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Adiposity measures and their relationship with metabolic risk factors for coronary heart disease in Bengalee Hindu men of Kolkata, India

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Abstract The aim of the present study was to investigate the associations of generalized and central adiposity with established metabolic risk factors for coronary heart disease (CHD) among Bengalee Hindu men of Kolkata, India. A cross-sectional study of 212 Bengalee Hindu men resident in Kolkata, India, was undertaken utilizing four measures of adiposity: body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), and conicity index (CI). Total cholesterol (TC), high density (HDL-C), low density (LDL-C) and very low density (VLDL-C) cholesterol lipoproteins, fasting blood glucose (FBG) and fasting triglyceride (FTG) levels were recorded. Results revealed that BMI did not have significant correlation with any of the metabolic variables. The Pearson correlation coefficients (r) of the central adiposity measures (WC, WHR and CI) were similar. WC, WHR and CI were significantly correlated (except WC and TC) with TC, VLDL-C, FBG and FTG. However, HDL-C and LDL-C did not show significant correlation with WC, WHR and CI. Regression analyses revealed that WC, WHR and CI had significant impact on TC, VLDL-C, FBG and FTG. All three measures of central adiposity had similar effect. This significant effect remained essentially the same even after controlling for BMI. In conclusion, the present investigation revealed that among Bengalee Hindu men, any one of these three measures (WC, WHR and CI) can be used in cross-sectional epidemiological studies dealing with the relationship of central adiposity and metabolic risk factors for CHD.

Key words: Bengalee men, body mass index, central obesity, metabolic variables, coronary heart disease

Introduction

The notion that accumulation of intra-abdominal or visceral fat is the main determinant of obesity related diseases like coronary heart disease (CHD), non-insulin dependent diabetes mellitus (NIDDM), hypertension, hyperlipidaemia, etc., is now well accepted. There are several methods available to measure directly the intra-abdominal fat volume. However, simple noninvasive techniques of anthropometry could be a valid alternative to direct measures like computed tomography (CT) and magnetic resonance imaging (MRI) (Valdez et al., 1993; Seidell and Bouchard, 1997). Although there are several indirect measures of adiposity, to date there is none which is universally accepted, nor is it established which one best predicts CHD.

Generalized obesity as measured by body mass index (BMI) is characterized by excess total body fat content without any particular concentration of fat in a given area of the body (Bouchard, 1994). Abdominal adiposity or central obesity characterized by excessive amount of fat in the abdominal area is estimated usually by three measures, namely, waist circumference (WC), waist to hip ratio (WHR) and conicity index (CI). Several investigations have revealed that WHR is strongly related to CHD risk factors and is a good predictor of CHD (Rimm et al., 1995; Cox et al., 1997). For purposes of health promotion, WC is now preferred in studies of health risks, since WC reflects total and abdominal fat accumulation and as a measure of adiposity is not greatly influenced by height (Lean et al., 1998). The use of CI on the other hand implies that abdominal obesity is modeled as the progression of a body from cylindrical shape towards the shape of a double cone having a common base at the waist level (Valdez et al., 1993).

There are several recent publications which have compared the associations of different measures of adiposity with metabolic risk factors for CHD among the different ethnic groups of India (Singh et al., 1996; Lubree et al., 2002; Venkataramana and Reddy, 2002, Ghosh et al., 2003). In view of these considerations, the present study was undertaken to examine the inter-relationships of four anthropometric measures, namely BMI, WC, WHR and CI, with some established metabolic risk factors for CHD among Bengalee Hindu men of Kolkata, India. Specifically, this study attempted to determine which measure of adiposity relates best with metabolic risk factors for CHD, among this population.

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Materials and Methods

Study population

The present study was conducted during the period of December 1999 to July 2000 at the outpatients department of B. R. Singh Hospital, Eastern Railways, Kolkata. A total of 212 male railway employees aged over 30 years participated in a health check-up program. All individuals were urban dwellers belonging to the Bengalee Hindu population. Bengalee Hindu population is a distinct ethnic group (Ghosh et al., 2001). Ethnicity of the subjects was verified based on the answer to a specific question used in the questionnaire. Anthropometric and lipid profile measurements were made after the subjects had completed a questionnaire which included questions on their age, medical history, exercise undertaken, alcohol consumption and smoking status. A total of five subjects were receiving treatment either for high cholesterol or diabetes and they were included in the analyses and presented here since the removal of these individuals does not result in any significant changes to the conclusions.

Anthropometric measurements

Height, weight, waist and hip circumferences were made using standard techniques (Lohman et al., 1988) by a trained investigator (AG). Height (anthropometer, Harpenden, UK) and weight (weighing scale, Doctor Beliram and Sons, New Delhi, India) were measured to the nearest 0.1 cm and 0.5 kg, respectively. Waist and hip circumferences were measured to the nearest 0.1 cm using a tape measure (Triced, Shanghai, China).

Body Mass Index (BMI), Waist-Hip ratio (WHR) and Conicity Index (CI) were computed using the standard formula (Valdez et al., 1993):

$$BMI = \text{Weight (kg)} / \text{Height}^2 (m^2)$$
$$WHR = \text{Waist circumference (cm)} / \text{Hip circumference (cm)}$$
$$CI = WC (m) / (0.109) \sqrt{} (\text{Weight (kg)} / \text{Height (m)})$$

Metabolic variables

A fasting blood sample of 7 ml was collected from each subject for the determination of metabolic variables. All subjects had maintained an overnight fast (at least 12 hours duration) prior to blood collection. Plasma was separated by centrifugation at 1000x g for 20 minutes at room temperature within 2 hours of collection. Estimation of total cholesterol (TC), fasting blood glucose (FBG) and fasting triglyceride (FTG) were done on separated plasma using a Technicon RA-XT autoanalyzer (Technicon Instruments Corporation, NY., USA). High density lipoprotein cholesterol (HDL-C) was measured after an overnight stand of plasma in refrigerator and then precipitation of non-high density lipoproteins (LDL-C, VLDL-C, chylomicrons) with manganese-heparin substrate (Varley et al., 1980).

Values of low density lipoprotein cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) were estimated using the following formulae (Friedwald et al., 1972):

$$LDL - C = TC - (HDL + FTG/5)$$
$$VLDL - C = FTG/5$$

All biochemical analyses were done at the Biochemistry Unit of the Department of Pathology, B. R. Singh Hospital, Kolkata. All metabolic variables were measured in mmol/l.

Statistical analyses

Correlation studies were undertaken using Pearson correlation coefficients (r). Linear regression analyses were used to investigate the relationship of WC, WHR and CI with the metabolic variables. The metabolic variables (each separately) were the dependent variables. All statistical analyses were performed using the SPSS (Statistical Package for Social Sciences) Version 5.

Results

The mean age of the study population was 50.8 years (sd = 10.2 years). The majority of the subjects were non-smokers (68.4%) leading a sedentary lifestyle (95.3%). None of them regularly consumed alcohol. Table 1 presents the mean, standard error of mean and standard deviations of the anthropometric and metabolic variables and indices of the Bengalee Hindu men.

Age did not have any significant correlation with BMI, WC, WHR and CI. The results of correlation analyses of the adiposity measures and metabolic variables are presented in Table 2. BMI did not have significant correlation with any of the metabolic variables. The Pearson correlation coefficients (r) of WC, WHR and CI were similar. Furthermore, WC, WHR and CI were significantly correlated (except WC and TC, r = 0.12, $p < 0.08$) with TC (WHR: r = 0.0169; CI: 0.157), VLDL-C (WC: r = 0.169; WHR: 0.163; CI: 0.189), FBG (WC: r = 0.202; WHR: 0.241; CI: 0.244) and FTG (WC: r = 0.169; WHR: 0.163; CI: 0.198). However, HDL-C and LDL-C did not show significant correlation with any measure of central adiposity.

Since there was significant correlation between WC, WHR and CI with TC, VLDL-C, FBG and FTG, regression analyses were undertaken to test the impact of the three measures of central adiposity on these metabolic variables. It was observed (Table 3) that these three measures of central

Table 1. Anthropometric and metabolic characteristics of the study population (n = 212)

Variable	Mean	sem	sd
Anthropometric			
Height (cms)	164.7	0.45	6.59
Weight (kgs)	64.9	0.63	9.16
BMI (kg/m^2)	23.9	0.19	2.80
Waist circumference (cm)	87.2	0.46	6.63
Hip circumference (cm)	90.3	0.34	4.92
Waist-Hip ratio	0.966	0.003	0.041
Conicity index	1.279	0.004	0.057
Metabolic			
Total cholesterol (mmol/l)	5.51	0.06	0.91
HDL cholesterol (mmol/l)	1.24	0.01	0.13
LDL cholesterol (mmol/l)	3.26	0.05	0.74
VLDL cholesterol (mmol/l)	0.46	0.02	0.24
Fasting blood glucose (mmol/l)	6.26	0.07	1.07
Fasting triglyceride (mmol/l)	2.30	0.08	1.21

sem = standard error of mean, sd = standard deviation.

Table 2. Pearson correlation coefficient (r) of BMI, WC, WHR and CI with metabolic variables

Adiposity measures	Metabolic variables					
	TC	HDL-C	LDL-C	VLDL-C	FBG	FTG
BMI	0.024	−0.034	−0.057	0.059	0.089	0.059
WC	0.119	0.017	−0.031	0.169**	0.202**	0.169**
WHR	0.169**	0.038	0.029	0.163**	0.241***	0.163**
CI	0.157*	0.095	0.047	0.189**	0.244***	0.198**

BMI = Body mass index, WC = Waist circumference, WHR = Waist hip ratio, CI = Conicity index.
TC = Total cholesterol, HDL-C = High density lipoprotein cholesterol, LDL-C = Low density lipoprotein cholesterol, VLDL-C = Very low density lipoprotein cholesterol, FBG = Fasting blood glucose, FTG = Fasting triglyceride.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3. Regression of central adiposity measures with TC, VLDL-C, FBG and FTG

Central adiposity measure	B	s.e.B	Beta	t	*p*
Metabolic variable = TC					
WC	0.016	0.009	0.119	1.739	< 0.080
WHR	3.796	1.524	0.169	2.490	< 0.025
CI	2.508	1.092	0.157	2.297	< 0.025
Metabolic variable = VLDL-C					
WC	0.006	0.002	0.169	2.482	< 0.025
WHR	0.970	0.405	0.163	2.394	< 0.025
CI	0.804	0.288	0.189	2.787	< 0.01
Metabolic variable = FBG					
WC	0.033	0.011	0.202	2.987	< 0.005
WHR	6.308	1.755	0.241	3.594	< 0.0005
CI	4.565	1.254	0.244	3.641	< 0.0005
Metabolic variable = FTG					
WC	0.031	0.012	0.169	2.482	< 0.025
WHR	4.852	2.027	0.163	2.394	< 0.025
CI	4.018	1.442	0.189	2.787	< 0.01

Abbreviations as in Table 2.
B = sample segression coefficient, s.e.B = standard error of regression coefficient, Beta = population regression coefficient, *p* = probablility.

adiposity had similar effect. The three measures of central adiposity had significant effect (except WC and TC, t = 1.793, $p < 0.08$) on TC (WHR: t = 2.49; CI: 2.297), VLDL-C (WC: t = 2.482; WHR: 2.394; CI: 2.787), FBG (WC: t = 2.987; WHR: 3.594; FBG: 3.641) and FTG (WC: t = 2.482; WHR: 2.394; CI: 2.787). This significant effect of WC, WHR and CI remained (results not shown) even after controlling for BMI.

Discussion

Abdominal obesity is a major contributor to the development of several metabolic complications like hypertension, dyslipidaemia, hyperlipidaemia and insulin resistance and NIDDM. It is also the most consistent risk factor for the development of CHD. Although there are several methods now available to measure abdominal fat volume directly, these are very costly and not practical for population studies. Therefore most population based cross sectional studies linking fat distribution to CHD risk factors have relied on anthropometric measurements (Valdez et al., 1993; Seidell and Bouchard, 1997; Bose and Mascie-Taylor, 1998; Kopelman, 2000; Yasmin and Mascie-Taylor, 2000). In the present study, we have used anthropometric indicators of generalized (BMI) and abdominal (WC, WHR and CI) adiposity and have attempted to examine which measure of adiposity best relates to the established metabolic risk factors for CHD among Bengalee Hindu men of Kolkata, India. Results of the present study indicated that there existed no significant relationship of BMI with any of the metabolic risk factors for CHD. Similar results were obtained in a recent study among migrant Indians in Britain (Bose and Mascie-Taylor, 1997) which also reported that BMI did not have significant association with metabolic risk factors of CHD. These results suggest that among Indians, both migrant as well as native, BMI does not have strong association with metabolic risk factors of CHD.

However, all three measures of abdominal adiposity (WC, WHR and CI) had significant (except WC and TC) associations with TC, VLDL-C, FBG and FTG. The correlations of WC, WHR and CI were similar. It has also been reported from Britain (Bose and Mascie-Taylor, 1998) that WHR and CI were significantly correlated with TC among migrant South Asians. It therefore seems that among South Asians, both migrant as well as native, central adiposity is significantly associated with metabolic risk factors of CHD. On the other hand, central adiposity was not significantly related to HDL-C and LDL-C among the Bengalee Hindu men. A recent study from Rajasthan N. W. India (Gupta and Majumdar, 1994) had also found no significant association between WHR with HDL-C and LDL-C. No significant association of WHR and CI with HDL-C and LDL-C has also been reported from The Netherlands, Poland and Portugal (Valdez et al., 1993). Results of the regression analyses further vindicated the positive impact of WC, WHR and CI on TC, VLDL-C, FBG and FTG.

Among the three measures of central adiposity, the common parameter is WC, and strong, positive correlation of measures of abdominal adiposity with established risk factors for CHD indicated the atherogenic nature of enlarged WC. Another interesting finding is that the relationship of the three measures of central adiposity were similar confirming a trend earlier reported among migrant South Asians in Britain (Bose and Mascie-Taylor, 1998). Absence of significant heterogeneity between the correlation coefficients of WC, WHR and CI suggested that all of them related equally with the metabolic risk factors of CHD. Therefore, none of these three measures can be preferred over the other, as surrogate measures of central adiposity in cross-sectional epi-

demiological investigation of risk factors of CHD among Bengalee men.

However, cross-sectional studies like the present one can only highlight the association between central adiposity and metabolic risk factors of CHD. Prospective studies involving various measures of central adiposity and established risk factors of CHD are required before any particular measure of central adiposity can be recommended for use to predict CHD incidence among Bengalees. Such studies are lacking from India. Since there are sex differences in body fat distribution, investigations should be undertaken among females to investigate whether these measures of central adiposity relate similarly with the established metabolic risk factors of CHD. To date, no investigation on these lines have been carried out among the Bengalee ethnic group. The association of central adiposity with metabolic risk factors is not the same in all ethnic groups. Since there exists vast ethnic heterogeneity in India, it would be interesting to study other populations to determine whether the trend observed in the present study also exists among these groups. There is a paucity of data on the association of central adiposity and metabolic risk factors of CHD among various ethnic groups in India (Singh et al., 1996; Joseph et al., 2000; Misra et al., 2001a, b, 2002; Lubree et al., 2002; Reddy et al., 2002; Sethi et al., 2002; Venkataramana and Reddy, 2002). Furthermore from anthropological viewpoint, there is a necessity of analyzing and comparing data among different populations of the world including Bengalee Hindu men to know the relationships between the adiposity measures and metabolic risk factors for coronary heart disease.

Conclusions

The present investigation revealed that among Bengalee Hindu men, cross-sectional epidemiological studies dealing with the relationship of central adiposity and metabolic risk factors for coronary heart disease, can utilize any one of the three measures of central adiposity, namely waist circumference, waist-hip ratio and conicity index.

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