Original Article

Association of overall and abdominal obesity with coronary heart disease risk factors: comparison between urban and rural Indian men

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The relationship of body mass index (BMI), conicity index (CI) and waist circumference to four coronary heart disease (CHD) risk factors (systolic and diastolic blood pressures, total cholesterol and high-density lipoprotein (HDL) cholesterol levels) was examined in urban (n = 110) and rural (n = 102) men aged ≥ 20 years, drawn from the 'Reddy' population of Southern Andhra Pradesh, India. Using ANCOVA we found significant difference (< 0.01) for systolic blood pressure, total cholesterol and HDL cholesterol between the urban and rural samples. The Pearson's correlation coefficients suggest that BMI and waist circumference had significant relationships with most of the risk factors in both the populations. The CI did not significantly influence any of the risk factors in the urban population; however, in the rural population, CI did show a significant positive relationship with both of the blood pressures and with TC. Even after controlling for age, smoking and physical activity (partial correlations), the relations remained constant. In multiple linear regression, BMI showed significant positive association with systolic and diastolic blood pressures (< 0.01) and HDL cholesterol (< 0.05) in the rural population only. However, the CI showed a significant association with HDL cholesterol, and waist circumference with total cholesterol and HDL cholesterol in the rural population. The results of the present study revealed that BMI and waist circumference had a greater influence on the CHD risk factors, and that the influence was more conspicuous in the rural sample. Comparing the association of abdominal obesity measures (CI and waist circumference) with CHD risk factors, waist circumference better correlated with most of the risk factors. Hence the present study suggests that BMI and waist circumference are better indicators of CHD risk factors. However, the importance of CI has to be further studied in South Asian populations.

Key words: abdominal obesity, Andhra Pradesh, blood pressure, coronary heart disease risk, high-density lipoprotein cholesterol, India, obesity, Tirupati, total cholesterol.

Introduction

Cardiovascular disease is a major public health problem both in developed and in developing countries, like India. Coronary heart disease (CHD) is now on the increase in India, possibly due to the changing lifestyle, and is causing grave concern. It has been predicted that cardiovascular diseases will be the most important cause of mortality in India by the year 2015.[1,2] The WHO[3] expert committee on cardiovascular disease and hypertension recommended epidemiological surveys in as many countries as possible to analyze the risk factors and prevalence of the disease in different countries. Many risk factors are responsible for this disease. However, the major and significant risk factors for CHD are hypertension, hypercholesterolemia, diabetes, obesity and sedentary lifestyle.[4] In addition, the role of body-fat distribution in human disease has recently attracted much attention from epidemiologists, physiologists and anthropologists. Obesity is considered to be a predisposing factor for several chronic diseases, including cardiovascular disease,[5,6] hypertension,[7] stroke[6] and noninsulin-dependent diabetes mellitus.[8,9] An understanding of the underlying etiology of obesity may be useful in reducing morbidity and mortality. The body mass index (BMI) refers to overall obesity whereas waist-to-hip ratio (WHR) and conicity index (CI) refer to abdominal adiposity. Both of the abdominal obesity measures (WHR and CI) have significant associations with most of the CHD risk factors in seven European and two American populations.[10]

Hypertension (or high blood pressure) is the most common risk factor for CHD and stroke, affecting 20% of the adult populations in both developed and developing countries.[11,12] It is a well known fact that high levels of cholesterol and low levels of high-density lipoprotein cholesterol (HDLc) are predictors of CHD. The purpose of this study was twofold: firstly, to examine the association of obesity with CHD risk factors and to observe the differences in the influence of obesity on these CHD risk factors in urban and rural Indian men, and secondly, to ascertain whether overall

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obesity or abdominal obesity better correlated with CHD risk factors.

Materials and methods

The data were collected from adult men aged ≥ 20 years from an endogamous 'Reddy' population of the Chittoor district (12.37–14.08 N and 78.03–79.50 E) in the south of Andhra Pradesh, India. A simple random house-to-house survey was employed in selecting the subjects. The aims and objectives of the study were explained to all the subjects and their consent was obtained. Only normal and healthy individuals were included in the study and extended their cooperation in carrying the bio-metrical characters. The response rate in the urban sample was as high as 90%, and about 75% in the rural sample. The non-responders, though normal, were shy and hesitated in participating in the study. However, their non-participation did not affect the results of the study. A total of 110 and 102 men from urban and rural areas, respectively, were interviewed and the data were collected. Caution was taken to avoid related individuals. The urban sample was drawn from Tirupati town and the rural sample in a cluster of three villages 100 km away from Tirupati town.

The data on anthropometry includes height, weight and waist (abdominal) circumference. Height was measured to the nearest 0.1 cm with a standard anthropometer and weight to the nearest 0.1 kg with a portable weighing machine and light clothing. By using standard non-elastic tape, waist circumference was measured to the nearest 0.1 cm at the umbilicus. Standard landmarks and methodology were followed in recording the anthropometric measurements.[13] The body mass index (BMI), to estimate overall obesity, was calculated by dividing body-weight in kilograms by height in metres squared (kg/m^2). The conicity index (CI), to determine abdominal obesity, was calculated by using the formula: $CI = \text{abdominal girth} / (0.109 \sqrt{W/H})$, where abdominal girth was measured in meters, weight (W) in kg, and height (H) in meters.[10] A body mass index ≥ 30 kg/m^2 was considered overweight.

Data on the age, smoking habits and physical activity of each individual were also collected. The smoking habits were categorised as smokers or non-smokers. Current smokers, past smokers and users of all forms of tobacco were pooled together as smokers. Physical activity was classified into three levels. Low/sedentary activity referred to people involved in office work, research, teaching, business and land ownership; medium activity was attributed to dual jobs and land owners involved in agriculture work; and high activity referred to farmers actively involved in the field and in agriculture labours. Though the subjects were classified into three categories based broadly on occupational status, the true sedentary nature of their leisure time and subsequent energy-related expenditure were not attempted in the present study. However, there have been some studies on the energy intake and expenditure of Indian populations.[14]

Systolic and diastolic blood pressures were measured by recording the appearance and disappearance of Korotkoff's sounds to the nearest 2 mmHg on a seated subject. Subjects were identified as hypertensive, based on the United States Fifth Joint National Committee recommendations,[15] if their blood pressure ≥ 140 mmHg systolic or 90 mmHg diastolic. We also classified the population as hypertensive based on the WHO[16] classification of a systolic blood pressure (SBP) of ≥ 160 mmHg and/or diastolic blood pressure (DBP) of ≥ 95 mmHg.

Samples of approximately 5 ml of venous blood were collected into vacutainers containing EDTA. Plasma was separated by centrifugation at 2500 g for 20 min. Total cholesterol and HDLc levels were estimated using standard protocols.[17,18] Hypercholesterolemia and low high-density cholesterol levels were determined according to the definitions of the United States National Cholesterol Education Programme.[19] Based on this criteria, high serum total cholesterol (TC) was taken as ≥ 200 mg/dL and low HDLc was taken as < 35 mg/dL.

Statistical analyses

SPSS (10.0 v) was used for statistical analyses. Analyses include the computation of descriptive statistics, *t*-test, χ^2-test, analysis of covariance (ANCOVA), Pearson's correlation coefficients, partial correlation coefficients and multiple linear regression analysis.

Results

Table 1 shows the descriptive statistics for anthropometry, blood pressures, TC and HDLc levels. The urban population showed significantly higher mean values for all variables except DBP. The difference in prevalence of various risk factors between the urban and the rural samples are presented in Table 2. The results showed that obesity, hypertension, hypercholesterolemia and sedentary life style were more prevalent in urban men, although smoking was more prevalent in the rural sample. Comparison of χ^2-values showed that the prevalence of obesity and sedentary lifestyle were significantly greater in the urban sample, but no significant difference was found for hypertension, hypercholesterolemia and low HDLc levels. Since there were differences in age, smoking habit and physical activity between the urban and rural populations, the mean values of the four risk factors (SBP, DBP, TC and HDLc) between these two populations were compared through ANCOVA adjusting for age, smoking and physical activity. The results suggest that the variance was significant for SBP ($F = 5.873$, $P = 0.000$); TC ($F = 2.804$, $P = 0.002$) and HDLc ($F = 3.036$, $P = 0.001$) while no significant variance was found for DBP ($F = 1.543$, $P = 0.117$). The R^2 values suggest that the factors and covariate together explain about 24, 8, 13 and 14% of the variation in SBP, DBP, TC and HDLc, respectively.

Table 3 shows the Pearson's correlation coefficients between age and body composition measures with blood pressures, TC and HDLc levels. Age showed a significantly positive correlation with SBP and TC, and a significantly negative correlation with HDLc in the urban population, whereas in the rural population, age had a positive significant association with SBP and DBP only. The BMI was positively

Table 1. Physical characteristics of the 'Reddy' population of Southern Andhra Pradesh, India

Characteristic	Urban (*n* = 110)	Rural (*n* = 102)	*P*-value
Age	47.4 ± 9.1	40.8 ± 14.2	< 0.01
Height	168.3 ± 6.5	166.2 ± 6.4	< 0.05
Weight	68.4 ± 11.2	59.9 ± 11.8	< 0.01
Waist circumference	89.9 ± 10.0	79.9 ± 11.1	< 0.01
Body mass index	24.1 ± 3.8	21.6 ± 3.6	< 0.01
Conicity index	1.3 ± 0.1	1.2 ± 0.1	< 0.01
Systolic blood pressure	128.6 ± 18.7	120.6 ± 14.8	< 0.01
Diastolic blood pressure	86.8 ± 11.3	84.6 ± 9.9	NS
Total cholesterol (mg/dL)	176.7 ± 45.8	163.0 ± 47.5	< 0.05
(mmol/L)	4.6 ± 1.2	4.2 ± 1.2	
HDL cholesterol (mg/dL)	42.2 ± 8.7	46.5 ± 9.0	< 0.01
(mmol/L)	1.1 ± 0.2	1.2 ± 0.2	

HDL, high-density lipoprotein; NS, not significant.

Table 2. Different cardiovascular disease risk factors between the urban and rural populations of the 'Reddy' population of Southern Andhra Pradesh, India

Characteristic	Urban (*n* = 110) *n* (%)	Rural (*n* = 102) *n* (%)	*P*-value
Overweight BMI ≥ 30	10 (9.0)	0 (0.0)	< 0.01
Hypertension ≥ 140/90	50 (46.0)	34 (33.0)	NS
Hypertension ≥ 160/95	26 (24.0)	16 (16.0)	NS
Total cholesterol ≥ 200	16 (15.0)	10 (10.0)	NS
HDL cholesterol < 35	18 (17.0)	10 (10.0)	NS
Smoking	30 (27.0)	34 (33.0)	NS
Low/sedentary physical activity	54 (49.0)	24 (26.0)	< 0.01

BMI, body mass index; HDL, high-density lipoprotein; NS, not significant.

Table 3. Comparisons between age and body composition measures and blood pressure and lipid levels in the 'Reddy' population of Southern Andhra Pradesh, India

	Urban				Rural			
Characteristic	Age	BMI	CI	Waist circumference	Age	BMI	CI	Waist circumference
SBP	0.326**	0.228*	0.173	0.242*	0.468**	0.579**	0.354**	0.502**
DBP	0.176	0.323**	0.163	0.566**	0.225*	0.578**	0.208*	0.443**
TC	0.327**	0.081	0.147	0.130	0.137	0.442**	0.290**	0.445**
HDLc	– 0.224*	– 0.054	– 0.036	– 0.035	– 0.049	– 0.331**	– 0.016	– 0.250*

Two-tailed statistical significance (Pearson's correlation coefficient): * 0.05 > P > 0.01; ** 0.01 > P > 0.01; *** P < 0.001. BMI, body mass index; CI, conicity index; DBP, diastolic blood pressure; HDLc, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol.

and significantly associated only with both the blood pressures in the urban sample but in the rural sample, BMI had a significant positive association with both the blood pressures and TC, and an inversely significant association with HDLc. The CI did not show a significant association with any of the variables in the urban population but in the rural population, CI had a significant positive association with SBP, DBP and TC. The waist circumference had a significant positive association with SBP and DBP in the urban population while in the rural population it had a significant positive association with SBP, DBP and TC and a significant inverse relation with HDLc. Further, we calculated partial correlation coefficients between adiposity measures, blood pressures and lipid levels corrected for age, smoking habit and physical activity. These results are presented in Table 4. Even after correcting for these factors, the relationship between adiposity measures and CHD risk factors remained constant in the urban and rural samples.

The results of the multiple linear regression analysis with SBP, DBP, TC and HDLc as dependent variables is presented in Table 5. The SBP was significantly positive in relation to age in the urban population and age and BMI in the rural Reddy population. The DBP was significantly positive in association with BMI in the rural population only. The TC

Table 4. Comparisons between body composition measures and blood pressure and lipid levels in the 'Reddy' population of Southern Andhra Pradesh, India; controlling for age, smoking and physical activity

Variable	Urban BMI	Urban CI	Urban Waist circumference	Rural BMI	Rural CI	Rural Waist circumference
SBP	0.227**	0.109	0.216*	0.547**	0.157	0.404**
DBP	0.324**	0.124	0.288**	0.556**	0.113	0.400**
TC	0.071	0.096	0.102	0.424**	0.255	0.427**
HDLc	– 0.057	– 0.012	– 0.023	– 0.326**	– 0.012	– 0.249**

Two-tailed statistical significance (partial correlation coefficients): * $0.05 > P > 0.01$; ** $0.01 > P > 0.001$; *** $P < 0.001$. BMI, body mass index; CI, conicity index; DBP, diastolic blood pressure; HDLc, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol.

Table 5. Multiple linear regression analysis of data collected from the 'Reddy' population of Southern Andhra Pradesh, India

Dependent variable	Variables in equation	Urban *B*	Urban *P*-value	Rural *B*	Rural *P*-value
SBP	Age	0.320	0.001	0.367	0.000
	BMI	0.050	0.891	1.182	0.001
	CI	–0.088	0.740	0.359	0.224
	Waist circumference	0.224	0.660	–0.990	0.059
	Smoking	0.153	0.100	0.027	0.714
	Physical activity	–0.042	0.966	0.014	0.850
		$R^2 = 0.180$		$R^2 = 0.488$	
DBP	Age	0.172	0.065	0.162	0.101
	BMI	0.225	0.544	1.047	0.005
	CI	–0.075	0.781	0.062	0.848
	Waist circumference	0.140	0.788	–0.604	0.288
	Smoking	0.054	0.569	0.056	0.492
	Physical activity	–0.089	0.336	–0.001	0.993
		$R^2 = 0.146$		$R^2 = 0.389$	
TC	Age	0.316	0.001	0.080	0.464
	BMI	–0.113	0.763	–0.407	0.311
	CI	–0.028	0.918	–0.640	0.075
	Waist circumference	0.217	0.678	1.314	0.039
	Smoking	0.103	0.279	–0.112	0.216
	Physical activity	0.070	0.452	–0.071	0.435
		$R^2 = 0.132$		$R^2 = 0.248$	
HDLc	Age	–0.222	0.023	–0.192	0.078
	BMI	–0.536	0.167	0.818	0.042
	CI	–0.321	0.257	1.383	0.000
	Waist circumference	0.690	0.203	–2.073	0.001
	Smoking	0.086	0.385	0.142	0.114
	Physical activity	0.029	0.762	0.059	0.514
		$R^2 = 0.072$		$R^2 = 0.257$	

BMI, body mass index; CI, conicity index; DBP, diastolic blood pressure; HDLc, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol.

showed a significant positive relationship with age in the urban population and waist circumference in the rural population. The HDLc was inversely significantly associated with age in the urban population and BMI, CI and waist circumference in the rural Reddy population. The age, smoking habit, physical activity and adiposity measures among the urban and rural Reddy populations, explained 18 and 49% of variation for SBP, 15 and 39% of variation for DBP, 13 and 25% of variation for TC, and 7 and 26% of variation for HDLc, respectively.

Discussion

The prevalence of cardiovascular disease risk factors (i.e. obesity, hypertension and hypercholesterolemia) was higher among urban men in the present study. However, smoking was more prevalent in rural men. Most of the urban population led a sedentary lifestyle comparable to the rural population. The differences in lifestyle may be the cause for differences in obesity, abdominal obesity, hypertension and hypercholesterolemia. The ANCOVA (adjusting for age, smoking and physical activity) suggested that there was a significant difference between the urban and rural populations in SBP, TC and HDLc ($P < 0.01$). Earlier studies on Indian populations[20–22] also showed a greater prevalence of coronary heart disease and risk factors in urban subjects. In a population-based study among Marwaris of Calcutta,[23] the Marwaris had 17% of hypertensives and the means of SBP, DBP, TC and HDLc were 125.30 mmHg, 82.28 mmHg, 176.86 mg/dL and 41.06 mg/dL, respectively. Although the results of our study showed similar findings, no significant difference was observed for hypertension and smoking habit between the urban and rural populations (Table 2).

In the present study BMI and waist circumference were significantly associated with many CHD risk factors whereas CI failed to show a significant association with most of the risk factors. However, in seven European and two American populations,[10] WHR and CI were equally important in explaining the association with cholesterol and HDLc. Pertaining to BMI and WHR, our results were consistent with other studies of black[24–26] and white[27–30] populations from outside India. The BMI of the women of Thailand showed significant association with TC and HDLc, while WHR had a significant association with HDLc only.[31] Lean *et al.*[32] showed that men with a large waist circumference (> 102 cm) may develop several disorders including shortness of breath, hypercholesterolemia, hypertension and difficulty with the basic activities of daily life.

Considering the Indian data, the abdominal obesity measured through WHR showed a significant association with blood pressure, but not with lipid levels, in rural men of Rajasthan State, India.[33] In another study, the BMI significantly influenced the lipid levels but not the WHR of men and women of Andhra Pradesh State.[34] In our earlier study BMI influenced blood pressure but not CI.[35] The present study supports the earlier studies conducted on Indian populations,[33–35] but not on European and American populations.[10] In general though, South Asians as a group are not more obese than other ethnic groups as assessed by their BMI. What certainly distinguishes the southern Asians from other ethnic groups is their predisposition to develop abdominal obesity, resulting in an increased WHR.[36] Abdominal obesity, therefore, appears to be a strong independent risk factor for coronary artery disease among South Asians and may go some way in explaining the high mortality rate due to coronary artery disease in this ethnic group. The importance of CI in South Asian populations must be studied further. We conclude that BMI and abdominal obesity measured by waist circumference were more powerful in influencing CHD risk factors and were more reliable risk factors in the present study.

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