J Public Health (2009) 17:301–308
DOI 10.1007/s10389-009-0254-9

ORIGINAL ARTICLE

Body mass index and blood pressure among adult Bengalee male slum dwellers of Kolkata, India

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Received: 26 June 2008 / Accepted: 19 January 2009 / Published online: 5 March 2009

Abstract
Aim To investigate the relationship of body mass index (BMI) with systolic (SBP), diastolic (DBP) and mean arterial (MAP) blood pressures among adult male slum dwellers of Kolkata, India.
Subjects and methods A total of 470 adult (18–84 years) male slum dwellers of Bengalee ethnicity residing in Dum Dum, a suburb of Kolkata, India, were investigated. Height, weight and blood pressures (BP) were recorded using standard techniques. The BMI was calculated using the standard equation. Participants were classified into nutritional categories by BMI values following the World Health Organization (2000) guidelines. Hypertension (HT) was determined following JNC–VII criteria. Standard statistical techniques were utilized. Significance was set at $p<0.05$.
Results Mean (SD) age and BMI of the subjects were 37.5 (14.2) years and 20.3 (3.2) kg/m^2. Means (SD) for SBP, DBP and MAP were 121.6 (15.5) mmHg, 79.6 (9.7) mmHg and 93.5 (11.1) mmHg, respectively. Significant ($p<0.001$) differences were observed for age, weight and BMI between hypertensive and normotensive individuals. For all the parameters, hypertensive individuals had higher means. Age had significant ($p<0.001$) correlations with SBP, DPB and MAP, but not with BMI. BMI was also significantly ($p<0.001$) correlated with SBP, DBP and MAP. Significant ($p<0.001$) partial correlations (after controlling for age) of BMI with SBP, DBP and MAP were also observed. Mean values of SBP, DBP and MAP increased steadily from the undernourished through the normal to the overweight individuals. There were significant differences in the percentage of HT between the nutritional categories. The prevalence of HT was lowest in the lowest BMI categories (undernourished and normal) (16.2 and 15%) and highest in the obese group (43.2%). Multiple regression analyses of BP variables on BMI demonstrated that BMI had significant influence on them, irrespective of age, MPCI, smoking and alcohol intake status. BMI independently explained 5.8%, 11.4% and 10.6% variation in SBP, DBP and MAP, respectively. Among the variables controlled for, age had the strongest significant effect on SBP (Adj R^2=0.132), DBP (Adj R^2= 0.054) and MAP (Adj R^2=0.086).
Conclusion In conclusion, our study demonstrated BMI as an independent risk factor for HT, and overweight status (BMI≥23 kg/m^2) significantly increases its risk among adult Bengalee male slum dwellers of Kolkata.

Keywords India · Bengalee · Body mass index · Blood pressure · Slum

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Introduction

Elevated blood pressure (BP) is a predictor and one of the most important causal factors for premature mortality and morbidity due to myocardial infarction, stroke and other cardiovascular complications (Selmer and Tverdal 1995; Ellekjaer et al 2001; Gu et al 2008). Many studies have investigated the relationship of body fatness with BP (Gerber et al. 1995; Baumgartner 1989). There are studies that have demonstrated an association of a progressive increase in BP with an increase in adiposity (Mark et al. 1999). Overweight and obesity are important determinants of health leading to adverse metabolic changes, including an increase in BP. Being overweight was reported to be associated with a two- to six-fold increase in the risk of developing hypertension (HT) (WHO 1996).

Body mass index (BMI) is a measure of overall adiposity (Bose and Mascie-Taylor 1998; Kopelman 2000). Studies indicate that BMI has its independent role in the identification of overweight and obesity, and has been widely recommended for epidemiological surveys because of their independent association with major cardiovascular and metabolic risk factors (Bjorntorp 1987; Seidell et al. 1990; Zhou et al. 2002; Canoy et al. 2004). The health risk has been shown to increase in a graded fashion when moving from the lower to higher BMI categories (Brown et al. 2000; Must et al. 1999). BMI has been shown to be a risk factor for total and ischemic stroke in men and women, and high blood pressure is one of the major risk factors for the same (Hu et al. 2007). BMI has been shown to be associated with BP among adults in Finland (Jousilahti et al. 1995), Sweden (Henriksson et al. 2003), Argentina (Feldstein et al. 2005), the African Diaspora (Cappuccio et al. 2008) and also in Pakistan (Khan et al. 2008).

Once believed to be a problem of developed and industrialized nations, HT is now considered as a major public health concern in developing countries, like India, too (Nirmala Reddy 1998; Kusuma et al. 2004; Kearney et al. 2004). Reports as early as the early 1990s said that India had nearly 20 million hypertensive people (Shah 1992). In India, 57% of all stroke deaths and 24% of all coronary heart disease deaths are due to HT, and there are 31.5 million and 34 million hypertensive people in rural and urban India, respectively (Gupta 2004). Recent studies from Kolkata, India (Ghosh et al. 2000, Bhadra et al. 2002; Bose et al. 2003, 2005; Sadhukhan et al. 2007; Ghosh and Bandyopadhyay 2007), have indicated that HT is a major problem among Bengalee people, too.

There are studies from other populations in India that showed a positive relationship of BP levels with various anthropometric measurements, e.g., waist-hip ratio (WHR) (Gupta and Mehrishi 1997); WHR and BMI (Santhirani et al. 2003); waist circumference (WC) and BMI (Deshmukh et al. 2006); WC, WHR and BMI (Gupta et al. 2007). There are works among the Bengalee population from in and around Kolkata, West Bengal, India, that have dealt with older hypertensive and normotensive men (Ghosh et al. 2000) and women (Bose and Das Chaudhuri 2001), young adults (Bhadra et al. 2002), male jute mill workers (Bose et al. 2003), adults of 18 years and above (Das et al. 2005) and adults aged 20–61 years (Ghosh and Bandyopadhyay 2007). But very few (Bose et al. 2003) of the above studies explored these kinds of relationships among distinctively low socio-economic urban groups, in particular, among the slum dwellers.

It has been noted that, in recent years, accompanying the economic and demographic transition in developing countries, there is a shift from diseases caused by poverty to the chronic, non-communicable, lifestyle-related diseases. The progressive risk of cardiovascular disease may be attributed to a large extent to a lack of public response to the conditions and an incorrect notion of the policy makers and the public that these are the problem of the urban rich only (Ramaraj and Alpret 2008). The urban poor face the worst consequences of an urbanized lifestyle, making them at significantly high risk of non-communicable diseases (Yadav and Krishnan 2008). In a very recent study in Kolkata, the prevalence of stroke incidence was greater among slum dwellers than the non-slum subjects (Das et al 2007). A poor understanding and control of risk factors, such as hypertension, has been proposed to be responsible for this (Pandian et al. 2007).

Therefore, in this study, we attempted to investigate the relationship of BMI with systolic (SBP), diastolic (DBP) pressure (MAP) as well as the prevalence of HT across different BMI categories among male slum dwellers of Kolkata, India.

Materials and Methods

Area of study

The district north 24 Parganas lies between 21° 31′ and 22° 57′ north latitude and between 88° 2′ and 89° 6′ east latitude. The South Dum Dum area is adjacent to Kolkata city and is one of the urban centers of the district of North 24 Parganas. It is about 10 km to the north from the heart of the city of Kolkata (formerly Calcutta). The fieldwork was conducted on adult Bengalee men (aged 18–84 years) living in a slum called 'Bidhan Colony' approximately 15 km from Kolkata town center. Most of the subjects were engaged in jobs of low socio-economic status, as per the local standards, ranging from factory workers to rickshaw pullers or day laborers for males and domestic helpers for females. There are landlords who were the first settlers of the locality, and they have a huge number of tenants. The general hygienic condition clearly seems to be poor. The sanitation, sewerage systems and house-hold structures are the silent but definite indications of the poverty and poor quality of life.

The sample

This study was carried out as a part of a research project on the nutritional status of the adult males of the area mentioned above. The municipal authorities and local community leaders were informed before commencement of the study. Households were selected randomly from the particular locality. The houses were situated in a linear fashion, one after another from one end to the other (east-west) of the slum. Each household was approached during field visits from one direction to another of the slum, and the available adult male member(s) were selected as participants. They were measured on the same day or another as per their agreement by fixing prior appointments. No household was visited twice for new enrollment of subjects. The whole slum was covered from one direction to the other in the same manner. Participants were interviewed and measured at their respective households. In some cases, due to logistical problems, they were taken to a common place where a number of them were examined. However, all the participants essentially resided inside the administrative boundary of the project area, i.e., Bidhan Colony. No strict statistical sampling for the inclusion of the participants could be followed due to operational compromise in the field (Khongsdier 2002). The whole slum area was covered in the total exercise of the data collection. The overall response rate was found to be around 80%. Informed consent was also obtained from each participant. Apparently healthy men who were reportedly not suffering from any acute illness and were self-satisfied with their normal day-to-day work schedule at the time of measurements were enrolled to participate in the study. The apparently and self-reportedly healthy male members of each family unit were thus sampled randomly. No subjects were taking anti-hypertensive drugs or under any other kinds of prolonged medication. A total of 475 men aged 18 years and above were interviewed and measured. Among them, five were excluded from the analyses for the present study due to missing data on hypertension. Therefore, the final sample size remained 470 for the study.

The field investigation, including anthropometric measurements, was done entirely by the first author (R.C.). Information on the ethnicity, age, number of family members, monthly family income (MFI), smoking status (smoker or non-smoker) and alcohol consumption (yes or no) was also collected from each subject with the help of a pre-tested questionnaire. Monthly per capita income (MPCI) was calculated by dividing the MFI by the number of family members. All the measurements were taken following the standard techniques (Lohman et al. 1988). Height was measured to the nearest 0.1 cm using a locally made Martin's type anthropometer and weight to the nearest 0.5 kg using a standard bathroom scale. Technical errors of measurements were found to be within acceptable limits (Ulijaszek and Kerr 1999). BMI was computed using the following standard equation: BMI = weight (kg)/height (m^2). Individuals were classified into different categories of BMI using cutoff values of BMI for the Asia-Pacific populations recommended by the International Obesity Task Force (WHO 2000) as follows:

- Undernourished: BMI <18.5
- Normal: BMI = 18.5–22.9
- Overweight: BMI = 23.0–24.9
- Obese: BMI ≥25.0

Measurement of blood pressure

An automatic digital BP monitor (Home Health, Switzerland) was used to measure BP following standard procedures. All subjects were measured between 7 P.M. and P.M. (±15 min). Resting systolic and diastolic BPs (in mmHg) were measured with the subject in a sitting position for at least 15 min prior to measurement and again at least 10 min after the first reading. The mean values of two measures were used in analyses. Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and diastolic blood pressure (DBP) ≥90 mmHg following the US Seventh Joint National Committee on Detection, Evaluation and Treatment of Hypertension (JNC VII) guidelines (Chobanion et al. 2003).

Statistical analyses

The distributions of the anthropometric and socio-economic variables were not significantly skewed; thus, they were not transformed. Age, anthropometry and BP variables were described by their means and standard deviations. One-way analyses (Scheffe's procedure) (Mascie-Taylor 1994a, b) were carried out to test for differences in mean SBP, DBP and MAP across the four BMI categories. Chi-square analysis was done to determine the differences in the prevalence of hypertension among nutritional categories. Odds ratios (OR) were calculated to determine the change of its values with increasing BMI. Multiple linear regression analysis was carried out to determine the influence of BMI on SBP, DBP and MAP, independent of age, MPCI, smoking and alcohol intake status. To do so, the independent variables age, MPCI, smoking and alcohol intake status were entered first in the equation en bloc and then BMI in the second block. For this analysis, smoking and alcohol intake status remained categorical (yes=1, no=0, in each case). Pearson's correlation coefficient (r) was computed to test the association of all the continuous variables.

Partial correlation coefficients (age effect removed) of BMI with SBP, DBP and MAP were also computed to show the independent associations. All statistical analyses were undertaken using the SPSS Statistical Package, version 7.5. Statistical significance was set at $p<0.05$.

Results

The characteristics of the sample are presented in Table 1. Mean age and BMI of the subjects were 37.5 years (SD = 14.2) and 20.3 kg/m^2 (SD=3.2). Means for SBP, DBP and MAP were 121.6 mmHg (SD=15.5), 79.6 mmHg (SD=9.7) and 93.5 mmHg (SD=11.1), respectively.

Table 2 presents the means of age, height, weight and BMI among normotensive and hypertensive subjects. Significant ($p<0.001$) differences were observed for age (T=-6.29), weight (T=-3.42) and BMI (T=-3.91) between these two groups. For all the parameters, hypertensives had the higher means.

Correlation analyses (results not presented) demonstrated that age had significant ($p<0.001$) correlations with SBP (r=0.40), DBP (r=0.24) and MAP (r=0.30). Age did not have any significant association with BMI. BMI was also significantly ($p<0.001$) correlated with SBP (r=0.24), DBP (r=0.34) and MAP (r=0.33). Significant ($p<0.001$) partial correlations (age effect removed) of BMI with SBP (r=0.27), DBP (r=0.36), and MAP (r=0.36) were also observed.

The prevalences of CED, overweight and obese subjects were 32.8%, 11.3% and 7.9%, respectively. Table 3 presents the mean values of SBP, DBP and MAP by BMI categories. Significant ($p<0.001$) differences in all the measures were observed among the categories. Mean values increased steadily from the undernourished through the normal to the overweight groups. Obese subjects had the highest means for all the BP variables. The magnitudes of differences were always significantly higher between the normal and the overweight than between the undernourished and the normal or between the overweight and the obese. Scheffe's test revealed that for the SBP, differences among all groups were statistically significant except between undernourished and the normal. On the other hand, DBP differed significantly among all the groups except between overweight and the obese. A noteworthy point was that age did not differ significantly among the nutritional categories.

Table 4 demonstrates the percentage prevalence of individuals with HT in different BMI categories. There were significant differences in the percentage of hypertensive among the categories except between the undernourished and the normal groups. Lower prevalences of HT were observed in the undernourished and the normal groups (16.2% and 15.0%, respectively) and higher in the overweight and the obese groups (37.7 and 43.2%, respectively). The Odds ratios became significantly higher in the overweight group, and it was about four times higher

Table 1 Characteristics of the sample (n=470)

Variables	Mean	SD	Range
Age (years)	37.5	14.2	18–84
Height (cm)	161.5	6.2	142.8–189.3
Weight (kg)	52.9	9.4	30.1–92.0
BMI (kg/m^2)	20.3	3.2	11.6–33.5
SBP (mmHg)	121.6	15.5	68.5–199.5
DBP (mmHg)	79.6	9.7	49.0–115.0
MAP (mmHg)	93.5	11.1	52.0–143.0

Table 2 Differences in mean characteristics between BP groups

	NT (n=375)	HT (n=95)	T
Age (years)	35.2 (12.9)	46.2 (15.7)	6.29**
Height (cm)	161.5 (6.0)	161.4 (7.0)	0.22
Weight (kg)	52.1 (8.8)	56.2 (10.9)	3.42*
BMI (kg/m^2)	19.9 (3.0)	21.6 (3.7)	3.91**

**$p<0.001$; *$p<0.01$

NT = normotensive, HT = hypertensive

Table 3 Differences in blood pressures among BMI categories

	BMI Categories				F *
	UN (n=154)	N (n=226)	OW (n=53)	OB (n=37)	
SBP	117.6 (17.2)	121.7 (13.8)	126.2 (12.8)	130.7 (16.2)	9.682
DBP	76.1 (9.8)	79.6 (8.7)	84.3 (8.8)	86.9 (10.2)	19.726
MAP	89.6 (11.6)	93.7 (9.7)	98.3 (9.4)	101.9 (11.5)	18.856

*$p<0.001$

Age did not differ among groups

UN = undernourished

N = normal

OW = overweight

OB = obese

Table 4 Prevalence (%) of hypertension according to the nutritional categories

	HT (%) (n=95)	OR	95% CI
UN (n=154)	16.2	1.00	—
N (n=225)	15.0	0.91	0.52–1.60
OW (n=53)	37.7	3.13	1.55–6.31
OB (n=37)	43.2	3.93	1.80–8.57

X^2 =20.19; p<0.001

UN = undernourished

N = normal

OW = overweight

in the obese group than in the undernourished and the normal groups.

Multiple regression analyses of the BP variables on BMI, age and other behavioral parameters demonstrated (Table 5) that BMI had significant influence on these measures. BMI explained 5.8%, 11.4% and 10.6% variation in SBP, DBP and MAP, respectively, independent of age, MPCI, smoking and alcohol consumption status. In the regression analyses, all the independent variables except for the BMI were entered first en bloc and then BMI in the second block. From the first block entered in the regression model, age was the only variable retained with significant influences on SBP (Adj R^2=0.132), DBP (Adj R^2=0.054) and MAP (Adj R^2=0.086) among the variables other than BMI. In the regression models for the three BP variables, the other variables were never entered, and their T values were insignificant (results not shown).

Discussion

Obesity and HT are two major inter-related cardiovascular risk factors (Khan et al. 2008). Adiposity is an established risk factor for cardiovascular disease, but the relationship of adiposity with the risk of cerebrovascular disease is still to some extent unclear (Hu et al. 2007). Being overweight is associated with a risk of developing HT. In general, overweight status exposes an individual to two to six times the increase in the risk of being hypertensive (WHO 1996). Studies consistently reported that both obesity and chronic diseases are equally prevalent in poor people like the urban slum dwellers (Bunnag et al 1990; Misra et al 2001).

In a recent study (Ghosh and Bandyopadhyay 2007) involving 180 middle-class adult Bengalee males (aged 20–61 years) from a Kolkata suburb, the mean (SD) age, BMI, SBP and DBP was reported to be 35.7 (9.3) years, 22.4 kg/m^2, 118.77 (11.85) mmHg and 78.10 (8.74) mmHg, respectively. They had higher mean BMI, but slightly lower BP values than those of our sample. This might be due to a lower age range (20–61 years) of the study as compared to ours. Deshmukh et al. (2006) found these values to be 38.2 (10.4) years, 19.1 (4.2) kg/m^2, 120.2 (17.6) mmHg and 77.7 (12.4) mmHg, respectively, in a rural adult population of low socio-economic status from western India. Male agriculturist (middle socioeconomic class) Reddies in southern India had mean values of age = 39.12 (14.8) years, BMI=21.5 (3.7) kg/m^2, SBP=127.67 (18.5) mmHg and DBP=83.6 (8.8) mmHg, whereas agricultural laborer (low socio-economic class) Malas were reported to have age = 36.8 (13.0), BMI=19.0 (2.5), SBP=113.0 (8.8) mmHg and DBP=76.0 (7.0) mmHg (Venkataramana et al. 2001). Among male agricultural laborers (Malas and Muslims) with reportedly ‘heavy’ physical activity levels in Andhra Pradesh, the mean values were 113.7 and 70.3 for SBP and DBP, respectively (Nirmala Reddy 1998). In the same study, the service and business communities demonstrated higher mean values (127.3 and 77.5). However, none of these groups belonged to an urban underprivileged group like that in the present study. In a study on coastal urban slum fishermen, the mean SBP and DBP were found to be 124.9 (9.6) and 82.7 (8.1), respectively (Gopi Chand and Sambasiva Rao 2007).

In our study, we found significant (p<0.001) positive associations of BMI with SBP (r=0.24), DBP (r=0.34) and MAP (r=0.30), independent of age, MPCI and smoking and alcohol consumption status. In a follow-up study among middle-aged people in Finland, BMI was found to be correlated positively with SBP and DBP cross-sectionally, and it also predicted the future increase in BP (Jousilahti et al. 1995). A similar finding was reported in another study among middle-aged Swedish men (Henriksson et al. 2003). A study from India demonstrated significant positive correlation of BMI with SBP and DBP in both men and women (Gupta et al. 2007). Another study among the adult Reddies and Malas of the southern part of India also showed positive correlations of BMI with SBP and DBP in both sexes. In the male Reddies, the correlation coefficient of BMI with SBP and DBP were 0.41 and 0.31, respectively. In the Mala males, those values were 0.29 and 0.23, respectively (Venkataramana et al. 2001). In the slum study

Table 5 Results of regressions showing the effect of BMI on SBP, DBP and MAP, after controlling for age, MPCI, smoking and alcohol intake status

	B	SeB	Beta	T *	R^2 change
SBP	1.170	0.202	.245	5.795	0.058
DBP	1.029	0.128	.344	8.047	0.114
MAP	1.129	0.143	.332	7.888	0.106

*p<0.001

mentioned above (Gopi Chand and Sambasiva Rao 2007), BMI had a significant positive correlation with SBP (r=0.33) and DBP (r=0.33) in men.

The Indian study mentioned above (Gupta et al. 2007) also reported that with increasing BMI, the prevalence of HT increased significantly. In a Norwegian population, an independent effect of change in BMI on change in SBP and DBP was reported in both women and men; also, people who increased their BMI were at increased risk for HT (Droyvold et al. 2005). In adolescent Bengalees of Kolkata, SBP and DBP of both sexes increased with an increase in weight, height and BMI with a significant positive linear correlation (Saha et al. 2007). In our study SBP, DBP, and MAP also increased significantly from the undernourished group through normal to the overweight group. Moreover, the prevalences of HT were lowest in the undernourished and normal groups (16.2% and 15.0%, respectively) and increased significantly in the overweight group (37.7%), being highest in the obese group (43.2%). It is also interesting to mention that the undernourished and the normal groups did not show significant differences in the prevalence of HT as well as in the mean values of SBP. The difference in mean DBP between the undernourished and the normal group was also less than the differences in the mean between the normal and the overweight groups. Similarly, the differences between the overweight and the obese groups was less and not statistically significant for both SBP and DBP. Therefore, it seems that the increase in BMI has a significant clinical effect on BP variables only when it reaches the critical value of 23.0 kg/m^2 or higher. It may be mentioned here that the value of 23.0 kg/m^2 is the proposed cutoff point of BMI for overweight in Asian populations (WHO 2000). In Finnish men (Jousilahti et al. 1995), HT was 18% among the leanest (BMI<20). It is also worth mentioning here that the prevalence of hypertension even in the lower BMI categories (15 and 16%) is no less in view of public health consequences. Therefore, it may be inferred that in this population with tough challenges in life, there are other important factors in addition to body weight and adverse dietary profile that contribute substantially to the elevated level of BP.

Regression analysis also revealed that BMI had a significant positive effect on BMI independent of age, MPCI, smoking and alcohol intake status. BMI explained more variation of DBP (16.8) than of SBP (8.3%), whereas age explained relatively more of SBP than DBP. It is also noteworthy to mention that the HT group had significantly higher values of age, weight and BMI than their NT counterparts. In the study mentioned above (Gopi Chand and Sambasiva Rao 2007), BMI had an independent significant influence on SBP and DBP, and both of these elevated markedly with increasing BMI.

In conclusion, our study demonstrated that even in a slum-dwelling population with low mean BMI and a high rate of under nutrition, increased BMI, particularly above a certain range (>22.9 kg/m^2), is an independent risk factor for HT. This may have serious public health implications and requires further research. More importantly, prospective studies on various ethnic groups having low BMI and a high rate of under nutrition are required to better understand the etiology of hypertension. There may be significant ethnic differences in the relationship of BMI and BP. Lastly, the relationship of body fat, as measured by skin folds and other methods of body composition, with hypertension should be investigated in populations having a low mean BMI. These studies will probably give a better insight into the relationship of adiposity, independent of BMI, with HT.

Acknowledgements All subjects who participated in the study are gratefully acknowledged. This work was partly funded by the University Grants Commission (India) Minor Research Project grant no. PSW054/03–04 ERO awarded to R.C. The authors acknowledge the help of Atul Dhali, Gopal Das and Swapan Mallik of Bidhanpally.

Conflict of interest The authors confirm that there are no relevant associations that might pose a conflict of interest.

References

Baumgartner RN, Siervogel RM, Roche AF (1989) Clustering of cardiovascular disease risk factor in associations with indices of adiposity and adipose tissue distribution in adults. Am J Biol 1:43–152

Bhadra M, Mukhopadhyay A, Bose K (2002) Adiposity, central body fat distribution and blood pressure among young Bengalee adults of Kolkata, India: sexual dimorphism. J Physiol Anthropol Appl Human Sci 21(6):273–276

Bjorntorp P (1987) Classification of obese patients and complications related to the distribution of surplus fat. Am J Clin Nutr 45(Suppl 5):1120–1125

Bose K, Chaudhuri AB (2001) A comparative study of adiposity and central body fat distribution of normotensive and hypertensive older Bengalee Hindu women of Calcutta, India. Coll Antropol 25(2):521–527

Bose K, Mascie-Taylor CGN (1998) Conicity index and waist-to-hip ratio and their relationship with total cholesterol and blood pressure in middle aged Europeans and migrant Pakistani men. Ann Hum Biol 25:11–16

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

Brown CD, Higgins M, Donato KA, Rohde FC, Garrison R, Oberzanek E, Ernst ND, Horan M (2000) Body mass index and the prevalence of hypertension and dyslipidemia. Obes Res 8:605–619

Bunnag SC, Amorn SC, Chandraprasert S (1990) The prevalence of obesity, risk factors and associated disease in Klong Toey slum and Klong Toey government apartment houses. Diabetes res clin pract 10(Suppl 1):S81–S87

Canoy D, Luben R, Welch A, Bingham S, Wareham N, Day N, Khaw KT (2004) Fat distribution, body mass index and blood pressure in 22,090 men and women in the Norfolk cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Norfolk) study. J Hypertens 22(11):2067–2074

Cappuccio FP, Kerry SM, Adeyemo A, Luke A, Amoah AG, Bovet P, Connor MD, Forrester T, Gervasoni JP, Kaki GK, Plange-Rhule J, Thorogood M, Cooper RS (2008) Body size and blood pressure: an analysis of Africans and the African diaspora. Epidemiology 19(1):38–46

Chobanion AV, Bakris GL, Black HR (2003) The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure – the JNC VII report. J Am Med Assoc 289:2560–2572

Das SK, Sanyal K, Basu A (2005) Study of urban community survey in India: growing trend of high prevalence of hypertension in a developing country. Int J Med Sci 2(2):70–78

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

Deshmukh PR, Gupta SS, Dongre AR, Bharambe MS, Maliya C, Kaur S, Garg BS (2006) Relationship of anthroipometric indicators with blood pressure levels in rural Wardha. Ind J Med Res 123:657–664

Droyvold WB, Midthjell K, nilsen TI, Holmen J (2005) Change in body mass index and its impact on blood pressure: a prospective population study. Int J Obes 29(6):650–655

Ellekjaer H, Holmen J, Vatten L (2001) Blood pressure, smoking and body mass in relation to mortality from stroke and coronary heart disease in the elderly. A 10-year follow-up in Norway. Blood Press 10(3):156–163

Feldstein CA, Akopian M, Olivieri AO, Kramer AP, Nasi M, Garrido D (2005) A comparison of body mass index and waist-to-hip ratio as indicators of hypertension risk in an urban Argentine population: a hospital-based study. Nutr Metab Cardiovasc Dis 15(4):310–315

Gerber LM, Schwartz JE, Schnall PL, Pickering TG (1995) Body fat and fat distribution in relation to sex differences in blood pressure. Am J Hum Biol 7:173–182

Ghosh JR, Bandyopadhyay AR (2007) Comparative evaluation of obesity measures: relationship with blood pressures and hypertension. Singapore Med J 48(3):232–235

Ghosh A, Bose K, Das Chaudhuri AB (2000) Comparison of anthropometric characteristics between normotensive and hypertensive individuals among a population of Bengalee Hindu elderly men in Calcutta, India. J R Soc Health 120(2):100–106

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(1):53–58

Gu Q, Burt VL, Paulose-Ram R, Yoon S, Gillum RF (2008) High blood pressure and cardiovascular disease mortality risk among U.S. adults: the third National Health and Nutrition Examination Survey mortality follow-up study. Ann Epidemiol 18(4):302–309

Gupta R (2004) Trends in hypertension epidemiology in India. J Hum Hypertens 18:73–78

Gupta R, Mehrishi S (1997) Waist-hip ratio and blood pressure correlation in an urban Indian population. J Ind Med Assoc 95:412–415

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 subejcts. J Assoc Physicians India 55:621–627

Henriksson KM, Lindblad U, Gullberg B, Agren B, Nilsson-Ehle P, Råstam L (2003) Body composition, ethnicity and alcohol consumption as determinants for the development of blood pressure in a birth cohort of young middle-aged men. Eur J Epidemiol 18(10):955–963

Hu G, Tuomilehto J, Silventoinen K, Sarti C, Mannisto S, Jousilahti P (2007) Body mass index, waist circumference, and waist-hip ratio on the risk of total and type-specific stroke. Arch Intern Med 167(13):1420–1427

Pandian JD, Srikanth V, Read SJ, Thrift AG (2007) Poverty and stroke in India: a time to act. Stroke 38:3063–3069

Jousilahti P, Tuomilehto J, Vartiainen E, Valle T, Nissinen A (1995) Body mass index, blood pressure, diabetes and the risk of anti-hypertensive drug treatment: 12-year follow-up of middle-aged people in eastern Finland. J Hum Hypertens 9(10):847–854

Kearney PM, Whelton M, Reynolds K, Whelton PK, He J (2004) Wordwide prevalence of hypertension: a systematic review. J Hypertens 22:11–19

Khan A, Haq FU, Pervez MB, Saleheen D, Frossard PM, Ishaq M, Hakeem A, Sheikh HT, Ahmad U (2008) Letter to the editor: Anthropometric correlates of blood pressure in normotensive Pakistani subjects. Int J Cardiol 29:259–262

Kopelman PG (2000) Obesity as a medical problem. Nature 404:635–643

Kusuma YS, Babu BV, Naidu JM (2004) Prevalence of hypertension in some cross cultural populations in Visakhapatnam district, South India. Ethn Dis 14:250–259

Mark AL, Corcia M, Morgan DA, Shaffer RA, Haynes WG (1999) Obesity induced hypertension: new concepts from the emerging biology of obesity. Hypertension 33:537–541

Mascie-Taylor CGN (1994a) Analysing cross sectional anthropometric data. Eur J Clin Nutr 48:S190-S202

Mascie-Taylor CGN (1994b) Statistical issues in anthropometry. In: Ulijaszek SJ, Mascie-Taylor CGN (eds) Anthropometry: The Individual and the Population, Cambridge University Press: Cambridge, pp 56–77

Misra A, Pandey RM, Rama Devi J, Sharma R, Vikram NK, Khanna N (2001) High prevalence of diabetes, obesity and dyslipidaemia in urban slum popu;ation in northern India. Int J Obes 25:1722–1729

Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH (1999) The disease burden associated with overweight and obesity. J Am Med Assoc 282:1523–1529

Nirmala Reddy B (1998) Blood pressure and adiposity: a comparative study of socio-economically diverse groups of Andhra Pradesh, India. Am J Hum Biol 10:5–21

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

Sadhukhan SK, Bose K, Mukhopadhyay A, Bhadra M (2007) Age variations in overweight men and women in rural areas of Hooghly District, West Bengal. Indian J Public Health 51 (1):59–61

Saha I, Raut DK, Paul B (2007) Anthropometric correlates of adolescent blood pressure. Indian J Public Health 51(3):190–192

Santhirani CS, Pradeepa R, Deepa R, Premalatha G, Saroja R, Mohan V (2003) Prevalence and risk factors of hypertension in selected South Indian population – the Chennai Urban Population Study. J Assoc Physicians India 51:20–27

Seidell JC, Cigolini M, Charzewska J et al (1990) Fat distribution in European women: a comparison of anthropometric measurements in relation to cardiovascular risk factors. Int J Epidemiol 19:303–308

Selmer R, Tverdal A (1995) Body mass index and cardiovascular mortality at different levels of blood pressure: a prospective study of Norwegian men and women. J Epidemiol and Community Health 49(3):265–270

Shah B (1992) Progress in cardiovascular research in India during the last two decades (1971–92). Ind C Med Res Bull 22:45–53

Venkataramana P, Geeta Vani C, Chengal Reddy P (2001) Association of body mass index, body fat distribution and fat patterning with blood pressure in two populations of Andhra Pradesh. J Hum Ecol 12:63–68

World Health Organisation (1996) Hypertension control. World Health Organisation (Technical Report Series No. 862). Geneva, Switzerland

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

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

Zhou B, Cooperative Meta-Analysis Group of Working Group on Obesity in China (2002) Prospective study for cut-off points of body mass index in Chinese adults. Zhonghua Liu Zing Bing Xue Za Zhi 23(6):431–434