4.51
CI>1.25*	2.832	<0.05	1.65	0.92-2.96
WHR>0.94*	1.704	n.s.	1.50	0.81-2.77

Each row is the result of separate regression analysis.
* 85th percentile values; OR = Odds ratio derived from logistic regression; p = significance level;
CI = confidence interval.

obesity determined by WHtR was significantly associated with greater diastolic blood pressure after adjusting for age in both black and white young adults (Srinivasan *et al.*, 2009). There was a significant positive correlation of BMI, waist-size and WHR with systolic BP (r= 0.46 to 0.13), diastolic BP (0.42 to 0.16) in the Western Indian urban (Jaipur) men (Gupta *et al.*, 2007). WHtR was stronger than BMI in association with diabetes, but both these indicators were equally strongly associated with HT in Asians (DECODA, 2008). In our present study, BMI performed slightly better in its association with BP (as continuous variables), followed by WC and WHtR, with almost equal strength. However, when it came to predicting the risk of HT, WC was best followed by WHtR, BMI, PBF and BAI. Subjects, who were obese by either WC or WHtR, had more than 4 times higher risk of HT than the non-obese. The waist-line component seemed therefore to have the most important association with the risk of HT. Among the non-slum Bengalee men, BMI, WHtR and WC were also important predictors of BP. But in contradiction to the present findings among the slum-men, BMI predicted HT status better among non-slum Bengalee Men (Ghosh & Bandyopadhyay, 2007b). Therefore, these findings are to be verified with other comparable slum and non-slum samples of Bengalee men.

This study indicated that the relationship of adiposity with blood pressure values might be different between non-hypertensive and hypertensive and/or between non-obese and obese, depending upon whether the measures were continuous (e.g., BMI, SBP, DBP) or discrete (obesity, HT). At the same time, as found from the correlations and regressions, there were indications that the predictive effect of abdominal adiposity on blood pressure (SBP and DBP) was modified by age-BMI interaction. For instance, the predictive values of WC and WHtR were retained even after controlling for BMI, but not for age and BMI together (see Tables 2 and 3). Studies

based on large representative samples dealing with obese/non-obese and/or HT/non-HT separately to predict each other are necessary to throw light on these probable interactions.

Epidemiological studies have consistently found a progressive elevation in blood pressure with increasing adipose tissue. Several studies indicate a better efficacy of WC, relative to other measures of central adiposity, to predict overall adiposity in India (Kurpad, Tandon & Srinivasan, 2003), as well as for the Bengalee population (Bose, 2006; Chakraborty & Bose, 2009). The WC had the strongest correlation with BMI and PBF among the slum men under study with the same dataset (Chakraborty & Bose, 2009). Among the same Bengalee slum people, analysis of sensitivity and specificity showed that a WC of around 80 cm was a significant predictor of HT independent of age and high PBF and BMI (Chakraborty *et al.*, 2011a; 2011b). In the present study, however, BMI also appeared to be a good predictor of blood pressure and hyper-tension. The new adiposity index, BAI, being a measure of overall adiposity much like BMI (Bergman *et al.*, 2011), also showed its lower but significant impact on HT. The explanation for this might exist in the low BMI and high body fat paradox in the Asians (Deurenberg-Yap *et al.*, 2000). It has been also hypothesised that in Bengalee men, a relatively greater amount of 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 increased PBF count, and when above critical level, exposed them to a higher likelihood of metabolic or CVD risk factors like hypertension (Chakraborty *et al.*, 2011a). Another recent study (Chakraborty *et al.*, 2011b) with the same sample population indicated that Bengalee males might not actually demonstrate high WC at a low BMI as was proposed for Asian Indian males (Yajnik, 2001); instead, the risk of HT seemed to appear at both low BMI and low WC condition with higher PBF.

It is also worth mentioning that the recent worldwide trend of the progressive risk of cardiovascular diseases may be attributed to a lack of public response to the conditions and conventional impression that these are the problems of the urban rich only (Ramaraj & Alpret 2008). Factually, the urban poor face the worst consequences of an urbanised lifestyle, exposing them to a significantly high risk of non-communicable diseases (Yadav & Krishnan 2008). For instance, the prevalence of stroke incidence was greater among slum dwellers than the non-slum subjects in Kolkata city (Das *et al.,* 2007). A poor understanding and control of risk factors such as hypertension could be responsible for this. Simple anthropometric measures such as WC may be utilised to screen hypertension in a poor and resource constrained setting like a slum. Further studies on the relationship of differential distribution of body fat among poorly nourished low-BMI populations could also reveal a better understanding of the epidemiology of the cardiovascular risk factors.

In conclusion, WC remains the best among the obesity measures to predict hypertension among the Bengalee men of low socio-economic status. Although BMI showed a strong association with both BP measures and HT status, the WC might be preferred to the former in view of its simplicity in application in resource constrained field-situations in large population screening programmes. The measure is easy to conduct and requires only a simple and low cost plastic tape measure, with a little or no discomfort to the subject. Besides, the newest proposed index, the BAI, did not show any advantage over other adiposity measures in predicting HT. More studies, however, are required to test the relative impacts of BAI and other adiposity measures on the metabolic risk factors across different socio-economic strata among different ethnic groups. Lastly, it must be mentioned here that large scale validation studies are required from various ethnic populations before BAI is preferred over other adiposity measures in studies dealing with various risk factors of syndrome-X.

ACKNOWLEDGEMENTS

REFERENCES

Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, Xiang AH & Watanabe RM (2011). A better index of body adiposity. *Obesity* 19: 1083-9.

Barreira TV, Harrington DM, Staiano AE, Heymsfield SB & Katzmarzyk PT (2011). Body adiposity index, body mass index, and body fat in white and black adults. *JAMA* 306: 829-30.

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: 247-52.

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. *The Open Obesity J* 1: 32-7

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: 141-8.

Chakraborty R, Bose K & Koziel S (2011a). 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. *Italian J Pub Health* 8(2): 137-48.

Chakraborty R, Bose K & Koziel S (2011b). Waist circumference in determining obesity and hypertension among 18-60 years old Bengalee Hindu male slum dwellers in Eastern India. *Ann Hum Biol* 38(6): 669–675

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr & Roccella EJ (2003). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 Report. *JAMA* 289: 2560-72.

Das K, Banerjee TK, Biswas A, Roy T, Raut DK, Mukherjee CS, Chaudhuri A, Hazra A & Roy J (2007). A prospective community-based study of stroke in Kolkata, India. *Stroke* 38: 906–910

DECODA Study Group (2008). *B*MI compared with central obesity indicators in relation to diabetes and hypertension in Asians. *Obesity* 16: 1622-35.

Deshmukh PR, Gupta SS, Dongre AR, Bharambe MS, Maliya C, Kaur S & Garg BS (2006). Relationship of anthropometric indicators with blood pressure levels in rural Wardha. *Ind J Med Res* 123: 57-64.

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: 1011–7.

Durnin JVGA & Womerseley J (1974). 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* 32: 77-97.

Fujimoto WY, Bergstrom RW, Boyko EJ, Chen KW, Leonetti DL, Newell-Morris L Shofer JB & Wahl PW (2009). 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: 1808–12.

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: relationships with blood pressure and hypertension. *Singapore Med J* 48(3): 232-5.

Gupta R (2004). Trends in hypertension epidemiology in India. *J Hum Hypertens* 18: 73-8.

Gupta R, Rastogi P, Sarna M, Gupta VP, Sharma SK & Kothari K (2007). Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subjects. *J Assoc Physicians India* 55: 621-7.

Joshi SR & Parikh RM (2007). India - diabetes capital of the world: now heading towards hypertension. *J Assoc Physicians India* 55: 323-4.

Khan A, Haq FU, Pervez MB, Saleheen D, Frossard PH, Ishaq M, Hakeem A, Sheikh HT & Ahmad U (2008). Anthropometric correlates of blood pressure in normotensive Pakistani subjects. *Int J Cardiol* 124(2): 259-62.

Khongsdier R (2002). Body mass index and morbidity in adult males of the War Khasi in Northeast India. *Eur J Clin Nutr* 56: 484-9.

Khongsdier R (2005). BMI and morbidity in relation to body composition: a cross-sectional study of a rural community in North-East India. *Br J Nutr* 93: 101-7.

Kurpad SS, Tandon H & Srinivasan K (2003). Waist circumference correlates better with body mass index than waist-to-hip ratio in Asian Indians. *Natl Med J India* 16: 189-92.

Kuriyan R, Petracchi C, Ferro-Luzzi A, Shetty PS & Kurpad AV (1998). Validation of expedient methods for measuring body composition in Indian adults. *Indian J Med Res* 107: 37-45.

Lohman TG, Roche AF & Martorell R. 1988. Anthropometric Standardisation Reference Manual. Chicago, IL: Human Kinetics Books.

Ramaraj R & Alpret JS (2008). Indian poverty and cardiovascular disease. *Am J Cardiol* 102(1): 102–106.

Rodgers A, Lawes C & MacMahon S (2000). Reducing the global burden of blood pressure related cardiovascular disease. *J Hypertens* 18(Suppl 1): S3-S6.

Sakurai M, Miura K, Takamura T, Ota T, Ishizaki M, Morikawa Y, Kido T, Naruse Y & Nakagawa H (2006). Gender differences in the association between anthropometric indices of obesity and blood pressure in Japanese. *Hypertens Res* 29: 75-80.

Sayeed MA, Mahtab H, Latif ZA, Khanam PA, Ahsan KA, Banu A & Azad Khan AK (2003). Waist-to-height ratio is a better obesity index than body mass index and waist-to-hip ratio for predicting diabetes, hypertension and lipidemia. *Bangladesh Med Res Counc Bull* 29: 1-10.

Siri WE (1961). Body composition from fluid spaces and density: analysis of methods. In Brozek J & Hensche A (eds.) *Techniques for Measuring Body Composition*, pp. 223-44. National Academy of Sciences, Washington DC.

Srinivasan SR, Wang R, Chen W, Wei CY, Xu J & Berenson GS (2009). Utility of waist-to-height ratio in detecting central obesity and related adverse cardiovascular risk profile among normal weight younger adults (from the Bogalusa Heart Study). *Am J Cardiol* 104(5): 721-4.

Valdez R, Seidell JC, Ahn YI & Weiss KM (1991). A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross population study. *Int J Obes* 17: 77-82.

Wang Y, Rimm EB, Stampfer MJ, Willett 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: 555-63.

World Health Organisation (1996). Hypertension Control. World Health Organisation Technical Report Series No. 862. WHO, Geneva

Yadav S, Boddula R, Genitta G, Bhatia V, Bansal B, Kongara S, Julka S, Kumar A, Singh HK, Ramesh V & Bhatia E (2008). Prevalence & risk factors of pre-hypertension & hypertension in an affluent North Indian population. *Indian J Med Res* 128: 712-20.

Yadav K & Krishnan A (2008). Changing pattern of diet, physical activity and obesity among urban, rural and slum populations in North India. *Obesity Reviews* 9: 400–408

Yajnik CS (2001). Commentary: fetal origins of cardiovascular risk—nutritional and non nutritional. *Int J Epidemiol* 30: 57-9.