Relations of Body Habitus, Fitness Level, and Cardiovascular Risk Factors Including Lipoproteins and Apolipoproteins in a Rural and Urban Costa Rican Population

Hannia Campos, Stephen M. Bailey, Lisa S. Gussak, Xinia Siles, Jose M. Ordovas, and Ernst J. Schaefer

Increased general and abdominal obesity has been independently associated with diabetes, increased risk of stroke, and coronary artery disease (CAD). It is more prevalent in developed countries and in urban areas of nonindustrialized nations than in less developed and rural areas. To evaluate the associations between general and abdominal obesity (as determined by total body fat, waist to hip ratio, umbilical to triceps ratio, and umbilical to subscapular ratio) with glucose, plasma lipoproteins, apolipoprotein (apo) A-I and B concentrations, and low density lipoprotein (LDL) particle size (LDL 1–7), we randomly selected 222 men and 243 women from rural and urban areas of Puriscal, Costa Rica. Abdominal obesity, as assessed by the waist to hip ratio, was independently and significantly associated with higher triglyceride levels (p<0.01) and with lower high density lipoprotein cholesterol levels (p<0.05) in men and women and with higher glucose levels (p<0.05) and smaller LDL particle size (p<0.01) in women. Abdominal obesity, as assessed by the umbilical to subscapular ratio, was independently and significantly associated with higher total cholesterol (p<0.005) and apo B (p<0.01) levels. Umbilical to triceps ratio was positively associated with blood pressure in men. Urban men had increased general and abdominal obesity (p<0.0001), number of cigarettes smoked per day (p<0.0001), and diastolic blood pressure (p<0.05) and had a decreased fitness level (p<0.001) as well as higher (p<0.05) plasma glucose, triglyceride, and total cholesterol concentrations and lower (p<0.05) apo A-I and HDL cholesterol levels compared with rural men. The differences between rural and urban women were not as striking. Urban women had increased general and abdominal obesity, glucose, and apo B levels (p<0.05) and a decreased fitness level (p<0.0001). Our data indicate that general and abdominal obesity, increased cigarette smoking, diastolic blood pressure, and decreased fitness level are more prevalent in an urban than in a rural area in Costa Rica, particularly in men. The higher prevalence of such risk factors in the urban area is associated with a more atherogenic plasma lipoprotein profile.

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be considered as a measure that may relate to an atherogenic lipid profile in both men and women. However, population differences exist in the incidence of abdominal obesity and lipoprotein levels, and this raises questions as to how different populations will respond to increased abdominal obesity in the presence of other CVD risk factors. Results from the European Fat Distribution Study suggested that the relations of body fat distribution with serum lipids differed in the five female populations studied. Haffner et al also reported that alterations in levels of body fat distribution indicators could in part account for ethnic differences in high density lipoprotein (HDL) cholesterol and triglyceride levels between Mexican-Americans and Anglos.

Adipose tissue distribution patterns have usually been assessed by several anthropometric indicators such as the waist to hip ratio (WHR) and several upper-body to lower-body or central to peripheral body contrasts by skinfold measurements at specific anatomic locations. Several studies suggest that an elevated WHR is associated with higher triglyceride and total cholesterol concentrations and lower HDL cholesterol levels. Abdominal obesity has also been associated with increased glucose and insulin levels as well as with increased prevalence of diabetes and higher systolic and diastolic blood pressures, as noted in some but not all studies. Abdominal obesity, as assessed by the ratios of several skinfold measurements, has also been associated with serum lipid levels. A subscapular to triceps ratio (STR) has been associated with higher triglyceride and total cholesterol levels as well as with lower HDL cholesterol levels.

It also has been suggested that apolipoproteins (apos) A-I and B may serve as better predictors of the presence of coronary artery disease (CAD) than does HDL cholesterol or low density lipoprotein (LDL) cholesterol alone. Apo A-I is a major protein constituent of HDL, while apo B is a major constituent of very low density lipoproteins (VLDLs) and is the sole protein constituent of LDL. In addition, heterogeneous groups of LDL with respect to size and density have also been identified, and small LDL particles have been found more frequently in men and in patients with CAD. An elevated WHR has been associated with increased apo B levels in men and women and with decreased apo A-I levels in postmenopausal women. Furthermore, significant associations between body fat distribution and lipoprotein subfractions have been reported in men and women, in whom WHR was negatively correlated with HDL and positively with small LDL and VLDL mass, while the STR was negatively correlated with large LDL and with VLDL mass.

In the present study we have examined the relation of general and abdominal obesity, fitness level, and smoking habits with blood pressure, plasma glucose, lipids, apolipoproteins, and LDL particle size in men and women from the rural and urban areas of Puriscal, Costa Rica. Our main objectives were to test whether CVD risk factors differ between a rural and an urban non-Anglo population and to examine, in this population, which abdominal obesity indicators are associated with a more atherogenic plasma lipid profile in the presence of other established CVD risk factors.

Methods

Study Population

The study sample was randomly selected from the canton (county) of Puriscal, Costa Rica. The Puriscal region extends from the middle of Costa Rica to the Pacific coast area and comprises about 800 km². There are about 26,000 inhabitants in approximately 150 localities of very sparsely distributed rural population, with fewer than 500 people in each locality. Santiago, while not a true urban center, is the canton's capital and is the only district in Puriscal with a centralized population of about 8,000 people. Moreover, Santiago is referred to as urban by the Center of Censuses and Statistics in Costa Rica, and their definition and maps were used in this study. This region is rapidly undergoing modernization; approximately 70% of the homes in the rural area and 100% in Santiago have access to electricity and a piped water supply. The rural population subsists mainly on agricultural products and the sale of food crops, while professional careers, retail business, and white-collar jobs predominate in Santiago. The population is predominantly mestizo (mixture of Spanish and Indian ethnic groups), with a small proportion of mulattoes (mixture of black and Spanish ethnic groups). Modern anthropological research suggests that in Costa Rica a tripartite racial mixing took place before the 1800s, accompanied by the development of a European way of life. Since that time a comparatively homogeneous Hispanic-American society has formed.

Stratified random sampling was performed in the rural and urban areas to obtain a similar number of participants in each group. Eligible households were defined as those having one man and one non-pregnant woman aged 20–65 years in 130 households randomly selected from the 3,415 identified houses in the rural area and 130 households randomly selected from the 918 identified houses in the urban area. Participation rates were 85% (n=222) for men and 93% (n=243) for women in both rural and urban areas.

Subjects with triglyceride levels greater than 400 mg/dl (n=11), glucose levels greater than 140 mg/dl (n=9), positive history of heart disease (n=4), taking medications known to affect lipid levels (n=26), taking oral contraceptives (n=41), or missing plasma samples (n=1) were not included in this analysis. The final sample size was 202 men and 174 women.

Data Collection

Data were collected from January through September 1988. Trained fieldworkers visited partici-
pants in their households for recruitment, where subjects signed a consent form, and subsequent appointments were made for data collection. A health history and general characteristics questionnaire was completed for each subject. The questionnaire included socioeconomic and demographic characteristics as well as a brief medical history, family history of heart disease, diabetes, hypertension, smoking habits, and physical activity patterns.

**Anthropometric measurements.** All anthropometric measurements were taken by three trained field-workers who were acquainted with standardized methods, with subjects wearing light clothing but not shoes. All measurements were performed in duplicate and were averaged for analyses. Waist (smallest horizontal circumference) and hip (largest horizontal circumference around the hip and buttocks) girths were measured with nonstretching fiberglass or metal tapes. Measured skinfold thicknesses included the triceps (posterior upper arm, midway between the elbow and acromion), subscapular (1 cm below the lower tip of the scapula), umbilical (2 cm to the right of the navel), suprailiac (at the midline and above the iliac crest), and medial calf. All measurements were taken on the right side of the body with the use of Holtain skinfold calipers. For this analysis the abdominal obesity indicators used were WHR, umbilical to triceps ratio (UTR), and umbilical to subscapular ratio (USBR). Height and sitting height were measured by use of a steel anthropometer. To ensure correct readings to the nearest 0.1 cm for heights, subjects always stood on a flat surface against a wall. Weight was determined by use of either a Detecto bathroom scale or a Seca Alpha Model 770 digital scale accurate to 50 g. Both scales were calibrated biweekly. BMI was calculated as weight in kilograms divided by height in meters squared. Metropolitan relative weight (MRW) was calculated as the ratio of observed weight to published values for desirable weight, with use of the midpoint of the weight range for individuals of medium frame. Individuals were considered obese if their MRW exceeded 130%. Subjects with an MRW less than 90% were also identified. Because it has been suggested that BMI should be used to determine obesity in cross-cultural comparisons, we calculated that the corresponding BMI cutoff point for an MRW greater than 130% was at least 27.6 kg/m² and for an MRW less than 90% was not more than 20.0 kg/m² for men and women. BMI was highly correlated with MRW (r=0.997).

**Bioelectric impedance assessment (BIA).** All bioelectric impedance measurements were performed during the morning, before any strenuous activity, and after a 12-hour fast with a bioelectric impedance analyzer (model 101, BIA Systems, Detroit, Mich.), following the procedures previously described by Lukaski et al. Four gel electrodes were attached to the anterior surfaces of the foot and ankle and to the posterior surfaces of the arm and wrist. Subjects were supine on a flat surface, with the arms relaxed at the sides, not touching the body, and with the thighs separated. Resistance and reactance were read directly from the instrument. Resistance (R), reactance (X), and impedance [(R²+X²) ½] values were measured directly on a subsample of 50 men and 44 women. To estimate total body fat in this subsample we used the equation developed by Khaled et al., where total body fat = impedance × weight/height². Lean body mass was then calculated as weight minus total body fat. In addition, total body fat for the whole population was calculated by deriving an equation by use of a Max R stepwise multiple regression procedure, with total body fat as the dependent variable and several anthropometric measurements available for the whole population as the independent variables. Significant (p<0.05) anthropometric measurements were used in the following equations:

For men

\[
\text{Body fat (kg)} = 21.86 - (\text{weight} \times 0.0982) + (\text{BMI} \times 0.3469) - (\text{sitting height} / \text{height} \times 28.77) + (\log \text{triceps} \times 0.8936) + (\text{umbilical} \times 0.0647) R^2 = 0.6599
\]

and for women

\[
\text{Body fat (kg)} = 22.40 - (\text{height} \times 0.1129) + (\text{hip} \times 0.1643) - (\text{wrist} \times 0.7793) + (\log \text{triceps} \times 1.7340) - (\text{umbilical} \times 0.0501) + (\text{suprailiac} \times 0.0711) R^2 = 0.8388
\]

**Fitness score.** To determine the level of fitness, a modified Harvard step test was performed on a portable wooden 40-cm step. Subjects were instructed to step up and down while following the beats of a metronome. Women were asked to maintain a rhythm of 76 beats/min, whereas men were asked to follow a rhythm of 96 beats/min. Subjects were requested to perform the test for 3 minutes, but when this was not possible the time during which the exercise was performed was recorded. Pulse rates were taken immediately after the test and at 1 and 3 minutes after the test. Fitness score (FS) was calculated as seconds during exercise divided by (pulse+2+3) times 100.

**Blood samples and blood pressure.** Blood samples were drawn into tubes containing 0.1% EDTA after a 12–14-hour fast. A drop of blood was immediately obtained from the tube for glucose analysis by an Accu-Check II Blood Glucose Monitor with Chemstrip bG Test Strips (Boehringer Mannheim Diagnostics, Indianapolis, Ind.) and standardized against an enzymatic (glucose oxidase–peroxidase) method. Blood tubes were then immediately stored at 4°C. Within 36 hours they were centrifuged at 2,500 rpm for 20 minutes at 4°C to isolate the plasma. HDL supernates were then obtained after precipitation of apo B–containing particles with dextran sulfate–Mg²⁺ by use of the method of Warnick et al. All
Lipoprotein Analyses

Plasma cholesterol, triglyceride, and HDL cholesterol levels were measured with an Abbott Diagnostics ABA-200 bichromatic analyzer and Abbott A-Gent enzymatic reagents. VLDL and LDL cholesterol levels were estimated for all subjects with triglyceride levels less than 400 mg/dl by use of the Friedewald equation. Total cholesterol, triglyceride, and HDL cholesterol assays were standardized through the Centers for Disease Control Lipid Standardization Program, Atlanta, Ga.

Plasma apo B quantification was performed by use of noncompetitive enzyme-linked immunosorbent assays as previously described. This method employs a double-sandwich technique in which the microtiter plates (Nunc Immunoplate I, Roskilde, Denmark) were coated with affinity-purified polyclonal antibody for apo B. The same methodology was used for quantification of apo A-I except that affinity-purified apo A-I antibody and plasma dilutions of 1:60,000 were used. Standards for these assays were calibrated with reference material obtained from the Centers for Disease Control.

Gradient gel electrophoresis on 4.9×82×82-mm 2–16% non-denaturing polyacrylamide gels (PAA 2–16%, Pharmacia, Piscataway, N.J.) was performed to separate LDL subfractions, as previously described. Seven LDL bands (LDL 1–7) have been identified and classified according to the particle density determined by sequential ultracentrifugation or by gradient gel electrophoresis. LDL 1s are the largest LDL particles and are found in the density range of 1.019–1.033 g/ml, whereas LDL 7s are the smallest particles and have a buoyant density range of 1.050–1.063 g/ml. Most subjects usually had one major band and one or two minor bands. To account for the minor bands, we assigned each subject a weighted LDL particle score, for which the relative area under each band present was multiplied by the band number. For example, a subject with a predominant band 3 (75% of area) and a minor LDL band 4 (25% of area) would have an LDL particle score of 3.25 or [(3×0.75)+(4×0.25)]. A larger LDL particle score corresponds to a small LDL particle score of 3.25 or [(3×0.75)+(4×0.25)]. A larger LDL particle score corresponds to a small LDL particle size because the largest LDL particles are LDL 1s (score=1.00) and the smallest LDL particles are LDL 7s (score=7.00).

Statistical Analysis

Differences between rural and urban areas for all parameters measured were evaluated by t test analysis and are presented as mean±SD. Pearson correlation coefficients were used to determine the significant correlations among the various anthropometric measurements, FS, smoking habits, blood pressure, plasma glucose, lipids, lipoproteins, apolipoproteins, and LDL particle size. The stepwise regression procedure was used to identify independent associations between the anthropometric variables and glucose, lipoproteins, and blood pressure. All the analyses were performed with the sas software package (SAS Institute, Cary, N.C.). Because the distribution of several variables (triglycerides; HDL cholesterol; apo A-I; triceps, subscapular, and calf skinfolds) was skewed, logarithmic transformations were performed for analyses involving these variables. Logarithmic transformations were also used for the skinfold ratios UTR and USBR.

Results

General Characteristics for Residents of Rural and Urban Puriscal

Table 1 shows the mean±SD for anthropometric characteristics in men and women from rural and urban Puriscal, Costa Rica. Men from the urban area were heavier (p<0.05), with significantly (p<0.05) higher lean body mass, total body fat (p<0.0001), waist and hip circumferences, and trunk skinfolds (subscapular, umbilical, and suprailiac) (p<0.01). There were twice as many men with an MRW greater than 130% in the urban compared with the rural area. The prevalence of obesity in the urban men (21%) was lower than that previously reported for the Framingham men (31%) by similar standards. The prevalence of an MRW less than 90% was very similar between rural and urban men. There were no significant rural–urban WHR differences in men, but the UTR and the USBR were significantly (p<0.0001) higher in urban men. Elevated diastolic blood pressure, lower fitness level, and a higher prevalence of smokers (39% versus 16%) were also found in urban men compared with rural men (Table 2).

Urban women had significantly higher total body fat (p<0.005), hip circumference (p<0.05), and elevated (p<0.0001) lower-trunk skinfolds (umbilical and suprailiac) than did rural women (Table 1). UTR and USBR were also significantly (p<0.005) higher in urban than in rural women, but no significant WHR differences were detected. In contrast with men, there were no significant differences in subscapular skinfold and waist circumference between rural and urban women, but urban women had significantly thicker limb skinfolds (triceps and calf) than did rural women. Urban women were heavier and had a higher prevalence of obesity (MRW>130%) than did rural women, but these differences were not statistically significant. The prevalence of obesity in urban Puriscal women (35%) was higher than that reported for Framingham women (19%) by similar standards. In addition, urban women had a significantly (p<0.0001)
Campos et al  Body Fat Distribution, Fitness Level, and CV Risk Factors 1081

TABLE 1. Anthropometric Characteristics for Men and Women in Rural and Urban Puriscal, Costa Rica

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural (n = 103)</th>
<th>Urban (n = 99)</th>
<th>Rural (n = 88)</th>
<th>Urban (n = 86)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>164.6±7.3</td>
<td>164.9±6.1</td>
<td>152.8±6.5</td>
<td>152.7±6.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.9±12.0</td>
<td>68.3±10.6*</td>
<td>59.3±11.3</td>
<td>61.0±10.1</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.8±3.1</td>
<td>25.1±3.7†</td>
<td>25.4±4.5</td>
<td>26.1±4.0</td>
</tr>
<tr>
<td>Body fat (kg)</td>
<td>11.7±1.1</td>
<td>12.6±1.4‡</td>
<td>14.7±1.8</td>
<td>15.4±1.6‡</td>
</tr>
<tr>
<td>Lean mass (kg)</td>
<td>52.7±11.2</td>
<td>55.9±9.8*</td>
<td>43.7±9.5</td>
<td>44.8±9.3</td>
</tr>
<tr>
<td>&gt;130% MRW</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>&lt;90% MRW</td>
<td>2%</td>
<td>2%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>Circumferences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>82.2±8.9</td>
<td>85.2±8.7†</td>
<td>77.3±10.0</td>
<td>78.6±8.8</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>92.7±6.8</td>
<td>95.7±6.1§</td>
<td>95.3±9.7</td>
<td>98.1±8.1*</td>
</tr>
<tr>
<td>Skinfolds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triceps (mm)</td>
<td>9.5±4.9</td>
<td>10.3±4.8</td>
<td>21.5±8.6</td>
<td>23.9±7.7*</td>
</tr>
<tr>
<td>Subscapular (mm)</td>
<td>14.5±7.8</td>
<td>18.7±8.6‡</td>
<td>25.6±11.2</td>
<td>28.2±10.3</td>
</tr>
<tr>
<td>Umbilical (mm)</td>
<td>18.3±9.9</td>
<td>28.3±12.6‡</td>
<td>26.0±9.9</td>
<td>34.3±9.5‡</td>
</tr>
<tr>
<td>Suprailiac (mm)</td>
<td>21.8±10.6</td>
<td>27.7±11.9#</td>
<td>29.4±9.9</td>
<td>35.9±8.5‡</td>
</tr>
<tr>
<td>Calf (mm)</td>
<td>7.1±4.7</td>
<td>8.2±4.6</td>
<td>20.2±8.9</td>
<td>23.3±9.5*</td>
</tr>
<tr>
<td>Skinfold ratios</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHR</td>
<td>0.89±0.05</td>
<td>0.89±0.06</td>
<td>0.81±0.04</td>
<td>0.80±0.05</td>
</tr>
<tr>
<td>UTR</td>
<td>2.03±0.91</td>
<td>2.82±1.06‡</td>
<td>1.30±0.46</td>
<td>1.52±0.48‡</td>
</tr>
<tr>
<td>USBR</td>
<td>1.30±0.51</td>
<td>1.61±0.59‡</td>
<td>1.09±0.38</td>
<td>1.34±0.41‡</td>
</tr>
</tbody>
</table>

BMI, body mass index; MRW, Metropolitan Relative Weight (in this population the correlation between MRW and BMI was \( r = 0.997 \). MRW >130% corresponded to a BMI >27.6 kg/m², and MRW <90% corresponded to a BMI <20.0 kg/m²) in both men and women. WHR, waist to hip ratio; UTR, umbilical to triceps ratio; USBR, umbilical to subscapular ratio.

*p<0.05, †p<0.01, ‡p<0.0001, §p<0.005.

decreased fitness level than did rural women. No significant rural-urban differences were found in blood pressure or smoking habits in women (Table 2).

Glucose and Lipoprotein Parameters in Rural and Urban Residents of Puriscal

Mean±SD for plasma glucose and lipoprotein parameters for rural and urban Puriscal residents are shown in Table 3. Urban men had significantly (\( p<0.05 \)) higher glucose, triglyceride, and total and VLDL cholesterol levels and significantly (\( p<0.05 \)) lower HDL cholesterol, apo A-I levels, and HDL to total cholesterol ratio (HDL/TC) than did rural men. LDL cholesterol and apo B concentrations were also higher in urban men compared with those of rural men, but these differences were not significant. No differences in LDL particle size were found between rural and urban men. Women from the urban area had significantly (\( p<0.05 \)) higher glucose and apo B concentrations. Urban women also had higher triglyceride, total cholesterol, VLDL cholesterol, and LDL cholesterol levels as well as larger LDL particles, but these differences were not significant. No significant differences in HDL cholesterol, apo A-I concentrations, and HDL/TC were found between rural and urban women.

Correlations Between Body Habitus, Age, Smoking, and Fitness Level

Correlations between body habitus, age, smoking habits, and fitness level are shown in Table 4. In men increased abdominal fat (WHR, UTR, and USBR) and decreased fitness level were significantly (\( p<0.05 \)) associated with BMI, total body fat, and lean mass. Increased smoking was negatively correlated with BMI and lean mass. In addition, age was
TABLE 3. Glucose, Lipids, Lipoproteins, and Apolipoproteins for Men and Women in Rural and Urban Puriscal, Costa Rica

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rural (n=103)</th>
<th>Urban (n=99)</th>
<th>Rural (n=88)</th>
<th>Urban (n=86)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mg/dl)</td>
<td>83±13</td>
<td>87±11†</td>
<td>84±14</td>
<td>88±14†</td>
</tr>
<tr>
<td>Triglyceride (mg/dl)</td>
<td>133±63</td>
<td>161±79‡</td>
<td>117±57</td>
<td>125±62</td>
</tr>
<tr>
<td>Total cholesterol (mg/dl)</td>
<td>173±34</td>
<td>183±31†</td>
<td>179±42</td>
<td>189±33</td>
</tr>
<tr>
<td>VLDL cholesterol (mg/dl)</td>
<td>27±13</td>
<td>32±16‡</td>
<td>23±11</td>
<td>25±12</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dl)</td>
<td>105±31</td>
<td>111±30</td>
<td>110±34</td>
<td>118±29</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dl)</td>
<td>42±9</td>
<td>39±9†</td>
<td>45±9</td>
<td>46±10</td>
</tr>
<tr>
<td>Apo A-I (g/l)</td>
<td>112±21</td>
<td>105±20†</td>
<td>116±22</td>
<td>116±21</td>
</tr>
<tr>
<td>Apo B (g/l)</td>
<td>108±36</td>
<td>115±35</td>
<td>97±36</td>
<td>108±34†</td>
</tr>
<tr>
<td>LDL particle score*</td>
<td>3.82±0.81</td>
<td>3.89±0.97</td>
<td>3.44±0.89</td>
<td>3.30±0.86</td>
</tr>
<tr>
<td>HDL/TC</td>
<td>0.25±0.06</td>
<td>0.22±0.07†</td>
<td>0.26±0.08</td>
<td>0.25±0.06</td>
</tr>
</tbody>
</table>

Values are given as mean±SD.

VLDL, very low density lipoprotein; LDL, low density lipoprotein; HDL, high density lipoprotein; apo, apolipoproteins; TC, total cholesterol; HDL/TC, HDL to total cholesterol ratio.

*LDL particle score is the sum of the relative areas under the LDL bands present in each subject, where the largest LDL particles are LDL 1 (score=1.00) and the smallest, LDL 7 (score=7.00). See text for details.

*p<0.05, †p<0.01.
Table 5. Pearson Correlation Coefficients for Body Habitus, Fitness Level, Smoking, Blood Pressure, and Biochemical Parameters in Rural and Urban Puriscal, Costa Rica

<table>
<thead>
<tr>
<th>Variable</th>
<th>TG</th>
<th>Chol</th>
<th>LDL</th>
<th>HDL</th>
<th>Glucose</th>
<th>Syst</th>
<th>Diast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.16†</td>
<td>0.22§</td>
<td>0.18†</td>
<td>-0.06</td>
<td>0.07</td>
<td>0.24§</td>
<td>0.27‡</td>
</tr>
<tr>
<td>BMI</td>
<td>0.48‡</td>
<td>0.29‡</td>
<td>0.18†</td>
<td>-0.32‡</td>
<td>0.33‡</td>
<td>0.28‡</td>
<td>0.38‡</td>
</tr>
<tr>
<td>Body fat</td>
<td>0.44‡</td>
<td>0.34‡</td>
<td>0.27‡</td>
<td>-0.35‡</td>
<td>0.34‡</td>
<td>0.24§</td>
<td>0.33‡</td>
</tr>
</tbody>
</table>

For ratios:

- **WHR**
  - Men: 0.41‡
  - Women: 0.26§

- **UTR**
  - Men: 0.27†
  - Women: 0.25§

- **USBR**
  - Men: 0.18†
  - Women: 0.24§

- **FS**
  - Men: -0.23§
  - Women: -0.24§

- **Smoking**
  - Men: 0.20§
  - Women: 0.20§

TG, triglycerides; Chol, total cholesterol; LDL, low density lipoprotein cholesterol; HDL, high density lipoprotein cholesterol; Syst, Diast, systolic and diastolic blood pressures, respectively; BMI, body mass index; WHR, waist to hip ratio; UTR, umbilical to triceps ratio; USBR, umbilical to subscapular ratio; FS (fitness score)=duration of exercise in seconds divided by (pulse 1+2+3) times 100; Smoking=cigarettes smoked per day.

*†p<0.05, †p<0.01, ‡p<0.0001, §p<0.005.

Increased age in women. Smaller LDL particles were positively associated with BMI, body fat, and abdominal fat (WHR) in men and women. The associations between body habitus, apolipoproteins, and LDL particle size are shown in Table 6. Elevated apo B levels were significantly (p<0.01) associated with increased BMI and body fat in men and women and with increased abdominal fat (WHR, UTR, and USBR) and decreased fitness level in men and increased abdominal fat (USBR only) in women. Apo A-I levels were significantly (p<0.01) associated with decreased body fat and smoking in men and with increased age in women. Smaller LDL particles were positively associated (p<0.01) with BMI, body fat, and abdominal fat (WHR) in men and women.

**Independent Associations Between Abdominal Fat, Blood Pressure, and Plasma Parameters**

Table 7 shows the standardized β coefficients of the stepwise regression models for significant independent associations between total body fat, abdominal fat, plasma parameters, and blood pressure in men and women. In men elevated total body fat was...
Abdominal obesity has been associated with an increased risk of stroke and CAD.\textsuperscript{1-3} In women this very strongly (p<0.0001) associated with blood pressure and all the plasma parameters. In men age was significantly (p<0.05) associated with increased total cholesterol, apo A-I and B levels, and blood pressure. In men abdominal fat as determined by WHR was significantly (p<0.01) associated with increased triglyceride and decreased HDL cholesterol and with smaller LDL particles, but the latter did not reach statistical significance (p<0.06). USBR was significantly (p<0.05) associated with higher total cholesterol and apo B levels in women, but UTR was not associated with any biochemical parameter or blood pressure in women.

In sum, two abdominal fat indicators were independently associated with different plasma lipoprotein profiles. Increased WHR was associated with a pattern of increased triglyceride and glucose levels, decreased HDL cholesterol and apo A-I levels, and smaller LDL particles. Increased USBR was associated with higher cholesterol and apo B levels. These associations were independent of other CVD risk factors such as age, body fat, smoking, and fitness level. WHR and USBR were the strongest abdominal fat correlates for these plasma parameters, with no other significant abdominal fat indicators in the model (Table 6). Abdominal fat, as determined by UTR in men, was the only abdominal fat indicator associated with blood pressure after adjustment for body fat. Area of residence was not significantly associated with any biochemical parameter or blood pressure in women.

### Table 7. Stepwise Regression Models for Pressure and Biochemical Parameters in Rural and Urban Pursical, Costa Rica

<table>
<thead>
<tr>
<th>Variable entered</th>
<th>Biochemical parameters</th>
<th>Blood pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trig (mg/dl)</td>
<td>Chol (mg/dl)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.037</td>
<td>0.007</td>
</tr>
<tr>
<td>Total body fat (kg)</td>
<td>0.45‡</td>
<td>0.32‡</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>...</td>
<td>0.22§</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.27‡</td>
<td>...</td>
</tr>
<tr>
<td>FS</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>WHR</td>
<td>5.30§</td>
<td>...</td>
</tr>
<tr>
<td>USBR</td>
<td>...</td>
<td>0.46*</td>
</tr>
<tr>
<td>UTR</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Total R²</td>
<td>0.32</td>
<td>0.20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable entered</th>
<th>Biochemical parameters</th>
<th>Blood pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trig (mg/dl)</td>
<td>Chol (mg/dl)</td>
</tr>
<tr>
<td>Intercept</td>
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<td>0.030</td>
</tr>
<tr>
<td>Total body fat (kg)</td>
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<td>...</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>0.41‡</td>
<td>0.55§</td>
</tr>
<tr>
<td>Smoking</td>
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<td>...</td>
</tr>
<tr>
<td>WHR</td>
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<td>...</td>
</tr>
<tr>
<td>USBR</td>
<td>...</td>
<td>0.85‡</td>
</tr>
<tr>
<td>Total R²</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Standardized β coefficients are given for the variables that met the 0.05 level of significance for entering the model. The variable that did not meet this criteria for any parameter was area of residence (rural or urban). For LDL score, see footnote to Table 3.

TG, triglycerides; Chol, cholesterol; HDL, high density lipoprotein; apo, apolipoproteins; LDL, low density lipoprotein; Smoking=cigarettes smoked per day. FS, fitness score=seconds divided by (pulse 1+2+3) times 100. WHR, waist to hip ratio; USBR, umbilical to subscapular ratio; UTR, umbilical to triceps ratio.

*p<0.05, †p<0.01, ‡p<0.005, §p<0.0005.
association has remained significant after adjustment for BMI, age, smoking, serum cholesterol and triglyceride levels, and systolic blood pressure. Previous data also indicate that an elevated WHR is associated with higher triglyceride and glucose levels, lower HDL cholesterol levels, and a decreased HDL mass and cholesterol. Our data are consistent with these findings. In both men and women an elevated WHR was significantly associated with higher triglyceride and lower HDL cholesterol levels, while an association with glucose was found in women only. Peiris et al, when comparing different anthropometric measurements as predictors of metabolic abnormalities, concluded that WHR seemed to be the most useful indicator in premenopausal women. Consistent with these findings, in our study WHR was independently and significantly associated with elevated triglyceride and glucose levels (in women) and with decreased HDL cholesterol and apo A-I levels, with no other significant abdominal fat indicators in the regression model. However, in both men and women total body fat usually presented a more significant association with triglyceride, HDL cholesterol, and glucose levels than did WHR. An elevated STR has also been associated with higher triglyceride and lower HDL cholesterol levels. In our study, an STR was not significantly associated with any lipoprotein parameter (data not shown) when other anthropometric indicators were included.

The associations between abdominal obesity and total cholesterol are more variable. A positive correlation between WHR and total cholesterol has been previously reported in normal men and women in some studies but not all studies. These discrepancies could be attributed to methodological or technical differences such as choice of skinfold site. However, the European Fat Distribution Study suggests that there might be considerable population differences in the relations found between anthropometric indicators of body fat distribution and lipoprotein parameters. Our data indicate that in the present population, USBR was significantly associated with higher total cholesterol in men and women. We did not find significant correlations between WHR and total cholesterol when USBR was in the model or after adjustment for other significant covariates. USBR and WHR are indicators of abdominal obesity, but a contrast with the upper body rather than the hip might be more relevant to an association with total cholesterol in this population. The mechanism whereby abdominal obesity relates to higher CAD risk is not clear. It has been reported that body fat is metabolically heterogeneous, with varying lipoprotein lipase activity. In addition, abdominal obesity has been characterized by large adipocytes, which demonstrate increased insulin resistance and increased free fatty acids released into plasma. An increased amount of free fatty acids reaching the liver could in turn be associated with increased triglyceride production and VLDL secretion. It has been suggested that plasma apo A-I and B concentrations may be better predictors of CAD than are HDL and LDL cholesterol levels. Anderson et al reported an independent association between BMI, WHR, and apo B level. In our study apo B levels in men and women were positively associated with BMI and particularly with total body fat. After adjustment for total body fat, fitness level, and age, a positive significant association between USBR and apo B levels was found in women. WHR was not significantly associated with apo B levels in this population after adjustment for body fat. In postmenopausal women it has been reported that apo A-I is negatively associated with WHR. Our data are consistent with these previous findings. Elevated WHR was significantly associated with lower apo A-I concentrations in women, but we did not find a significant association in males.

We have previously reported that small LDL particles are associated with male gender and increased age. Small LDL particles have also been associated with the presence of CAD in men. It has also been reported that WHR is positively associated with small LDL particles and VLDL mass in men. In the present study we found a positive association between LDL particle size and age only in women. In addition, smaller LDL particles were associated with higher BMI and total body fat in men and women. WHR was also independently associated with smaller LDL particles in women. In men the same was true, but the association was not statistically significant.

Increased prevalence of general and abdominal obesity has been associated with changes from traditional (rural) to modern (urban) lifestyles. Population differences in prevalence of abdominal obesity and how it relates to an atherogenic lipid profile have also been reported. Our data indicate that subjects from the urban area are heavier, and body composition measurements indicate that the differences observed in weight are particularly due to elevated total body fat. This observation is also confirmed by the differences observed in skinfold measurements, particularly the subscapular, suprailliac, and umbilical sites and by the skinfold ratios, which were significantly higher in the urban subjects. It should be noted that no difference in the WHR was found between rural and urban subjects despite the significant difference found in total body fat. The prevalence of obesity in urban Puriscal was 10% lower in men and 16% higher in women than the prevalence of obesity previously reported for the Framingham population in the United States. A higher prevalence of current smokers was also found in urban compared with rural men. Smoking habits were in turn associated with higher triglyceride and apo B levels, as well as with lower HDL cholesterol and apo A-I concentrations. Our data also indicate that urban men had higher diastolic blood pressures than did rural men. It has been reported that central adiposity is associated with elevated systolic blood pressure.
itive association between UTR and diastolic blood pressure in men, supporting these previous findings. However, in this population blood pressure was not associated with abdominal obesity in women. This finding in women is consistent with previous observations of the associations between body fat distribution and blood pressure in women from the European Fat Distribution Study but differs from other previous reports.

It has been suggested that some non-Anglo populations may be genetically predisposed to an increased prevalence of central obesity. However, population comparisons should be interpreted with caution because our population was also shorter (13 cm) than Caucasians. This degree of stunting may also be associated with different patterns in body composition (i.e., elevated abdominal fat with higher BMI) that are associated with increased risk of CAD.

Sedentary lifestyles have been associated with an increased risk of CAD. In our study, fitness level was significantly lower in the urban men and women. Decreased fitness level was associated with higher glucose levels in men. In addition, when we adjusted for total body fat, decreased fitness levels were associated with higher apo A-I concentrations. This counterintuitive finding may be explained by the highly significant association between decreased fitness levels and increased body fat. Furthermore, it has been reported that when diet and weight loss are controlled for, no changes in apo A-I were observed.

Finally, elevated glucose, triglyceride, and total and VLDL cholesterol concentrations were higher and HDL cholesterol and apo A-I levels were lower in urban men compared with rural men. Rural–urban differences in plasma parameters were not as striking in women, for whom significant differences were found for glucose and apo B levels. These rural–urban differences in plasma parameters were not significant after adjustment for anthropometric measurements, smoking, age, and fitness level, suggesting that elevated total and abdominal obesity, increased cigarette smoking, and decreased fitness level explained in part the differences observed in plasma parameters and blood pressure between urban and rural men and women. These factors seem to contribute to the increased incidence of CAD observed in several developing countries, particularly in the urban areas. Our data are consistent with previous reports on general and abdominal obesity and how they relate to CAD risk factors. Additionally, we report an increased prevalence of general and abdominal obesity, cigarette smoking, elevated systolic and diastolic blood pressure, and decreased fitness level in urban compared with rural Puriscal, particularly in men. The higher prevalence of such risk factors in the urban area is associated with a more atherogenic plasma lipoprotein profile.

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H Campos, S M Bailey, L S Gussak, X Siles, J M Ordovas and E J Schaefer

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