Obesity and High-Density Lipoprotein Cholesterol in Black and White 9- and 10-Year-Old Girls: The National Heart, Lung, and Blood Institute Growth and Health Study

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It has been hypothesized that the role of obesity in the pathogenesis of coronary heart disease (CHD) may be mediated in part through its inverse relationship with high-density lipoprotein cholesterol (HDL-C). Obesity is inversely correlated with HDL-C, and HDL-C has been shown to be protective against CHD. Defining obesity as excess weight due to excess fat, the purpose of this analysis was to determine whether the effects of obesity are due to increased weight or to increased adiposity. Using baseline lipid and anthropometric data from the National Heart, Lung, and Blood Institute Growth and Health Study, cross-sectional associations among body mass, adiposity, HDL-C, and related lipid parameters (apolipoprotein [apo] AI and triglycerides [TGs]) were assessed in 821 white and 763 black 9- and 10-year-old girls, using multivariate linear regression models. Equations predicting HDL-C, apo AI, and TGs from age, race, sexual maturation stage, adiposity (sum of truncal—subscapular and suprailiac—skinfolds), and ponderosity (a ratio of weight to height) revealed that adiposity, not ponderosity, was the significant body composition variable to explain the variability of each of the lipids assessed. The amount of variance explained in each of the models was small ($R^2 \leq .10$). When apo AI and TGs were added to the HDL-C model, R^2 increased to 0.44 and race differences were no longer significant. These findings suggest that adiposity, not ponderosity, explains the effects of obesity on HDL-C, the effects are mediated through apo AI and TGs, and that black-white differences in HDL-C are a result of apo AI– and TG-metabolic differences between the races.
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THE PURPOSE of this report is to assess associations between levels of serum high-density lipoprotein cholesterol (HDL-C) and measures of ponderosity and adiposity. Understanding these associations is important, because body weight is inversely correlated with HDL-C[1,2] and HDL-C has a protective role in the pathogenesis of coronary heart disease (CHD).[3-5] Thus, the associations of weight (ponderosity) and fatness (adiposity) with HDL-C could be partly responsible for the increased risk of CHD associated with obesity. The mechanisms for these associations remain to be explained.

Assessing the relationship between obesity and HDL-C is complicated by the fact that there is no single measure to characterize obesity optimally in people of every age, race, and sex.[6] In epidemiologic studies, weight, weight to height ratios, and skinfold thickness measurements are commonly used. Some of these measures spotlight ponderosity, and others adiposity. Obesity is a diagnostic category—defined as a condition in which the energy stores of the body, mostly in the form of fat, are excessive,[7]—not a continuum. Excess weight due to excess adiposity is the key. Obesity differs from overweight in that overweight includes measures of muscle and bone, as well as fat; excess adiposity need not be present in overweight. Nevertheless, overweight and excess adiposity are highly correlated in populations. In this analysis, the cross-sectional relations of ponderosity and adiposity with HDL-C are evaluated.

Using data obtained from 9- and 10-year-old black and white girls participating in the baseline examination of the National Heart, Lung, and Blood Institute Growth and Health Study (NGHS), this report examines several aspects of the association of HDL-C with ponderosity and adiposity. First, given the high correlation between overweight and overfat, this report examines whether it is ponderosity or adiposity that explains the inverse association of HDL-C with obesity. Second, this report examines whether the effects of obesity are directly related to HDL-C or whether they are mediated through its effects on other lipid parameters, such as apolipoprotein (apo) AI, the major apolipoprotein associated with HDL-C,[8] and triglycerides (TGs). Obesity is directly correlated with TGs and inversely correlated with apo AI.[9] On the other hand, obesity could influence HDL-C levels independently of its effects on apo AI levels. For example, the cholesterol moiety of HDL is critically influenced by interplasmic processing enzymes,[10] some of which concurrently influence TG levels, eg, lipoprotein lipase (LpL). Moreover, the function of these enzymes, especially LpL, is known to be influenced by adiposity.[10] LpL levels are negatively associated with adiposity and positively associated with HDL-C. Apo AI is synthesized by the intestine and liver, where synthesis and catabolism have determinants distinct from those related to the processing enzymes. In this report, we examine whether obesity is associated with lower levels of both apo AI and HDL-C similarly (ie, proportionately) or whether it is associated with differences in the apo AI:cholesterol ester interaction, as reflected by differences in the ratio of HDL-C to apo AI.

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SUBJECTS AND METHODS

The NGHS has been described previously in detail.[11] Briefly, it is a collaborative cohort study involving three clinical centers: the University of California at Berkeley, University of Cincinnati Medical Center and Cincinnati Children's Hospital, and Westat, Inc, with the Humana Group Health Plan in Washington, DC. A total of 2,379 girls were enrolled (1,213 black and 1,166 white). The Berkeley and Cincinnati centers recruited participants from public and parochial schools, and Westat recruited subjects from the above-mentioned prepaid group practice in Washington, DC. Maryland Medical Research Institute in Baltimore serves as the Coordinating Center.

Two methods for assessing body habitus were used for this analysis: (1) weight to height ratios (ponderosity) and (2) skinfold thicknesses (adiposity). Measurements were made as follows. Height was measured with girls in socks, heels together, toes apart at a 45° angle, and head in the Frankfort horizontal plane, using custom-made portable stadiometers (Creative Health Products, Plymouth, MI). Weight was measured using a Health-o-meter electronic scale (model 482). Measurements of skinfold thickness were obtained at the triceps, suprailiac, and subscapular sites with Holtain calipers (Crymych, UK; imported by Pfister Import-Export, Carlstadt, NJ). All measurements were made following a common protocol.[11] Each variable was measured twice and repeated a third time if the first two measurements differed by greater than 1.0 mm for skinfolds, 0.5 cm for height, and 0.3 kg for weight. During the measurements, girls wore either paper hospital gowns or large T-shirts supplied by the center. To assess the possible role of sexual maturation in the effects of obesity on apo AI and HDL-C, a three-stage maturation score was used as follows: stage one was prepubertal, stage two pubertal (areolar and/or pubic hair development) but premenarchal, and stage three postmenarchal.

Fasting total cholesterol, TG, HDL-C, and apo AI levels were measured by the Central Lipid Laboratory at The Johns Hopkins University Medical Center (Bethesda, MD), which participates in phase three of the Centers for Disease Control lipid standardization program. Total cholesterol and HDL-C levels were determined using the Cholesterol CHOD-PAP method (Boehringer-Mannheim Diagnostics, Somerville, NJ). TGs were analyzed enzymatically using a commercially available method (Abbott A-Gent Triglycerides Reagent Set, Abbott Park, IL). Apo AI level was measured by radioimmunodiffusion in commercially prepared agarose plates containing monospecific goat antibody to apo AI (Diffu-Gen Apo-AI plates; TAGO, Burlingame, CA).

A weight to height index was computed as weight (kilograms) divided by height (centimeters) 3.22×10^6, where the exponent of 3.22 was chosen in an exploratory analysis of the data set to minimize the correlation between the index and height, a method reported by Benn.[12] Evaluating indices of relative weight and obesity, Benn showed that the body mass index, a commonly used weight to height ratio, is a power-type index (weight divided by height to the *P*-power) where the exponent is 2.0. However, previous reports by other pediatric studies have shown that the exponent 2.0 does not yield an index in children that is minimally correlated with height.[5,13] Consequently, the exponent was determined specifically for this cohort, and this weight to height ratio was used as the ponderosity index. Descriptive statistics on baseline measures (mean ± SD) were computed by race and age (9 *v* 10 years); racial differences were evaluated after adjusting for age using ANOVA. Differences in the percent of pubertal versus prepubertal subjects between races were evaluated, controlling for age, using the Mantel-Haenszel statistic.[14] Pearson correlation coefficients were calculated to describe associations between anthropometric measurements and HDL-C, TGs, and apo AI. Differences between correlation coefficients for blacks and whites were tested using the Fisher *z*-transformation; if the correlations were similar between the races, a weighted average of the transformed correlations was calculated and used to estimate a pooled correlation coefficient. Linear regression models were used first to explain the variation in HDL-C, apo AI, the ratio of HDL-C to apo AI, and TGs using ponderosity, adiposity, race, age, and pubertal maturation stage as explanatory variables; second, to describe the association of HDL-C with these same factors, given levels of TGs and apo AI; and third, to describe the association of the HDL-C to apo AI ratio to these variables, given levels of TGs. The presence of interactions between race and other predictor variables in these models was also tested.[15]

To reduce inflation of type I error in testing for adding multiple interactions, a multiple partial F test[15] was performed for jointly adding all interactions considered for each model; if the *P* value for that test was less than .05, tests were performed for the presence of individual interactions. Measures of adiposity (eg, triceps and subscapular skinfolds individually and sums of skinfolds) are highly correlated. Preliminary analyses revealed no consistent pattern of relationships between lipid parameters and adiposity as determined by truncal fat versus total fat, but the sum of truncal skinfolds was a slightly better predictor of HDL-C than the sum of all skinfolds. The sum of truncal skinfold thicknesses (subscapular and suprailiac) was selected as the adiposity-explanatory variable in the models, since investigators have increasingly focused on the role of truncal fat, as opposed to peripheral or total fat, in explaining relationships between obesity and cardiovascular risk factors.[16-18] Because of the high correlation between the triceps skinfold thickness and the sum of truncal skinfolds, only truncal adiposity was included in the final models, to avoid unstable estimation due to multicolinearity. Because of the correlations among other predictor variables, diagnostic statistics to detect problems with colinearity (eg, the variance inflation factor) were calculated; no important problems with colinearity were detected.[15]

RESULTS

Of 2,379 girls seen at baseline, 1,911 girls gave blood for lipid profiles and had HDL-C, TGs, and apo AI results (933 white and 978 black). Of these 1,911 girls, 218 (68 white and 150 black) had fasted less than 12 hours before the visit, 11 had missing anthropometry data, 41 had missing pubertal staging, 56 had reached menarche (a number too small for separate analysis), and one had TGs greater than 500 mg/dL. The remaining 1,584 girls (821 white and 763 black) were available for these analyses. The mean weight and ponderosity indices (weight divided by height^{3,22}) in subjects used in the analyses and subjects excluded were not significantly different; the mean sum of truncal skinfolds was 1.4 mm greater in excluded subjects.

Summary statistics by race and age for baseline anthropometric measures and HDL-C, TGs, and apo AI are presented in Table 1. Statistically significant differences between blacks and whites were present for all of these variables: on average, black girls were taller, heavier, and had higher measures of adiposity and ponderosity, higher levels of HDL-C and apo AI, and lower levels of TGs than white girls of the same age. A higher percentage of black subjects were pubertal at both ages 9 and 10. Table 2 presents Pearson correlation coefficients between anthropo-

Table 1. Anthropometric and Lipid Measurements in NGHS Girls at Baseline by Race and Age (mean ± SD)

Measurement	White		Black		
	Age 9 (n = 438)	Age 10 (n = 383)	Age 9 (n = 346)	Age 10 (n = 417)	P*
Weight (kg)	32.8 ± 7.1	37.5 ± 9.1	36.7 ± 9.4	42.0 ± 12.0	.001
Height (cm)	137.0 ± 6.0	142.6 ± 7.0	139.5 ± 6.7	145.6 ± 7.2	.001
$WT/HT^{3.22} \times 10^6$	4.3 ± 0.7	4.3 ± 0.7	4.5 ± 0.9	4.5 ± 1.0	.001
Skinfold thickness (mm)					
Suprailiac	8.7 ± 5.5	10.0 ± 6.2	9.9 ± 7.3	11.0 ± 7.6	.002
Subscapular	9.4 ± 5.7	10.4 ± 6.4	11.5 ± 7.9	12.2 ± 8.0	.001
Sum of skinfolds	18.1 ± 10.9	20.4 ± 12.3	21.4 ± 14.8	23.2 ± 15.3	.001
Pubertal (% of subjects)	22.6	41.5	49.7	79.4	.001
HDL-C (mg/dL)	53.5 ± 11.4	52.8 ± 11.4	55.9 ± 13.7	54.5 ± 13.6	.001
Apo AI (mg/dL)	141.0 ± 25.8	138.3 ± 24.4	147.9 ± 26.7	144.2 ± 27.9	.001
TGs (mg/dL)	76.3 ± 30.1	82.0 ± 39.9	69.5 ± 30.6	73.9 ± 33.4	.001

*P for black white difference, adjusted for age with ANOVA or logistic regression as appropriate.

metric measures and HDL-C, TGs, and apo AI in the entire cohort. Body composition measures and HDL-C and apo AI were inversely correlated, ranging from −.24 to −.26 for HDL-C and from −.15 to −.22 for apo AI, and body composition measures and TG were directly correlated, ranging from .25 to .29. All correlations were highly significant (Table 2). The correlations were similar among black and white 9- and 10-year-olds, so only weighted averages of the correlation estimates from the combined data set are shown in Table 2. Partial correlation coefficients for the associations of the sum of truncal skinfolds with HDL-C and apo AI after adjustment for TGs were −.18 and −.13, respectively. The partial correlation estimates did not differ between blacks and whites.

Results from multiple linear regression models predicting HDL-C, apo AI, the HDL-C to apo AI ratio, and TGs from age, race, sexual maturation stage (prepubertal *v* pubertal), adiposity, and ponderosity are presented in Table 3. After accounting for differences in these other variables, racial differences remained for HDL-C (whites, 2.9 mg/dL less, on average), apo AI (whites, 8.6 mg/dL less, on average), and TGs (whites, 9.4 mg/dL higher, on average). Ponderosity was not significantly related to HDL-C, apo AI, or TGs after taking adiposity into account, whereas adiposity was a statistically significant predictor of all three lipid parameters. Sexual maturation stage was a significant explanatory factor for apo AI, but not for HDL-C or TGs. After adjusting for age, race, adiposity, and ponderosity, apo AI was, on average, 3.56 mg/dL higher in prepubertal versus pubertal girls ($P < .01$). The amount of variation in HDL-C, apo AI, and TGs accounted for by these models incorporating race, age, sexual maturation, body mass index, and skinfolds was small ($R^2 = .08, .05$, and .10, respectively). In the model predicting the HDL-C to apo AI ratio from adiposity, ponderosity, race, sexual maturation stage, and age at baseline, a marginal association with the sum of truncal skinfolds was found ($P = .06$); no other explanatory variables were significant. Racial differences in the HDL-C to apo AI ratio were not statistically significant. The population variance in the HDL-C to apo AI ratio accounted for in this model was small ($R^2 = .02$). Tests for interactions of race with sexual maturation stage, adiposity, and ponderosity, and of sexual maturation stage with adiposity and ponderosity, were not statistically significant.

Table 2. Pearson Correlations of HDL-C, Apo AI, and TGs With Anthropometric Measures, HDL-C, Apo AI, and TGs in NGHS Participants at Baseline

Measurement	HDL-C	Apo AI	TG
Weight	−.26	−.22	.28
$WT/HT^{3.22} \times 10^6$	−.24	−.15	.25
Skinfolds			
Suprailiac	−.25	−.17	.28
Subscapular	−.26	−.18	.28
Sum of skinfolds	−.26	−.18	.29
HDL-C	1.00	.61	−.30
Apo AI	.61	1.00	−.14
TGs	−.30	−.14	1.00

NOTE. Correlations on combined black and white data, using a weighted average of the correlations to estimate a pooled correlation coefficient. All correlations are significant ($P < .01$).

Table 4 presents multiple linear regression models that included apo AI and TGs as predictor variables for HDL-C, in addition to the anthropometry variables presented earlier. Both apo AI and TGs were highly significant explanatory variables ($P < .0001$), and once these variables entered the model, the racial difference in HDL-C was no longer significant ($P = .93$). Moreover, the magnitude of the β for adiposity decreased from −0.20 (±0.04) to −0.05 (±0.03) and was no longer statistically significant ($P = .13$), suggesting that much of the influence of adiposity on HDL-C is mediated through its effects on TGs and apo AI. The proportion of the variation in HDL-C accounted for by the model (R^2) increased to .44 after the addition of apo AI and TGs. When TGs were added to the model explaining the HDL-C to apo AI ratio, TGs were significantly and inversely associated with the ratio, but no other explanatory variable was significant.

DISCUSSION

This analysis examined the relationships between HDL-C and adiposity and ponderosity based on models that describe HDL-C and other lipid parameters (apo AI, the HDL-C to apo AI ratio, and TGs) using ponderosity, adiposity, race, age, and sexual maturation stage as explanatory variables. In these models, adiposity was highly signifi-

Table 3. Multiple Regression of HDL-C, Apo AI, the HDL-C to Apo AI Ratio, and TGs as Dependent Variables With Race, Age, Sexual Maturation Stage, Ponderosity ($WT/HT^{3.22} \times 10^6$), and Adiposity (sum of suprailiac and subscapular skinfolds) as Independent Variables in NGHS Subjects at Baseline (N = 1,584)

	HDL-C		Apo AI		HDL-C to Apo AI Ratio		TGs	
	β	*P*	β	*P*	β	*P*	β	*P*
Intercept	62.84 ± 2.44	.0001	149.87 ± 5.19	.0001	0.4225 ± 0.0148	.0001	58.93 ± 6.50	.0001
Race (white = 1; black = 0)	−2.94 ± 0.65	.0001	−8.56 ± 1.38	.0001	0.0023 ± 0.0039	.55	9.44 ± 1.73	.0001
Age (9 = 1; 10 = 0)	0.52 ± 0.64	.41	1.52 ± 1.35	.26	−0.0004 ± 0.0038	.91	−3.64 ± 1.69	.03
Sexual maturation stage (0 = pubertal; 1 = prepubertal)	0.40 ± 0.69	.56	3.56 ± 1.46	.01	−0.0061 ± 0.0041	.14	0.54 ± 1.83	.77
$WT/HT^{3.22} \times 10^6$	−0.77 ± 0.70	.27	0.51 ± 1.50	.74	−0.0062 ± 0.0043	.15	−0.61 ± 1.88	.74
Sum of skinfolds (suprailiac and subscapular)	−0.20 ± 0.04	.0001	−0.37 ± 0.09	.0001	−0.0005 ± 0.0003	.06	0.77 ± 0.12	.0001
	$R^2 = .08$		$R^2 = .05$		$R^2 = .02$		$R^2 = .10$	

NOTE. β is the mean ± SEM.

cant in explaining levels of HDL-C, apo AI, and TGs, but ponderosity was not. Adiposity was inversely associated with both apo AI and HDL-C, and was positively associated with TGs. Adiposity was also marginally and inversely associated with the HDL-C to apo AI ratio ($P = .06$).

Measurements of adiposity may be better estimates of obesity than ponderal indices, because the latter incorporate not only body fat but also lean body mass and bone mass, and to some extent height. Further, the regional distribution of body fat, captured to some degree with truncal skinfold measurements, is also relevant to the risk for cardiovascular disease.[19,20] Correlations between HDL-C and the adiposity measures in adults have been reported to be higher[20-22] than correlations for the ponderosity measures, although others suggest the relationships are equivalent.[23-25] Our data on 9- and 10-year-old girls show that the correlations for ponderosity and adiposity with lipids are similar, but that once both adiposity and ponderosity are entered into the model, no association between ponderosity and HDL-C was discerned. This suggests that the information contained in the ponderosity measure as it relates to HDL-C comes from its association with adiposity. In addition, we found that in girls, the relationship between adiposity and HDL-C is primarily explained by TGs and apo AI (Table 4). After the addition of these other two lipid parameters, adiposity no longer contributed significantly to the prediction of HDL-C ($P = .13$). In adults, ponderosity alone, without more direct body fat measures, explains some of the HDL-C variability before the inclusion of TG and apo AI, but little after their inclusion.[26] This finding is consistent with body mass being highly associated with lipid and apolipoprotein determinants of HDL-C.

Table 4. Multiple Regression of HDL-C and the HDL-C to Apo AI Ratio as Dependent Variables With Race, Age, Sexual Maturation Stage, Ponderosity ($WT/HT^{3.22} \times 10$), Apo AI, and TGs as Independent Variables in NGHS Subjects at Baseline (N = 1,584)

	HDL-C		HDL-C to Apo AI Ratio	
	β	*P*	β	*P*
Intercept	25.86 ± 2.42	.0001	0.4473 ± 0.0149	.0001
Race (white = 1; black = 0)	0.04 ± 0.52	.93	0.0063 ± 0.0039	.11
Age (9 = 1; 10 = 0)	−0.14 ± 0.49	.77	−0.0019 ± 0.0038	.61
Sexual maturation stage (0 = pubertal; 1 = prepubertal)	−0.53 ± 0.53	.32	−0.0059 ± 0.0041	.15
$WT/HT^{3.22} \times 10^6$	−0.95 ± 0.55	.08	−0.0065 ± 0.0042	.12
Sum of skinfolds (suprailiac and subscapular)	−0.05 ± 0.03	.13	−0.0002 ± 0.0003	.52
Apo AI	0.27 ± 0.01	.0001		
TGs	−0.07 ± 0.01	.0001	−0.0004 ± 0.0001	.0001
	$R^2 = .44$		$R^2 = .06$	

HDL-C and apo AI levels are higher in black girls than in white girls, despite greater obesity in black girls whether measured by adiposity or ponderosity (Table 1). This finding seems in contradiction to the low HDL-C–elevated body weight paradigm,[27] but the finding has been previously reported.[28,29] One possible explanation for this finding is that the HDL-C–weight relationship holds within each racial group, but the intercept is higher for black girls than for white girls. A parallel finding is the lower TG levels in blacks. Ama et al[30] suggested that the lower TG and higher HDL-C levels in blacks versus whites may be the result of higher LpL activity in blacks. LpL, an enzyme critical to the inverse relationship of HDL-C and TGs,[8] is synthesized in adipose tissue and is active in the hydrolysis of TG-rich lipoproteins. LpL-dependent TG hydrolysis may serve as one conduit for the accumulation of lipid into adipose cells from the bloodstream, and is thus a hypothesized physiologic mechanism for the development of obesity.[22] In a reciprocal fashion, enhanced adiposity is associated with decreased LpL activity, perhaps due to some feedback mechanism related to insulin sensitivity.[10] The loss of a significant racial difference for HDL-C, once apo AI and TGs are included in the model (Table 4), is consistent with the hypothesis that HDL-C is the metabolic product of apo AI and TG metabolism.[8] As TGs are processed as either chylomicrons from the intestine or very–low-density lipoproteins from the liver, lipid material is incorporated into HDL. TG and apo AI levels are potentially related to the black-white differences in LpL activity. In other investigations, analyses of the relative contribution of protein and lipid to the HDL particle have permitted separation of

HDL into HDL_2 and HDL_3 fractions, which are lipid-rich/protein-poor and lipid-poor/protein-rich, respectively.[27] As demonstrated by the cross-sectional regression models from the Atherosclerosis Risk in Communities Study,[26] an increase in the cholesterol content of the molecule corresponds to an increase in HDL_2, and concomitantly a relative decrease in HDL_3, for black and white subjects 45 to 64 years of age. Even though higher TG levels are associated with lower levels of both HDL_2 and HDL_3, a higher ponderosity index is, in contrast, primarily associated with lower HDL_2.[26] These relationships would suggest a metabolic divergence between the body mass–TG and body mass–HDL associations, which would not be detected through the simple measure of HDL-C level alone. The NGHS did not quantify the HDL fractions, but did discern a minimally lower HDL-C to apo AI ratio in association with enhanced adiposity. This would be consistent with a greater number of protein-enriched HDL_3 versus HDL_2 particles in subjects with atherosclerotic disease, as reported by Miller.[31]

Adiposity measures explain little of the variability in HDL-C even with race and maturation in the model, with an overall R^2 of .08. With the addition of apo AI and TGs, the model accounts for over 44% of HDL-C variability. This would suggest that other variables, such as insulin resistance, might help account for the common clinical finding of both adiposity and low HDL-C levels.[32] These results are relatively robust, in that few of the confounding environmental variables with significant effects on HDL-C observed in adult studies, eg, cigarette smoking and alcohol use, are present in children.[33-35] However, maturational changes are occurring rapidly in this population,[36] and the lack or the presence of secondary sexual characteristics (the maturational variable included in our model) does not preclude marked hormonal shifts that may influence lipoprotein levels. In a review of cross-sectional and prospective studies of HDL-C, apo AI, and other lipid and apolipoprotein parameters, Miller[31] concluded that lower HDL-C to apo AI ratios appear to be associated with ischemic heart disease. Although most of the studies reviewed by Miller were of men, not women, this conclusion is consistent with the marginally lower ratios associated with increased adiposity observed in our study (Table 3). However, any effects of adiposity on this ratio are probably mediated through TG metabolism, since adiposity was a significant explanatory variable for TG levels (Table 3) and once TGs were added to the model the anthropometry variables were no longer significant (Table 4).

In summary, adiposity accounts for a minor portion of the variability in HDL-C and apo AI in black and white girls, whereas ponderosity has no significant association. In both races, adiposity measures are associated with lower levels of both HDL-C and apo AI and with only slightly lower HDL-C to apo AI ratios. The effect of adiposity on HDL-C is mediated primarily through its effects on apo AI and TGs, although some marginal effect of adiposity on HDL-C may remain after adjustment for these variables ($P = .13$). Racial differences in HDL-C were no longer significant after adjustment for TGs and apo AI. This suggests that the HDL-C differences are a result of apo AI and TG metabolic contrasts between the racial groups. The sum of truncal skinfolds as a marker of body fat is a better determinant of HDL-C than the weight to height index. A recent study in postmenopausal women indicates that the waist to hip ratio is a better predictor of cardiovascular mortality than body mass index,[37] a finding consistent with reports that truncal fat is more strongly associated with CHD risk factors than total adiposity.[16-18] Measures of adiposity and truncal fat could improve the clinical assessment of cardiovascular risk above that afforded by body mass alone.

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