Body-Mass Index, Waist-Size, Waist-Hip Ratio and Cardiovascular Risk Factors in Urban Subjects

R Gupta*, Priyanka Rastogi**, M Sarna*, VP Gupta***, SK Sharma****, K Kothari+

Abstract

Background and Objective: Influence of obesity as determinant of cardiovascular risk factors has not been well studied. To determine association of obesity, measured by body-mass index (BMI), waist-size or waist-hip ratio (WHR), with multiple risk factors in an urban Indian population we performed an epidemiological study.

Methods: Randomly selected adults ≥ 20 years were studied using stratified sampling. Target sample was 1800 (men 960, women 840). 1123 subjects (response 62.4%) were evaluated and blood samples were available in 532 men and 559 women (n=1091, response 60.6%). Measurement of anthropometric variables, blood pressure, fasting blood glucose and lipids was performed. Atherosclerosis risk factors were determined using current guidelines. Pearson’s correlation coefficients (r) of BMI, waist and WHR with various risk factors were determined. BMI was categorized into five groups: <20.0 Kg/m², 20.0-22.9, 23.0-24.9, 25.0-29.9, and ≥ 30 Kg/m²; waist size was divided into five groups and WHR into six groups in both men and women. Prevalence of cardiovascular risk factors, smoking, hypertension, diabetes, metabolic syndrome and dyslipidaemias was determined in each group and trends analyzed using least-squares regression.

Results: There is 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), fasting glucose (0.15 to 0.26), and LDL cholesterol (0.16 to 0.03) and negative correlation with physical activity and HDL cholesterol (-0.22 to -0.08) in both men and women (p<0.01). With increasing BMI, waist-size and WHR, prevalence of hypertension, diabetes, and metabolic syndrome increased significantly (p for trend <0.05). WHR increase also correlated significantly with prevalence of high total and LDL cholesterol and triglycerides (p <0.05).

Conclusions: There is a continuous positive relationship of all markers of obesity (body-mass index, waist size and waist hip ratio) with major coronary risk factors- hypertension, diabetes and metabolic syndrome while WHR also correlates with lipid abnormalities.
viscosity. Weight gain during young adulthood may be one of the most important determinants of cardiovascular risk.

In India, escalating population levels of major coronary risk factors have contributed to the coronary heart disease (CHD) epidemic. Studies and reviews have amply demonstrated that parallel to the CHD increase in Indian urban populations there has been an increase in prevalence of hypertension, diabetes, high LDL cholesterol, low HDL cholesterol and the metabolic syndrome. Correlation of body-mass index (BMI) and other markers of obesity with these risk factors has not been well studied. We hypothesise that the major coronary risk factors correlate positively with generalised obesity compared to other measures such as waist size or waist-hip ratio (WHR). To test this hypothesis we performed an epidemiological study in an urban Indian population.

**METHODS**

The study was approved by the institutional ethics committee. Detailed protocol of the study has been reported. Details of major cardiovascular risk factors such as smoking, alcohol intake, amount of physical activity, diabetes and hypertension were inquired. The physical examination emphasized measurement of height, weight, waist-hip ratio (WHR) and blood pressure. Height was measured in centimetres and weight in kilograms using calibrated spring-balance. Waist girth was measured at the level of umbilicus with person breathing silently and hip measured as standing inter-trochanteric girth according to the WHO guidelines. Blood pressure (BP) was measured using standard mercury manometer. At least two readings at 5 minutes intervals were recorded and if a high BP (≥ 140/90) was noted a third reading was taken after 30 minutes. The lowest of the three readings was taken as BP. Fasting blood sample was obtained from all the individuals for estimation of glucose, total, HDL and LDL cholesterol and triglycerides using previously standardised techniques.

The study was designed to investigate people at random and to cover large and varied areas of Jaipur with a view to include persons from all walks of urban life. Randomly chosen wards from different regions of the city were identified so as to cover different socioeconomic groups. Details of the population in these wards were available from the Voters' Lists. We randomly selected population proportionate sample of 300 persons (160 males, 140 females) from each locality. The total study sample was 1800 (960 males, 840 females) who were invited for participation. This sample size was considered adequate for identification of major coronary risk factors. The formulae for calculation of the sample size have been reported. The study was preceded by meetings with local leaders who cooperated in identifying and ensuring participation of selected subjects.

The diagnostic criteria for risk factors have been reported. Smokers in India consume tobacco in various forms, therefore, users of all types of tobacco products and present and past smokers were included in smoker category. Physical activity was measured by asking about both work-related and leisure-time activities. Hypertension was diagnosed when systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg or a person was a known hypertensive. BMI (weight in Kg)/(height in metres)² was calculated and overweight and obesity defined as BMI ≥ 25 kg/m². Truncal obesity was diagnosed when WHR was >0.90 in men and >0.80 in women according to second report of National Cholesterol Education Program (ATP-2). Abdominal obesity was diagnosed when waist size was more than 102 cm in men and > 88 cm in women according to the third report of National Cholesterol Education Program (ATP-3). Diabetes was diagnosed when history of diagnosis was present or fasting blood glucose was ≥ 126 mg/dl. Dyslipidaemia was defined by the presence of high total cholesterol (≥ 200 mg/dl), high LDL cholesterol (≥ 130 mg/dl), low HDL cholesterol (men <40 mg/dl; women <50 mg/dl) or high triglycerides (≥ 150 mg/dl) according to ATP-3. Metabolic syndrome was defined when any three of the five diagnostic criteria suggested by ATP-3 (abdominal obesity, high triglycerides ≥ 150 mg/dl, low HDL cholesterol men <40 mg/dl, women <50 mg/dl) or high blood pressure ≥ 130/85 mm Hg, and fasting glucose ≥ 110 mg/dl) were present.

**Statistical analysis**

Continuous variables are reported as mean ± 1 SD. The prevalence rates are reported as percent. Variables have been compared using either t-test or χ² test as appropriate. For calculations of correlation coefficients BMI, waist size (cm) and WHR were correlated with continuous variables of age, systolic BP, diastolic BP, waist, WHR, fasting glucose, cholesterol, LDL cholesterol, HDL cholesterol and triglycerides. Smoking was graded as 0= no tobacco users, 1= non-smoke tobacco users, 2= smokers), physical activity was graded as 0= no activity, 1= occupational physical activity and 2= leisure-time physical activity, and included in correlation analysis. Regression analysis was performed with BMI, waist and WHR as independent variables and trend graphs were prepared using GBStat Version 7.0 statistical program (Dynamic Microsystems, Silver Spring, MD, USA). BMI was classified into various groups for inter-group comparison of risk factors: Group I <20.0 kg/m², Group II 20.0-22.9, Group III 23.0-24.9, Group IV 25.0-29.9 and Group V ≥ 30 Kg/m² modified from WHO classification and the Second US Cancer Prevention Study. The waist-size was classified into five groups and the criteria used were different for men.
and women. In men these groups were <80 cm, 80-89 cm, 90-99 cm, 100-109 cm and ≥ 110 cm. WHR was grouped into six categories. Men were classified into <0.8, 0.80-0.84, 0.85-0.89, 0.90-0.94, 0.95-0.99 and ≥ 1.00 and women into <0.75, 0.75-0.80, 0.80-0.85, 0.85-0.90, 0.90-0.94 and ≥ 0.95. Prevalence of risk factors was determined in various groups and trends examined using least-squares regression method. In view of large sample size for correlation analyses p value <0.01 was considered significant while for other statistics p values <0.05 considered significant.

RESULTS

1123 of 1800 eligible subjects were clinically examined. Fasting blood samples were available in 1091 subjects (response 60.6%). 532/960 men (55.4%) and 559/840 women (66.5%) were evaluated. The prevalence of major coronary risk factors is shown in Table 1. There is a high prevalence of smoking or tobacco use, physical inactivity (either work-related or leisure time), overweight and obesity, truncal obesity, hypertension, diabetes and the metabolic syndrome. The most common dyslipidaemia in both males and females is low HDL cholesterol. Prevalence of high total- and LDL cholesterol and triglycerides was also seen in significant proportions.

There is a significant correlation of age with waist and WHR in men and with BMI, waist and WHR in women (Table 2). In men, BMI correlated significantly with waist (r= 0.77), WHR (0.38), systolic BP (0.46), diastolic BP (0.42) and fasting glucose (0.20) and negatively with smoking (-0.19), physical activity (-0.41) and HDL cholesterol (-0.18). There is a weak positive correlation with total cholesterol and LDL cholesterol. In women there is a significant positive correlation with waist (r= 0.80), WHR (0.19), systolic BP (0.44), diastolic BP (0.27), cholesterol (0.11) and LDL cholesterol (0.15) and negative correlation with smoking (-0.13), physical activity (-0.29) and HDL cholesterol (-0.22). Waist circumference and WHR also correlate positively with multiple coronary risk factors as shown in Table 2. There is a significant increase in mean levels of systolic BP, diastolic BP and fasting glucose with increasing BMI, waist-size and WHR in both men and women. Any physical activity (work-related or leisure-time) was inversely related to BMI (r²= 0.92 men, 0.98 women), waist-size (r²= 0.92 men, 0.90 women) as well as WHR (r²= 0.93 men, 0.95 women) (Tables 3-5).

<table>
<thead>
<tr>
<th>Table 1: Prevalence of coronary risk factors</th>
</tr>
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<tbody>
<tr>
<td>Risk Factor</td>
</tr>
<tr>
<td>Physical inactivity (work-related or leisure-time)</td>
</tr>
<tr>
<td>Smoking/ tobacco use</td>
</tr>
<tr>
<td>Overweight or obesity, BMI ≥ 25 kg/m²</td>
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<tr>
<td>Obesity, BMI ≥ 30 kg/m²</td>
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<tr>
<td>Abdominal obesity (waist, men &gt;102 cm, women &gt;88 cm)</td>
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<tr>
<td>Truncal obesity (waist/hip ratio men &gt;0.9, women &gt;0.8)</td>
</tr>
<tr>
<td>Hypertension (BP ≥ 140/ ≥ 90 or known)</td>
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<tr>
<td>Diabetes (history or fasting glucose ≥ 126 mg/dl)</td>
</tr>
<tr>
<td>High Total cholesterol ≥ 200 mg/dl</td>
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<tr>
<td>High LDL cholesterol ≥ 130 mg/dl</td>
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<tr>
<td>Low HDL cholesterol &lt;40 mg/dl</td>
</tr>
<tr>
<td>High Triglycerides ≥ 150 mg/dl</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Correlation coefficients obesity indices with coronary risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men (n= 532)</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>Waist</td>
</tr>
<tr>
<td>WHR</td>
</tr>
<tr>
<td>Systolic BP</td>
</tr>
<tr>
<td>Diastolic BP</td>
</tr>
<tr>
<td>Fasting glucose</td>
</tr>
<tr>
<td>Cholesterol</td>
</tr>
<tr>
<td>LDL cholesterol</td>
</tr>
<tr>
<td>Triglycerides</td>
</tr>
<tr>
<td>HDL cholesterol</td>
</tr>
</tbody>
</table>

BMI - body mass index, WHR - waist hip ratio, BP - blood pressure. Two-tailed significance * p<0.01, ** p<0.001
<table>
<thead>
<tr>
<th>Risk factors</th>
<th>&lt;20.0</th>
<th>20.0-22.9</th>
<th>23.0-24.9</th>
<th>25.0-29.9</th>
<th>≥ 30.0</th>
<th>r² (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men (n=532)</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
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<td>87</td>
<td>106</td>
<td>133</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td><strong>Smoking/tobacco</strong></td>
<td>70 (50.7)</td>
<td>34 (39.1)</td>
<td>37 (34.9)</td>
<td>41 (30.8)</td>
<td>18 (26.5)</td>
<td>0.94 (0.007)</td>
</tr>
<tr>
<td><strong>Any physical activity</strong></td>
<td>95 (70.4)</td>
<td>36 (41.4)</td>
<td>26 (24.5)</td>
<td>18 (13.5)</td>
<td>5 (7.3)</td>
<td>0.92 (0.009)</td>
</tr>
<tr>
<td><strong>Truncal obesity WHR &gt;0.9</strong></td>
<td>31 (22.5)</td>
<td>40 (46.0)</td>
<td>70 (66.0)</td>
<td>105 (78.9)</td>
<td>59 (86.8)</td>
<td>0.96 (0.003)</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>22 (15.9)</td>
<td>19 (21.8)</td>
<td>43 (40.6)</td>
<td>69 (51.9)</td>
<td>44 (64.7)</td>
<td>0.98 (&lt;0.001)</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>6 (4.3)</td>
<td>12 (13.8)</td>
<td>14 (13.2)</td>
<td>27 (20.3)</td>
<td>11 (16.2)</td>
<td>0.66 (0.093)</td>
</tr>
<tr>
<td><strong>Metabolic syndrome</strong></td>
<td>7 (5.1)</td>
<td>8 (9.2)</td>
<td>16 (15.1)</td>
<td>54 (40.6)</td>
<td>37 (54.4)</td>
<td>0.77 (0.052)</td>
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<tr>
<td><strong>Cholesterol ≥ 200mg/dl</strong></td>
<td>34 (24.6)</td>
<td>39 (44.8)</td>
<td>44 (41.5)</td>
<td>56 (42.1)</td>
<td>26 (38.2)</td>
<td>0.33 (0.315)</td>
</tr>
<tr>
<td><strong>LDL cholesterol ≥ 130mg/dl</strong></td>
<td>32 (23.2)</td>
<td>42 (48.3)</td>
<td>45 (42.4)</td>
<td>53 (39.8)</td>
<td>25 (36.8)</td>
<td>0.10 (0.604)</td>
</tr>
<tr>
<td><strong>HDL cholesterol &lt; 40mg/dl</strong></td>
<td>58 (42.0)</td>
<td>47 (45.0)</td>
<td>68 (64.2)</td>
<td>80 (60.2)</td>
<td>39 (57.4)</td>
<td>0.46 (0.205)</td>
</tr>
<tr>
<td><strong>Triglycerides ≥ 150mg/dl</strong></td>
<td>28 (20.3)</td>
<td>27 (31.0)</td>
<td>40 (37.7)</td>
<td>56 (42.1)</td>
<td>21 (30.9)</td>
<td>0.39 (0.262)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are percent. BMI - body mass index, WHR - waist-hip ratio, BP - blood pressure, LDL - low density lipoprotein, HDL - high density lipoprotein. Trends (r²) were determined by least-squares regression method.

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>&lt;80 cm</th>
<th>80-89 cm</th>
<th>90-99 cm</th>
<th>100-109 cm</th>
<th>≥ 110</th>
</tr>
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<tbody>
<tr>
<td><strong>Women (n=559)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>121</td>
<td>96</td>
<td>61</td>
<td>169</td>
<td>112</td>
</tr>
<tr>
<td><strong>Smoking/tobacco</strong></td>
<td>27 (22.3)</td>
<td>11 (11.5)</td>
<td>3 (4.9)</td>
<td>14 (8.3)</td>
<td>10 (8.9)</td>
</tr>
<tr>
<td><strong>Any physical activity</strong></td>
<td>83 (68.6)</td>
<td>51 (53.1)</td>
<td>28 (45.9)</td>
<td>54 (31.9)</td>
<td>16 (13.5)</td>
</tr>
<tr>
<td><strong>Truncal obesity WHR &gt;0.8</strong></td>
<td>42 (34.7)</td>
<td>61 (63.5)</td>
<td>49 (80.3)</td>
<td>70 (78.9)</td>
<td>59 (86.8)</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>12 (9.9)</td>
<td>22 (22.9)</td>
<td>23 (37.7)</td>
<td>78 (76.8)</td>
<td>75 (70.6)</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>2 (1.7)</td>
<td>7 (7.3)</td>
<td>6 (9.8)</td>
<td>22 (20.3)</td>
<td>27 (24.1)</td>
</tr>
<tr>
<td><strong>Metabolic syndrome</strong></td>
<td>13 (10.7)</td>
<td>18 (18.7)</td>
<td>20 (32.8)</td>
<td>87 (77.4)</td>
<td>85 (75.9)</td>
</tr>
<tr>
<td><strong>Cholesterol ≥ 200mg/dl</strong></td>
<td>38 (31.4)</td>
<td>39 (40.6)</td>
<td>33 (54.1)</td>
<td>83 (49.1)</td>
<td>48 (42.9)</td>
</tr>
<tr>
<td><strong>LDL cholesterol ≥ 130mg/dl</strong></td>
<td>41 (33.9)</td>
<td>36 (37.5)</td>
<td>33 (54.1)</td>
<td>88 (52.1)</td>
<td>54 (48.2)</td>
</tr>
<tr>
<td><strong>HDL cholesterol &lt; 40mg/dl</strong></td>
<td>52 (43.0)</td>
<td>34 (35.4)</td>
<td>36 (57.0)</td>
<td>103 (60.9)</td>
<td>78 (69.6)</td>
</tr>
<tr>
<td><strong>Triglycerides ≥ 150mg/dl</strong></td>
<td>32 (26.4)</td>
<td>31 (32.3)</td>
<td>22 (36.1)</td>
<td>51 (30.2)</td>
<td>24 (21.4)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are percent. BMI - body mass index, WHR - waist-hip ratio, BP - blood pressure, LDL - low density lipoprotein, HDL - high density lipoprotein. Trends (r²) were determined by least-squares regression method.
Prevalence of various risk factors with increasing BMI is shown in Table 3. Smoking shows significant inverse correlation with BMI in men \((r^2 = 0.94, p=0.007)\) There is a significant increase in the prevalence of hypertension, diabetes, and metabolic syndrome with BMI in both men and women. BMI <20 kg/m² was associated with the lowest prevalence of hypertension, diabetes, and metabolic syndrome and a progressive increase is seen in these risk factors groups with increasing BMI (Fig. 1, top panel). A steep increase in the prevalence of hypertension, diabetes and metabolic syndrome is observed at BMI \(\geq 20\) kg/m².

Increasing trends are also observed with waist-size for prevalence of hypertension, diabetes and metabolic syndrome in both men and women (Table 4). In men the lowest prevalence of these risk factors is seen in waist <80 cm and in women with waist <70 cm and a steep increase is observed at waist size >90 cm in men and >80 cm in women (Fig. 1, middle panel).

Increase in prevalence of hypertension, diabetes and metabolic syndrome is also observed as WHR increases (Table 5). Lowest prevalence of these risk factors was observed in WHR <0.80 in men and <0.75 in women with a progressive increase with increasing WHR (Fig. 1, bottom panel). In addition there is a significant positive correlation of WHR with prevalence of high total cholesterol \((r^2 = 0.66\) men, 0.77 women\), high LDL cholesterol (0.55 men, 0.89 women), low HDL cholesterol (0.67 men, 0.64 women) and high triglycerides (0.77 men, 0.75 women) \((p<0.05\).

### Table 5: Prevalence of coronary risk factors in WHR categories

<table>
<thead>
<tr>
<th>WHR Groups</th>
<th>&lt;0.75</th>
<th>0.75-0.79</th>
<th>0.80-0.84</th>
<th>0.85-0.89</th>
<th>0.90-0.94</th>
<th>0.95-0.99</th>
<th>1.00</th>
<th>(r^2) (p value)</th>
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<tr>
<td><strong>Men (n=532)</strong></td>
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<td>Number</td>
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<td>169</td>
<td>136</td>
<td>116</td>
<td>82</td>
<td></td>
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</tr>
<tr>
<td>Smoking/tobacco</td>
<td>6</td>
<td>13 (12.9)</td>
<td>20 (11.8)</td>
<td>16 (11.8)</td>
<td>5 (6.9)</td>
<td>5 (13.5)</td>
<td></td>
<td>0.25 (0.318)</td>
</tr>
<tr>
<td>Any physical activity</td>
<td>27</td>
<td>60 (94.9)</td>
<td>67 (39.6)</td>
<td>49 (36.0)</td>
<td>21 (29.2)</td>
<td>8 (21.6)</td>
<td></td>
<td>0.95 (&lt;0.001)</td>
</tr>
<tr>
<td>Overweight/Obesity BMI (\geq 25.0)</td>
<td>10</td>
<td>22 (27.3)</td>
<td>79 (36.7)</td>
<td>94 (69.1)</td>
<td>41 (56.9)</td>
<td>25 (67.6)</td>
<td></td>
<td>0.83 (0.012)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11</td>
<td>25 (24.8)</td>
<td>63 (37.3)</td>
<td>57 (41.9)</td>
<td>33 (45.8)</td>
<td>21 (66.8)</td>
<td></td>
<td>0.95 (&lt;0.001)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4</td>
<td>9 (1.8)</td>
<td>19 (11.2)</td>
<td>22 (13.0)</td>
<td>10 (13.9)</td>
<td>6 (16.2)</td>
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<td>0.66 (0.049)</td>
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<tr>
<td>Metabolic syndrome</td>
<td>11</td>
<td>25 (20.9)</td>
<td>52 (30.8)</td>
<td>67 (49/3)</td>
<td>48 (66.7)</td>
<td>27 (73.0)</td>
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<td>0.90 (0.004)</td>
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<tr>
<td>Cholesterol (\geq 200)mg/dl</td>
<td>11</td>
<td>25 (20.6)</td>
<td>73 (43.2)</td>
<td>64 (47.0)</td>
<td>33 (45.8)</td>
<td>19 (51.4)</td>
<td></td>
<td>0.77 (0.022)</td>
</tr>
<tr>
<td>LDL cholesterol (\geq 130)mg/dl</td>
<td>13</td>
<td>29 (29.6)</td>
<td>79 (46.7)</td>
<td>63 (46.3)</td>
<td>35 (48.6)</td>
<td>22 (59.4)</td>
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<td>HDL cholesterol &lt;40mg/dl</td>
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<td>94 (55.6)</td>
<td>66 (48.5)</td>
<td>48 (66.7)</td>
<td>28 (75.7)</td>
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<td>0.64 (0.057)</td>
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<tr>
<td>Triglycerides (\geq 150)mg/dl</td>
<td>9</td>
<td>20 (25.7)</td>
<td>48 (28.4)</td>
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</tr>
<tr>
<td>Smoking/tobacco</td>
<td>6</td>
<td>13 (12.8)</td>
<td>20 (11.8)</td>
<td>16 (11.8)</td>
<td>5 (6.9)</td>
<td>5 (13.5)</td>
<td></td>
<td>0.25 (0.318)</td>
</tr>
<tr>
<td>Any physical activity</td>
<td>27</td>
<td>60 (94.8)</td>
<td>67 (39.6)</td>
<td>49 (36.0)</td>
<td>21 (29.2)</td>
<td>8 (21.6)</td>
<td></td>
<td>0.95 (&lt;0.001)</td>
</tr>
<tr>
<td>Overweight/Obesity BMI (\geq 25.0)</td>
<td>10</td>
<td>22 (27.3)</td>
<td>79 (36.7)</td>
<td>94 (69.1)</td>
<td>41 (56.9)</td>
<td>25 (67.6)</td>
<td></td>
<td>0.83 (0.012)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11</td>
<td>25 (24.8)</td>
<td>63 (37.3)</td>
<td>57 (41.9)</td>
<td>33 (45.8)</td>
<td>21 (66.8)</td>
<td></td>
<td>0.95 (&lt;0.001)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4</td>
<td>9 (1.8)</td>
<td>19 (11.2)</td>
<td>22 (13.0)</td>
<td>10 (13.9)</td>
<td>6 (16.2)</td>
<td></td>
<td>0.66 (0.049)</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
<td>11</td>
<td>25 (20.9)</td>
<td>52 (30.8)</td>
<td>67 (49/3)</td>
<td>48 (66.7)</td>
<td>27 (73.0)</td>
<td></td>
<td>0.90 (0.004)</td>
</tr>
<tr>
<td>Cholesterol (\geq 200)mg/dl</td>
<td>11</td>
<td>25 (20.6)</td>
<td>73 (43.2)</td>
<td>64 (47.0)</td>
<td>33 (45.8)</td>
<td>19 (51.4)</td>
<td></td>
<td>0.77 (0.022)</td>
</tr>
<tr>
<td>LDL cholesterol (\geq 130)mg/dl</td>
<td>13</td>
<td>29 (29.6)</td>
<td>79 (46.7)</td>
<td>63 (46.3)</td>
<td>35 (48.6)</td>
<td>22 (59.4)</td>
<td></td>
<td>0.89 (0.005)</td>
</tr>
<tr>
<td>HDL cholesterol &lt;40mg/dl</td>
<td>23</td>
<td>52 (43.6)</td>
<td>94 (55.6)</td>
<td>66 (48.5)</td>
<td>48 (66.7)</td>
<td>28 (75.7)</td>
<td></td>
<td>0.64 (0.057)</td>
</tr>
<tr>
<td>Triglycerides (\geq 150)mg/dl</td>
<td>9</td>
<td>20 (25.7)</td>
<td>48 (28.4)</td>
<td>42 (30.9)</td>
<td>25 (34.7)</td>
<td>11 (29.7)</td>
<td></td>
<td>0.75 (0.026)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are percent. BMI body mass index, WHR waist-hip ratio, BP blood pressure, LDL low density lipoprotein, HDL high density lipoprotein. Trends \((r^2)\) were determined by least-squares regression method.
DISCUSSION

This study shows that obesity measured either as body-mass index, waist-size or waist-hip ratio, is a major determinant of cardiovascular risk factors—hypertension, diabetes and metabolic syndrome in both men and women in an Indian urban population. WHR is also important determinant of hypercholesterolaemia, low HDL and hypertriglyceridaemia.

Body weight is determined by many factors, such as genetic, behavioural, cultural, socio-economic, psychosocial and psychological mechanisms. Many of these factors influence health independently or through mechanisms other than body weight. Excess body weight is a risk factor for a variety of health hazards, but it is also a marker of other factors that are directly or indirectly related to health, such as physical activity, diet, socio-economic status and smoking. The present study shows that regular physical activity of any type (work-related or leisure-time) is inversely related to all measures of obesity, viz., BMI, waist and WHR. The other major determinant of obesity is diet. We did not inquire detailed dietary history of the subjects and this is a study limitation.

Despite the positive association between bodyweight and the risk of CHD in many studies the question of whether this risk is independent of other factors is still debated. Obesity is closely related to several known cardiovascular risk factors, lipid abnormalities and impaired glucose metabolism and it has a complicated association with smoking. Obese subjects on average have higher BP, higher serum total cholesterol, lower HDL cholesterol, higher serum triglycerides, higher blood glucose and a higher plasma insulin levels than lean persons. The present study also shows that increasing obesity measured by BMI, waist or WHR is associated with escalating prevalence of multiple cardiovascular risk factors. The individual and independent effect of body weight on the risk of coronary heart disease is difficult to estimate because obesity exerts much of its effect through the enhancement of other risk factors.

In Framingham Study, Hubert et al and Garrison et al reported that obesity as determined by body-weight >20% of desirable was an independent risk factor for cardiovascular disease. Jousilhati et al reported that among Finnish men obesity, as determined by BMI, was an independent risk factor for coronary heart disease mortality in men and was an important contributor for mortality in women. In this study a higher cardiovascular mortality was observed at very low BMI (<20 kg/m²) which was possibly related to greater smoking among this group. Calle et al studied more than 1 million adults in United States and reported a J-shaped curve for cardiovascular mortality with BMI with the lowest mortality found in those with BMI of 23.5-24.9 in men and 22.0-23.4 in women. The J-curve was observed for non-smokers as well as smokers although the highest mortality from cardiovascular diseases was observed at higher ranges of BMI. The present study shows that there is a continuous positive relationship of BMI with cardiovascular risk factors. Prospective studies among this group are needed to determine the prognostic importance of these findings.

Results of the European Fat Distribution Study and Paris Prospective Study demonstrated importance of abdominal fat and greater WHR in cardiovascular and coronary heart disease mortality. Among Indians too, studies have shown that WHR is an important cardiovascular risk factor and greater levels are associated with multiple risk factors. However as no prospective studies exist it is difficult to define cut-off levels. The present study shows that WHR >0.9 in men and >0.8 in women is associated with a significant increase in multiple risk factors. These cut-offs are similar to those suggested by earlier reports of US National Cholesterol Education Program (ATP-II). Importance of waist-size as a marker of cardiovascular risk factors has not been evaluated in any previous Indian study. The present study shows that there is a significant increase in prevalence of hypertension, diabetes and metabolic syndrome at waist size >90 cm in men and >80 cm in women. These levels are lower than those suggested by the US National Cholesterol Education Program (ATP-III) where the cut-off levels are >102 cm for men and >88 cm for women. Zhou reported a meta-analysis of Chinese studies reporting influence of body-fat on cardiovascular disease mortality. He suggested a lower cut-off level for diagnosis of obesity as measured by BMI or WHR. These conclusions are similar to the observations in the present study.

BMI is the most commonly used indicator of obesity in population studies, although it is not a perfect one. It does not take into account body fat patterning as waist size, WHR and skin-fold measurements do. Increased central or visceral fat independent of relative body weight is associated with a variety of metabolic disorders and increased cardiovascular mortality. Furthermore, weight is usually positively related to increased morbidity and mortality whereas height is often associated with good health. Therefore, among obese subjects, the BMI can reflect the negative effects of both fatness and shortness. The risks of fatness and shortness are most likely mediated via different mechanisms. However, BMI also has several advantages compared with other methods of measuring obesity. BMI measurement is simple, inexpensive and reliable. It is widely used and the results of different studies are therefore easily compared. Results are also easily transferred for use in practical healthcare and disease prevention. However, the present study shows that although BMI predicts accurately the presence of hypertension, diabetes and metabolic
The epidemic of obesity is escalating worldwide. The World Health Report (2002) estimates that currently overweight is the 10th leading cause of global burden of diseases following underweight, unsafe sex, blood pressure, tobacco, alcohol, unsafe water, cholesterol, indoor pollution and iron deficiency. Obesity is a major determinant of high blood pressure, raised cholesterol and metabolic syndrome and clearly an important primordial cardiovascular risk factor. Weight control should be an integral part of the prevention of cardiovascular disease. The question of whether obesity is an independent risk factor for cardiovascular diseases or whether its effect is mediated via BP, lipid abnormalities, impaired glucose metabolism, or other mechanisms is not important in health practice because mechanisms cannot be separated. Similarly, although fat distribution plays an important role in the research of the pathophysiological mechanisms of obesity and its relation to other diseases, in practical prevention it can be used only in individual counselling. In community-based prevention programs, identification and use of different subtypes of obesity are difficult. By preventing overweight in early adulthood it is likely that a substantial amount of cardiovascular mortality can be prevented. Message for the urban Indians clearly is—Leaner the Better.

REFERENCES