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Racial/Ethnic Differences in the Association of Triglycerides with Other Metabolic Syndrome Components: The Multi-Ethnic Study of Atherosclerosis

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Abstract

Objective: The aim of this study was to examine whether there are ethnic differences in the association of triglycerides (TG) with waist circumference (WC), blood pressure, high-density lipoprotein cholesterol (HDL-C), fasting glucose, and insulin resistance and to examine the disparities in the prevalence of the metabolic syndrome components between African Americans and non-Hispanic whites who do not have hypertriglyceridemia.

Methods: This study used the baseline data from the Multi-Ethnic Study of Atherosclerosis (MESA) study. The analysis included non-Hispanic whites ($N = 2{,}427$) and African Americans ($N = 1{,}519$) aged 45–84 years free of clinically evident cardiovascular disease and diabetes at baseline. The revised National Cholesterol Education Program (NCEP) criteria were used to define the metabolic syndrome and its components.

Results: African Americans had lower prevalence of elevated TG as compared with non-Hispanic whites. The association of TG with other components of the metabolic syndrome appeared to be similar between African Americans and non-Hispanic whites except for one. There was significant association of TG with WC among white women but not among African American women after adjusting for demographic and other variables (P for interaction of TG with ethnicity <0.001). In participants with TG < 150 mg/dL, African American women had higher prevalence rates than white women of abdominal obesity, elevated blood pressure, low HDL-C, elevated fasting glucose and homeostasis model assessment of insulin resistance (HOMA-IR). In men, the prevalence rates of high blood pressure, elevated fasting glucose, and HOMA-IR were significantly higher in African Americans than in whites.

Conclusions: The study findings suggest that further evaluation is warranted regarding the cutoffs for elevated TG and its clustering effect with other cardiometabolic risk factors on predicting risk for diabetes and cardiovascular disease (CVD) in African Americans.

Introduction

Elevated serum triglyceride (TG) is a common feature of dyslipidemia and often coexists with other cardiovascular disease (CVD) risk factors, such as central obesity, elevated blood pressure, low high-density lipoprotein cholesterol (HDL-C), and high fasting glucose. These clustered cardiometabolic risk factors comprise the components of the so-called metabolic syndrome. Studies have consistently shown that African Americans have lower TG and higher HDL-C concentrations,[1–3] but little is known about whether association of TG with other metabolic syndrome components and insulin resistance differs by ethnicity.

Understanding whether ethnicity modifies the association of TG with other cardiometabolic factors may provide key information on the clustering pattern of metabolic syndrome components and help to determine whether the cutoff points for a specific risk factor should be different depending on the background of race/ethnicity. Despite the fact that African Americans seem to have a more favorable lipid profile, they

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have higher rates of hypertension, elevated fasting glucose, and insulin resistance than whites.[4–6] However, no previous studies have examined the ethnic disparities in these cardiometabolic risk factors among those who do not have hypertriglyceridemia. We conducted analyses to examine whether: (1) there are ethnic differences in the association of TG with other cardiometabolic risk factors; (2) the other metabolic syndrome components differ between whites and American Americans who do not have hypertriglyceridemia, and (3) taking into account differences in markers of insulin resistance attenuates racial differences in the prevalence of abdominal obesity, elevated blood pressure, and low HDL-C after adjusting for other demographic and sociobehavioral variables.

Methods

Multi-Ethnic Study of Atherosclerosis study population

The Multi-Ethnic Study of Atherosclerosis (MESA) is a multicenter cohort study of 6,814 men and women aged 45–84 years free of clinically evident CVD at baseline, recruited from six different communities: Baltimore City and Baltimore County, Maryland; Chicago, Illinois; Forsyth County, North Carolina; Los Angeles County, California; northern Manhattan and the Bronx, New York; and St. Paul, Minnesota. Detailed information about the design of the MESA study is provided elsewhere.[7] MESA included non-Hispanic whites, African Americans, Hispanics, and Chinese Americans. For the purposes of these analyses, only non-Hispanic whites and African Americans are included. The analysis also excluded 29 participants with missing values on the key outcome variables. The final sample size for the analysis included 2,427 non-Hispanic whites and 1,519 African Americans.

Questionnaires were used to obtain information about socioeconomic status, medical history, medication and tobacco use. Waist circumference (WC) at the umbilicus was measured to the nearest 0.1 cm using a steel measuring tape. Resting blood pressure was measured three times with participants in the seated position with a Dinamap model Pro 100 automated oscillometric sphygmomanometer (Critikon); the average of the last two measurements was used in the analysis. Triglycerides, HDL-C, glucose levels, and insulin were measured from blood samples obtained after a 12-h fast. We excluded participants with diabetes (taking medicines for diabetes or fasting glucose >125mg/dL), those whose diabetes status was unknown, and also those with missing values of TG, insulin, blood pressure, WC, or HDL-C. A total number of 3,946 remained for analysis.

Metabolic syndrome was classified using the updated Adult Treatment Panel III (ATP III) definition[8] as three or more of the following: Large WC (WC > 102 cm for men and WC > 88 cm for women); elevated TG (≥150 mg/dL); low HDL-C (men < 40 and women < 50 mg/dL); elevated blood pressure [systolic blood pressure (SBP) ≥ 130 or diastolic blood pressure (DBP) ≥ 85 mmHg or use of medications for hypertension]; and elevated fasting glucose (≥100 mg/dL). Because our study did not include any people with diabetes, elevated fasting glucose was between 100 mg/dL and 125 mg/dL. Insulin resistance was estimated by homeostasis model assessment of insulin resistance (HOMA-IR), calculated using the formula (insulin (mU/I)×(glucose [mg/dL] 0.055)/22.5). The top quartile value was used as cutoff point to determine insulin resistance.

Statistical analysis

Descriptive statistics were used to describe the characteristics of the study population. Regression models were used to examine the association of log-transformed TG with WC, SBP, DBP, HDL-C, and HOMA-IR, respectively. To examine whether the association of TG with other metabolic syndrome components was modified by race, we tested the interaction of race with TG in unadjusted linear models and linear models adjusting for age, education and income level, smoking status, lipid medication use, and clinic sites, as well as other risk factors if appropriate. To evaluate whether ethnic differences in metabolic syndrome components were present among those with normal TG levels, we calculated the prevalence of abdominal obesity, elevated blood pressure, low HDL-C, fasting glucose, and insulin resistance (HOMA-IR) among those with values in the normal TG range (<150 mg/dL).

We used generalized linear models to calculate unadjusted and adjusted prevalence ratios for abdominal obesity, elevated blood pressure, low HDL-C, elevated fasting glucose, and HOMA-IR in black as compared with white participants. Prevalence ratios are more appropriate than odds ratios in cross-sectional studies when outcomes are not rare.[9] More analyses were conducted to examine whether HOMA-IR attenuated the prevalence ratios for abdominal obesity, elevated blood pressure, low HDL-C in the model that already adjusted for age, education and income level, smoking status, physical activity, lipid medication use, and clinic sites. Because HOMA-IR was calculated using fasting glucose, we did not run an analysis to examine whether HOMA-IR attenuated the prevalence ratio for fasting glucose due to the problem of over adjustment. The significance level (alpha) was set at 0.05 for statistical tests. All analyses were conducted separately for women and men because of substantial heterogeneity in the components of the metabolic syndrome.[10,11] STATA software version 11.0 was used to conduct statistical analysis.[12]

Results

Of the 3,946 non-Hispanic whites (61.5%) and African Americans (38.5%) without type 2 diabetes at baseline, 45% were males (Table 1). Compared with whites, African Americans had lower education and income levels. Current smoking was more prevalent among African Americans than among whites. White men were more likely than African-American men to use lipid medications, whereas the use of antihypertension medications was significantly higher among African-American men and women. African Americans had higher mean blood pressure and fasting glucose values than did whites. African-American women had higher mean body mass index (BMI), WC, and HOMA-IR values than did white women. Whereas mean BMI was higher among African-American men, mean WC was significantly higher among white men. African-American men had higher mean HDL-C than did white men.

There were no significant racial/ethnic differences in the prevalence of the metabolic syndrome based on ATP III

Table 1. Characteristics of the Study Population (MESA, 2000–2002)

	Men			*Women*		
	Non-Hispanic white N = *1,147*	*African Americans* N = *664*	P *value*	*Non-Hispanic white* N = *1,280*	*African Americans* N = *855*	P *value*
Age, year[a]	62.5 (10.1)	61.6 (10.3)	0.08	62.3 (10.4)	61.8 (10.1)	0.21
Education less than high school, %	3.9	10.9	<0.001	5.5	10.5	<0.001
Income level, < $25,000 %	10.8	22.3	<0.001	20.1	33.4	<0.001
Current smoker, %	11.1	20.5	<0.001	12.0	16.4	<0.001
Use of antihypertensive medication, %	31.5	41.7	<0.001	30.5	47.8	<0.001
Use of lipid medications,%	19.3	12.7	<0.001	15.9	13.8	0.19
Body mass index (BMI), @	27.7 (3.9)	28.4 (4.6)	0.001	27.3 (5.7)	30.9 (6.4)	<0.001
Waist circumference, cm[a]	100.5 (11.2)	99.6 (12.5)	0.13	94.4 (15.9)	100.1 (15.9)	<0.001
Triglycerides, mg/dL[a]	129.6 (77.5)	104.8 (64.1)	<0.001	129.2 (75.7)	95.9 (45.8)	<0.001
SBP, mmHg[a]	123.6 (18.3)	129.1 (19.2)	<0.001	122.5 (21.9)	132 (23)	<0.001
DBP, mmHg[a]	73.9 (9.1)	77.2 (9.4)	<0.001	67 (9.6)	72.9 (10.4)	<0.001
HDL-C, mg/dL[a]	45.5 (12.1)	47.4 (12.8)	0.001	59.2 (15.7)	57.9 (15.9)	0.07
Fasting glucose[a]	90.1 (9.8)	91.3 (10.9)	0.02	85.8 (9.7)	89.3 (10.3)	<0.001
HOMA-IR[a]	1.38 (1)	1.47 (1.1)	0.11	1.17 (.97)	1.56 (1.1)	<0.001
ATP-III Metabolic syndrome, %	26	25.2	0.70	29.3	30.9	0.44
Metabolic syndrome components						
Abdominal obesity, %	40.5	39.5	0.65	61.6	76.0	<0.001
Elevated blood pressure, %	46.6	64.3	<0.001	45.1	65.9	<0.001
Elevated fasting glucose, %	14.4	21.2	<0.001	9.0	14.5	<0.001
Low HDL-C, %	33.7	26.5	0.02	28.9	32.0	0.12
Elevated triglycerides, %	29.6	15.7	<0.001	29.5	11.7	<0.001
HOMA-IR, %	25	29.4	<0.001	17	33.0	<0.001

ATP III criteria: Abdominal obesity (WC>100 for men and WC>88 for women); elevated triglycerides (≥150 mg/dL); low HDL-C (men <40 and women <50 mg/dL); elevated blood pressure (systolic blood pressure ≥130 or diastolic blood pressure ≥85 mmHg or use of medications for hypertension); and elevated fasting glucose (100–125 mg/dL).

[a]Mean (standard deviation) reported.

MESA, Multi-Ethnic Study of Atherosclerosis; SD, standard deviation; SBP, systolic blood pressure; DPB, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; HOMA-IR, homeostasis model assessment of insulin resistance.

definition in either men or women. As expected, the prevalence of elevated TG was significantly lower among African Americans compared with whites. The prevalence of abdominal obesity was significantly higher among African-American than white women, but no ethnic difference was seen in men. Both African-American men and women had higher rates of elevated blood pressure and elevated fasting glucose. Although low HDL-C was more common in white than in African-American men, there was no significant ethnic difference in women. The prevalence rates of high HOMA-IR using the top quartile as the cutoff value and elevated fasting glucose were higher in both African-American men and women as compared with their white counterparts.

Table 2 displays the multivariable-adjusted association of TG with other metabolic syndrome components and HOMA-IR for each ethnic and gender group separately. TG was significantly positively associated with blood pressure, fasting glucose, and HOMA-IR and inversely associated with HDL-C in both sexes and ethnicities. TG was significantly associated with WC in whites and African American men.

There was an apparent interaction between ethnicity and TG in women. One unit increase in log TG (mg/dL) was independently and positively associated with a 12.9-cm change in WC in white women, but no statistically significant association was observed in African American women (P for interaction <0.001). No interactions of TG with ethnicity in other metabolic syndrome components were seen.

In participants with TG < 150 mg/dL, prevalence of all metabolic syndrome components and HOMA-IR were significantly higher in African-American women than in white women (Table 3). In men, the prevalence rates of high blood pressure, elevated fasting glucose, and HOMA-IR were significantly higher in African Americans than in whites. The estimated prevalence ratios for these metabolic syndrome components were presented in Table 4. Further adjustment of HOMA-IR in regression models reduced the African American-to-white prevalence ratio for abdominal obesity from 1.4 to 1.3 and the prevalence ratio for low HDL-C from 1.6 to 1.3 in women, which remained statistically significant. The adjustment for HOMA-IR did not change the prevalence ratios for elevated blood pressure in both men and women.

Discussion

In this sample of middle-aged and older adults who were free of clinical coronary heart disease and type 2 diabetes at baseline, using the current ATP III definitions, no significant differences were observed in the prevalence of the metabolic syndrome between African Americans and non-Hispanic whites. However, African-American men and women were found to have a lower prevalence of elevated TG concentrations and higher rates of elevated fasting glucose, HOMA-IR, and high blood pressure. Because African Americans tend to have higher insulin resistance but lower TG concentrations, there is a concern that, compared to whites, the

Table 2. Multivariable-Adjusted Association of TG with Other Metabolic Syndrome Components and HOMA-IR, (MESA, 2000–2002)

	Non-Hispanic white		*African American*		*Interaction of race with TG*	
	Beta coefficient[a]	P *value*	*Beta coefficient*[a]	P *value*	*Beta coefficient*[a]	P *value*
Men						
Waist circumference, cm	7.3	<0.001	10.9	<0.001	4.1	N.S.
SBP, mmHg	12.7	<0.001	10.3	0.01	−2.9	N.S.
DBP, mmHg	5.60	<0.001	5.7	0.006	−1.5	N.S.
HDL-C, mg/dL	−26.4	<0.001	−21.9	<0.001	1.7	N.S.
Fasting glucose	6.4	<0.001	5.4	0.016	1.3	N.S.
HOMA-IR	0.9	<0.001	0.6	<0.001	−0.3	N.S.
Women						
Waist circumference, cm	12.9	<0.001	1	0.70	−13.1	<0.001
SBP, mm Hg	11.1	<0.001	8.6	0.050	−3.8	N.S.
DBP, mmHg	3.4	0.016	4.2	0.046	−1.1	N.S.
HDL-C, mg/dL	−25.8	<0.001	−29.7	<0.001	−4.1	N.S.
Fasting glucose	2.8	0.031	4.3	0.029	3.1	N.S.
HOMA-IR	0.5	<0.001	0.7	0.001	0.3	N.S.

[a]Change in each metabolic syndrome component and HOMA-IR per unit change in log triglyceride level after adjustment for age, education, income level, smoking status, lipid medication use, and other metabolic syndrome components, if appropriate.

N.S., not statistically significant ($P > 0.05$).

TG, triglycerides; HOMA-IR, homeostasis model assessment of insulin resistance; MESA, Multi-Ethnic Study of Atherosclerosis; SBP, systolic blood pressure; DPB, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol.

current ATP III definition of the metabolic syndrome may under diagnose African Americans at high risk for type 2 diabetes and CVD.[13,14] There are debates on whether continuous variables should be used instead of the specific cutoff points for the metabolic syndrome[15,16] and whether specific metabolic syndrome components should be weighted in the definition of the metabolic syndrome[17]; therefore, future studies are needed to evaluate and determine how the clustered cardiometabolic risk can be adequately measured and identified in African Americans and other ethnic groups.

Insulin resistance is considered as the underlying factor for the clustering of cardiometabolic risk factors[18] and increases risk for type 2 diabetes and CVD.[19,20] Because of the difficulties in measuring insulin resistance in clinical settings, researchers have examined the use of TG and TG-to-HDL-C ratio to identify individuals with insulin resistance.[21] However, it is still debatable whether the use of TG and the TG-to-HDL-C ratio is appropriate for African Americans.[6,22–24] Our study showed that the association of TG with HOMA-IR was significant among whites and African Americans, and that the association did not differ by ethnicity after adjustment for demographic and other risk factors. Given that ethnicity does not seem to modify the association of TG with HOMA-IR and African Americans tend to have higher insulin resistance as compared with whites, further studies should be conducted to examine and determine whether the cutoff points for elevated TG need to be modified in identifying people at higher risk for type 2 diabetes and CVD among African Americans.

We found the association of WC with TG to differ between African-American and white women. African-American women had higher rates of abdominal obesity than did white women, but the association of WC with TG was only observed in white women (P for interaction <0.001). These findings are consistent with a few population-based studies that reported either lack of association of obesity measures

Table 3. Prevalence of Metabolic Syndrome Components and HOMA-IR in Participants with TG < 150 mg/dL (MESA, 2000–2002)

	Men			*Women*		
Metabolic syndrome components/HOMA-IR	*Non-Hispanic white (%)* N = *808*	*African Americans (%)* N = *506*	P *value*	*Non-Hispanic white (%)* N = *903*	*African Americans (%)* N = *756*	P *value*
Abdominal obesity	33.9	35.7	0.5	53.3	75.6	<0.001
Elevated blood pressure	42.2	62.7	<0.001	40.2	64.2	<0.001
Elevated fasting glucose	12.3	19.1	0.003	6.8	14	0.007
Low HDL-C	21.9	21.4	0.8	17.4	28.2	<0.001
HOMA-IR	17.8	25.5	0.001	10.8	30.5	<0.001

ATP-III criteria: Abdominal obesity (WC >100 cm for men and WC >88 cm for women); elevated triglycerides (≥150 mg/dL); low HDL-C (men <40 and women <50 mg/dL); elevated blood pressure (systolic blood pressure ≥130 or diastolic blood pressure ≥85 mmHg or use of medications for hypertension); and elevated fasting glucose (100–125 mg/dL).

HOMA-IR, homeostasis model assessment of insulin resistance; MESA, Multi-Ethnic Study of Atherosclerosis; HDL-C, high-density lipoprotein cholesterol.

Table 4. African American: White Prevalence Ratios for the Metabolic Syndrome Components, Participants with TG < 150 mg/dL (MESA, 2000–2002)

Metabolic syndrome components	Men			Women		
	Prevalence ratios (95% CI)			Prevalence ratios (95% CI)		
	Unadjusted	Adjusted[a]	Adjusted[b]		Adjusted[a]	Adjusted[b]
Abdominal obesity	1.1 (0.9–1.2)	1 (0.9–1.2)	1 (0.8–1.2)	1.4 (1.3–1.5)[c]	1.4 (1.3–1.5)[c]	1.3 (1.3–1.4)[c]
Elevated blood pressure	1.5 (1.3–1.67)[c]	1.6 (1.4–1.7)[c]	1.5 (1.4–1.7)[c]	1.6 (1.5–1.8)[c]	1.6 (1.4–1.8)[c]	1.5 (1.4–1.7)[c]
Elevated fasting glucose	1.4 (1.1–1.8)[c]	1.5 (1.09–1.94)[c]	NA	2.1 (1.5–2.8)[c]	1.9 (1.4–2.6)[c]	NA
Low HDL-C	1 (0.8–1.2)	0.8 (0.7–1.1)	0.8 (0.7–1.0)	1.6 (1.4–1.9)[c]	1.5 (1.2–1.8)[c]	1.3 (1.1–1.6)[c]

Metabolic syndrome components based on ATP III criteria: Abdominal obesity (WC >100 cm for men and WC >88 cm for women); elevated triglycerides (>150 mg/dL); low HDL-C (men <40 and women <50 mg/dL); elevated blood pressure (systolic blood pressure >130 or diastolic blood pressure >85 mmHg or use of medications for hypertension); and elevated fasting glucose (100–125 mg/dL).

[a]Adjusted for age, education, income level, smoking status, physical activity, lipid medication use. and clinic site.

[b]Adjusted for age, education, income level, smoking status, physical activity, lipid medication use, clinic site. and HOMA-IR.

[c]Significantly different from whites ($P < 0.001$).

TG, triglycerides; MESA, Multi-Ethnic Study of Atherosclerosis; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; ATP III, adult treatment panel III; WC, waist circumference.

with TG or a stronger, nongender-stratified association of TG with obesity measures in whites than in African Americans.[25–27] Racial differences in the association of obesity with TG have implications for evaluating the effectiveness of intervention programs aiming at weight reduction. The differentiated association of obesity with TG by ethnicity suggests that weight reduction may not achieve the same effect in improving the lipid profile in different ethnic groups.

Ethnic differences in cardiometabolic risk factors between non-Hispanic whites and African Americans have been extensively reported in the literature. Our study, however, appears to be the first to examine the distribution of these risk factors among people who do not meet the criteria for elevated TG (<150 mg/dL). We found striking disparities in the prevalence of the metabolic syndrome components and HOMA-IR between African Americans and whites who did not have hypertriglyceridemia. African-American women had higher prevalence rates of abdominal obesity, elevated blood pressure, elevated fasting glucose, low HDL-C and HOMA-IR whereas African men were found to have higher prevalence rates of elevated blood pressure, fasting glucose, and HOMA-IR. These findings may offer some explanation as to why African Americans, particularly women, do not seem to benefit from lower TG concentrations. It should be emphasized that African-American women with TG < 150 mg/dL had even higher rates of low HDL-C compared with white women (28.3% vs. 17.4%). A low level of HDL-C is an independent risk factor for coronary heart disease (CHD),[28] and low levels of HDL-C among African women with normal level TG may be associated with a higher CHD mortality rate for black than for white females.[29] There were persistent racial disparities in these risk factors after adjustment for HOMA-IR. The observed racial differences in these risk factors may reflect a multifactorial interplay of behavioral, biological, and societal factors and the cumulative effect of socioeconomic determinants and psychosocial behavioral factors, which require further investigations.

The advantages of our study include its population-based and geographically diverse sample and stringent quality control measures. However, our study also has limitations. HOMA-IR is an estimate of insulin resistance, although there is a good correlation between estimates of insulin resistance derived from homeostatic model assessment in normal and diabetic subjects.[30] The observed associations are cross sectional, and thus the temporal relation of TG with other risk factors over time could not be examined. Given the racial/ethnic differences in the distribution of TG and other metabolic syndrome components, further evaluation is warranted regarding the cutoffs for elevated TG and its clustering effect with other cardiometabolic risk factors on predicting risk for type 2 diabetes and CVD in African Americans.

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Author Disclosure Statement

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