Ethnic Differences in Coronary Calcification

The Multi-Ethnic Study of Atherosclerosis (MESA)

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Background—There is substantial evidence that coronary calcification, a marker for the presence and quantity of coronary atherosclerosis, is higher in US whites than blacks; however, there have been no large population-based studies comparing coronary calcification among US ethnic groups.

Methods and Results—Using computed tomography, we measured coronary calcification in 6814 white, black, Hispanic, and Chinese men and women aged 45 to 84 years with no clinical cardiovascular disease who participated in the Multi-Ethnic Study of Atherosclerosis (MESA). The prevalence of coronary calcification (Agatston score >0) in these 4 ethnic groups was 70.4%, 52.1%, 56.5%, and 59.2%, respectively, in men ($P<0.001$) and 44.6%, 36.5%, 34.9%, and 41.9%, respectively, ($P<0.001$) in women. After adjustment for age, education, lipids, body mass index, smoking, diabetes, hypertension, treatment for hypercholesterolemia, gender, and scanning center, compared with whites, the relative risks for having coronary calcification were 0.78 (95% CI 0.74 to 0.82) in blacks, 0.85 (95% CI 0.79 to 0.91) in Hispanics, and 0.92 (95% CI 0.85 to 0.99) in Chinese. After similar adjustments, the amount of coronary calcification among those with an Agatston score >0 was greatest among whites, followed by Chinese (77% that of whites; 95% CI 62% to 96%), Hispanics (74%; 95% CI 61% to 90%), and blacks (69%; 95% CI 59% to 80%).

Conclusions—We observed ethnic differences in the presence and quantity of coronary calcification that were not explained by coronary risk factors. Identification of the mechanism underlying these differences would further our understanding of the pathophysiology of coronary calcification and its clinical significance. Data on the predictive value of coronary calcium in different ethnic groups are needed. (***Circulation*. 2005;111:1313-1320.**)

Key Words: epidemiology ■ atherosclerosis ■ coronary disease ■ calcium

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Coronary calcification is a specific marker of atherosclerosis[1] that, as measured by computed tomography, correlates with atherosclerotic plaque[2,3] and is predictive of future coronary events.[4–6] Several,[7–10] although not all,[11] recent studies have found that the presence and quantity of coronary artery calcification are substantially higher among middle-aged and older US white populations than among blacks. As a marker of coronary atherosclerosis, the finding of a lower prevalence and quantity of coronary calcification among blacks than whites is not consistent with the generally higher levels of traditional coronary heart disease risk factors, particularly hypertension, obesity, and diabetes, and with higher rates of coronary heart disease mortality[12] in the black population. The few data available on other ethnic groups also suggest that differences in the prevalence of coronary calcification exist among whites, Hispanics, and Asians.[9]

Differences in coronary calcification across ethnic groups that are not explained by differences in coronary risk factors would have implications for understanding the pathogenesis and clinical significance of coronary calcification in different groups. We analyzed data from the Multi-Ethnic Study of Atherosclerosis (MESA) to determine the relative prevalence and quantity of coronary calcification across ethnic groups and to determine whether ethnic differences persist after controlling for concurrent traditional coronary heart disease risk factors.

Methods

MESA was initiated to investigate the prevalence, correlates, and progression of subclinical cardiovascular disease (CVD), ie, disease

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detected noninvasively before it has produced clinical signs and symptoms, in men and women. Details about the study design have been published elsewhere.[13] In brief, between July 2000 and August 2002, 6814 men and women who identified themselves as white, black, Hispanic, or Chinese and were 45 to 84 years old and free of clinically apparent CVD were recruited from portions of 6 US communities: Baltimore City and Baltimore County, Maryland; Chicago, Ill; Forsyth County, North Carolina; Los Angeles County, California; Northern Manhattan and the Bronx, New York; and St. Paul, Minn. Each field site recruited from locally available sources, which included lists of residents, lists of dwellings, and telephone exchanges. In the last few months of the recruitment period, supplemental sources (lists of Medicare beneficiaries from the Centers for Medicare and Medicaid Services and referrals by participants) were used to ensure adequate numbers of minorities and elderly subjects. The institutional review boards at all participating centers approved the study, and all participants gave informed consent.

Standardized questionnaires were used to obtain information about level of education, annual household income, smoking history, and medication usage for high blood pressure, high cholesterol, or diabetes. Smoking was defined as current, former, or never.

Height and weight were measured with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Resting blood pressure was measured 3 times with participants in the seated position with a Dinamap model Pro 100 automated oscillometric sphygmomanometer (Critikon). The average of the last 2 measurements was used in analysis. Hypertension was defined as systolic pressure $\geq$140 mm Hg, diastolic pressure $\geq$90 mm Hg, or current use of antihypertensive medication.

Total and HDL cholesterol, triglycerides, and glucose levels were measured from blood samples obtained after a 12-hour fast. LDL cholesterol was calculated with the Friedewald equation.[14] Diabetes was defined as fasting glucose >6.99 mmol/L (126 mg/dL) or use of hypoglycemic medication. Impaired fasting glucose was defined as fasting glucose 6.11 to 6.94 mmol/L (110 to 125 mg/dL).[15]

Computed tomography scanning of the chest was performed either with an ECG-triggered (at 80% of the RR interval) electron-beam computed tomography scanner (Chicago, Los Angeles, and New York field centers; Imatron C-150, Imatron)[16] or with prospectively ECG-triggered scan acquisition at 50% of the RR interval with a multidetector computed tomography system[17] that acquired 4 simultaneous 2.5-mm slices for each cardiac cycle in a sequential or axial scan mode (Baltimore, Forsyth County, and St. Paul field centers; Lightspeed, General Electric or Siemens, Volume Zoom). Each participant was scanned twice. Scans were read centrally at the Harbor-University of California, Los Angeles Research and Education Institute to identify and quantify coronary calcification. Calcium scores among scanning centers and between participants were adjusted with a standard calcium phantom scanned simultaneously with the participant. The average Agatston score was used in all analyses.[18] The presence of calcification was defined as an average Agatston score >0 (or >0 on either scan). Agreement with regard to presence of coronary calcification was high (κ-statistic 0.90 to 0.93 between and within readers), and the intraclass correlation coefficient for the Agatston score between readers was 0.99.[19]

Data Analysis

Distributions of risk factors were compared across ethnic groups, and distributions of coronary calcium scores were displayed graphically with a smoothed probability density function[20] and compared across ethnic groups within gender. We tested for gender–risk factor interactions in the prediction of the presence and amount of calcium to determine whether men and women would require separate analyses. Among the 14 possible gender–risk factor interactions tested, there was 1 significant but weak interaction between gender and BMI in the prediction of the presence of coronary calcium that did not remain significant in the full models. There were no interactions between risk factors and gender in predicting the amount of coronary calcium. Therefore, men and women were combined in the multivariable analyses.

The relationship between each risk factor and the presence of coronary calcification for each ethnic group, controlling for all other risk factors in the model, was assessed with exponential models that were fit by nonlinear least squares, including all variables that were associated with coronary calcification in bivariate models.[21] For each ethnic group, the relationship between each risk factor and the presence of coronary calcification was determined with nonlinear least squares regression with the model $y=\exp(B^TX)$, where y indicates the presence or absence of coronary calcification. Relative risk estimates, which represent relative cumulative incidence, are presented from these models rather than ORs because the high prevalence of calcification in the cohort results in ORs overestimating the relative risk. The area under the receiver-operator curve was estimated with this model. Nonlinear least squares regression was then used to determine relationships between nonwhite ethnicity and the presence of coronary calcification, relative to whites, after adjustment for coronary risk factors that were associated with coronary calcification with a probability value <0.05.

Among those with detectable calcium, the relationship between each risk factor and the amount of coronary calcification as measured by the (ln)Agatston score was assessed for each ethnic group with multivariable linear regression and control for all other risk factors in the model. The relationship between ethnicity and amount of coronary calcium relative to whites was then determined with a linear regression model, with adjustment for risk factors. This relationship was expressed as percent difference in coronary calcification for a given increment in the risk factor. In separate models for each risk factor, interactions with ethnicity in the prediction of presence and amount of calcification were sought. S-PLUS 6.0, SPSS 12.0, and Stat 8 were used to analyze the data.

Results

The mean age was 62 to 63 years in all ethnic groups (Table 1). Education and income levels varied substantially across ethnic groups: Hispanics had the lowest levels, and whites had the highest. Blacks and Hispanics had the highest mean BMIs ($\approx$30 kg/m^2). Blacks had the highest systolic and diastolic blood pressures and the lowest total cholesterol and triglyceride levels. Hispanics had the highest LDL-cholesterol levels and lowest HDL-cholesterol levels. Whites reported the highest rates of taking cholesterol-lowering medicine (17.5%), with the other groups ranging from 14.1% to 16.5%. Blacks reported the highest rate of current smoking (18.0%), and Chinese reported the lowest (5.6%). The prevalence of diabetes was lower among whites (7.8%) than among black and Hispanics ($\approx$21%) and Chinese (15.7%). Blacks had the highest rate of hypertension (55.4%); 35% to 37% of the other groups had hypertension. Most of the participants with hypertension were taking antihypertensive medications.

White men had the highest prevalence of coronary calcification (70.4%), followed by Chinese (59.2%), Hispanic (55.6%), and black men (52.1%; Table 2). White men also had the highest calcium scores at the 50th, 75th, and 90th percentiles. Figure 1 shows the distribution of calcium scores among men with detectable calcification. Most notable is the shift to the right among white men relative to the other ethnic groups, which indicates generally higher scores in whites. Similarly, white women had the highest prevalence (44.6%), followed by Chinese (41.9%), black (36.5%), and Hispanic women (34.9%).

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TABLE 1. Characteristics of Participants in MESA

	White (n=2619)	Black (n=1898)	Hispanic (n=1494)	Chinese (n=803)	*P*
Age, y	63.1±10.3	63.0±10.1	61.8±10.4	62.9±10.3	0.001
Women, %	51.9	55.5	51.9	51.4	0.060
Education less than high school, %	4.9	12.3	44.6	24.8	<0.001
Income <$25 000, %	16.1	30.6	49.5	49.6	<0.001
BMI, kg/m^2	27.7±5.1	30.2±5.9	29.4±5.1	24.0±3.3	<0.001
Systolic blood pressure, mm Hg	123.5±20.4	131.7±21.6	126.7±21.9	124.6±21.6	<0.001
Diastolic blood pressure, mm Hg	70.2±10.0	74.5±10.2	71.5±10.1	72.0±10.3	<0.001
Total cholesterol, mmol/L (mg/dL)	5.07±0.91 (195.7±35.1)	4.91±0.94 (189.6±36.2)	5.13±0.97 (197.9±37.6)	4.99±0.82 (192.6±31.8)	<0.001
LDL cholesterol, mmol/L (mg/dL)	3.03±0.78 (117.1±30.1)	3.01±0.85 (116.4±33.0)	3.10±0.85 (119.5±32.9)	2.98±0.75 (115.1±29.0)	0.010
HDL cholesterol, mmol/L (mg/dL)	1.35±0.41 (52.2±15.7)	1.36±0.40 (52.4±15.3)	1.24±0.34 (47.7±13.1)	1.28±0.33 (49.5±12.7)	<0.001
Triglycerides, mmol/L (mg/dL)	1.50±1.02 (133.0±90.2)	1.19±0.78 (105.0±68.9)	1.77±1.14 (156.8±100.9)	1.61±0.96 (142.7±84.8)	<0.001
Cholesterol-lowering medication, %	17.5	16.5	14.1	14.7	0.078
Smoking, %					<0.001
Current	11.6	18.0	13.5	5.6	
Former	44.0	36.4	32.3	19.1	
Never	44.4	45.6	54.2	75.3	
Diabetes status, %					<0.001
Diabetic	7.8	20.6	20.8	15.7	
Impaired fasting glucose	6.5	7.8	8.7	8.9	
No diabetes	85.7	71.6	70.4	75.4	
Hypertension, %	34.6	55.4	37.4	36.1	<0.001
Use of antihypertensive medications, %	32.1	48.5	31.5	27.9	<0.001

Mean±SD or percentages are presented.
P value is for comparison of means or proportions across ethnic groups.

White women had the highest scores at the 75th and 90th percentiles. As in men, the distribution of scores was shifted to the right for white women compared with the other ethnic groups (Figure 2).

Age, male gender, and hypertension were significant predictors of the presence of coronary calcification in all 4 ethnic groups (Table 3). A 10-year age increase and male gender were each associated with a 30% to 49% increase in the prevalence of coronary calcification, whereas hypertension was associated with a 10% to 23% increase. LDL cholesterol, current smoking, former smoking, and use of cholesterol-lowering medication were significantly associated with coronary calcification in all but Chinese. BMI was significantly associated with coronary calcification in whites only, but the magnitude of association was similar in all groups, with a 4% to 8% increase in prevalence for a 5-unit increase in BMI. In Hispanics only, having less than a high school education versus more education was associated with a lower prevalence of coronary calcification. Areas under the receive-operator curve for the entire model ranged from 0.77 in blacks to 0.82 in whites. There were significant differences by ethnicity in the relationships between the presence of coronary calcification and BMI ($P<0.001$), gender ($P=0.003$), HDL cholesterol ($P=0.005$), hypertension ($P=0.03$), and education ($P=0.001$); however, except for education, relationships were in the same direction for each group and not very different in magnitude. After adjustment for these risk

TABLE 2. Distribution of Coronary Calcification by Gender and Ethnicity in MESA

	Men					Women				
	White (n=1259)	Black (n=845)	Hispanic (n=719)	Chinese (n=390)	*P*	White (n=1360)	Black (n=1053)	Hispanic (n=774)	Chinese (n=413)	*P*
Prevalence, %	70.4	52.1	56.5	59.2	<0.001	44.6	36.5	34.9	41.9	<0.0001
Calcium score										
Mean±SD	298±601	176±508	203±545	127±322	<0.001	96±254	82±296	59 ±201	65±199	0.006
50th Percentile	48	3	8	11		0	0	0	0	
75th Percentile	298	87	122	116		54	24	18	38	
90th Percentile	1595	1044	1098	583		291	193	143	155	
Maximum	6316	6047	5148	3774		2528	4013	2434	2440	

P value for difference in prevalence of calcification across ethnicity within gender was calculated by Pearson χ^2; *P* value for differences in mean calcium score across ethnicity within gender was calculated by univariate ANOVA.

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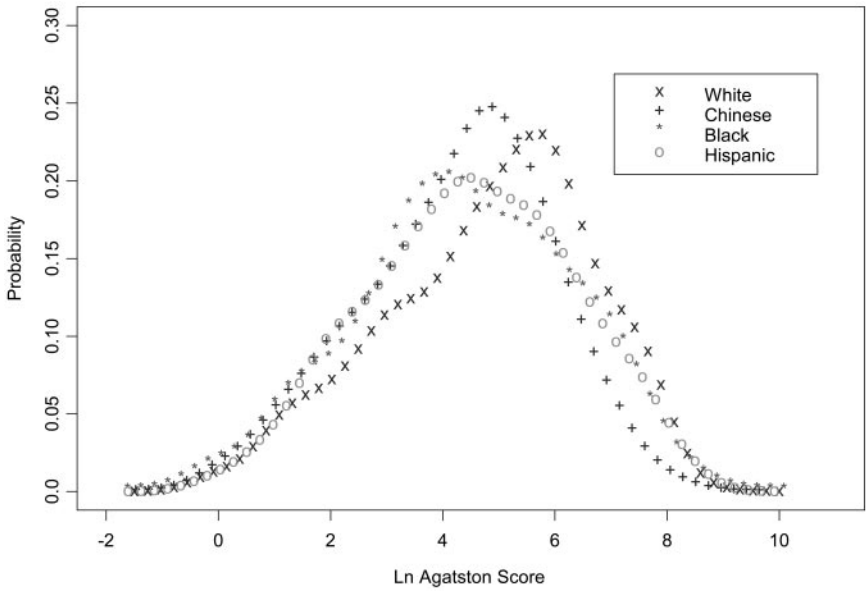

Figure 1. Distribution of coronary calcification among those with detectable calcification by ethnicity, men: MESA.

factors, the relative risk of coronary calcification compared with whites was 0.78 in blacks (95% CI 0.74 to 0.82), 0.85 in Hispanics (95% CI 0.80 to 0.91), and 0.92 in Chinese (95% CI 0.85 to 0.995; Figure 3).

Age and diabetes were significantly associated with the coronary calcium score among those with detectable calcification in all ethnic groups (Table 4). The association of a 10-year age difference (older) with a difference in coronary calcium score ranged from 48% more calcification in Chinese to 114% more calcification in whites, whereas the effect of diabetes ranged from 37% more calcification in whites to 137% more calcification in Chinese. Male gender was also associated with greater calcification in all groups, although it was not statistically significant in Chinese (37% to 142% more calcification). Hypertension was associated with a significantly greater coronary calcium score, which ranged from 34% greater in blacks to 62% greater in Hispanics, but the association was weaker and not significant in Chinese. Other significant associations with amount of coronary calcium were current smoking in whites and Hispanics, former smoking in whites, and less than high school education in Hispanics (negative association). These models explained 13% to 21% of the variability in amount of coronary calcification. After adjustment for these risk factors, coronary calcium scores relative to whites were lower in blacks (69% that of whites, 95% CI 59% to 80%), Hispanics (74% that of whites, 95% CI 61% to 90%), and Chinese (77% that of whites, 95% CI 62% to 96%; Figure 4). There were significant differences by ethnicity in the relationships between the amount of calcification and age ($P=0.003$) and education ($P=0.001$); age had a significantly stronger positive effect on the amount of calcification in whites than in Chinese; and low level of education had a protec-

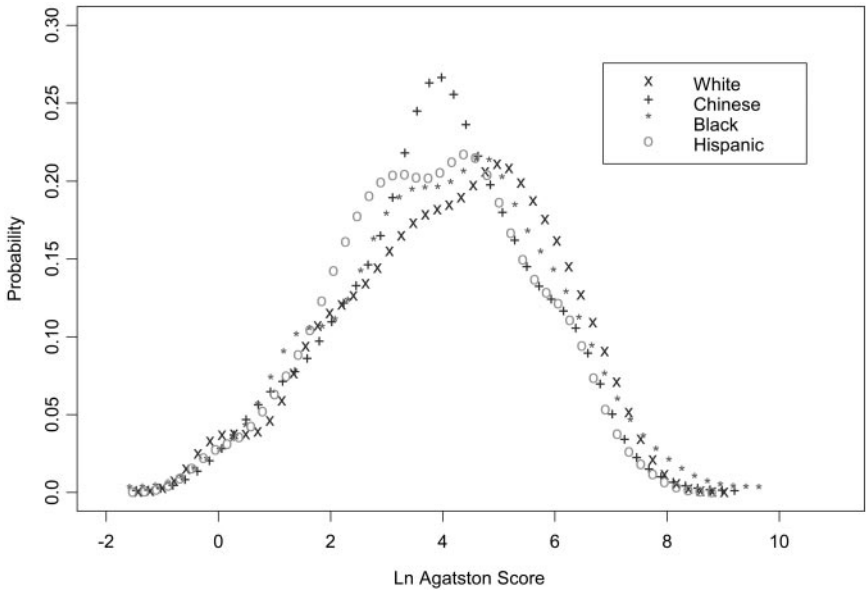

Figure 2. Distribution of coronary calcification among those with detectable calcification, by ethnicity, women: MESA.

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TABLE 3. Multivariable Relative Risk Estimates for Factors Associated With Presence of Coronary Calcification in MESA

	White (n=2575) RR (95% CI)	Black (n=1874) RR (95% CI)	Hispanic (n=1463) RR (95% CI)	Chinese (n=789) RR (95% CI)
Age, 10 years	1.36* (1.32–1.40)	1.49* (1.41–1.56)	1.43* (1.36–1.50)	1.30* (1.21–1.39)
Male gender	1.37* (1.28–1.45)	1.34* (1.22–1.47)	1.45* (1.31–1.62)	1.33* (1.15–1.54)
BMI, 5 units	1.05* (1.02–1.08)	1.04 (0.999–1.09)	1.05 (1.00–1.10)	1.09 (0.99–1.20)
Education less than high school	1.04 (0.94–1.16)	1.03 (0.91–1.14)	0.91 (0.84–1.00)	1.04 (0.94–1.16)
LDL cholesterol, 0.78 mmol/L (30 mg/dL)	1.06* (1.03–1.09)	1.10* (1.06–1.14)	1.08* (1.04–1.12)	1.03 (0.97–1.10)
HDL cholesterol, 0.26 mmol/L (10 mg/dL)	0.97* (0.95–0.996)	1.00 (0.97–1.03)	0.98 (0.94–1.02)	0.97 (0.92–1.03)
Current smoking	1.21* (1.10–1.33)	1.40* (1.24–1.58)	1.24* (1.07–1.44)	1.05 (0.81–1.37)
Former smoking	1.09* (1.03–1.16)	1.20* (1.09–1.32)	1.12* (1.01–1.23)	0.96 (0.82–1.13)
Diabetes	1.07 (0.99–1.17)	1.10 (1.00–1.21)	1.08 (0.97–1.19)	1.09 (0.94–1.27)
Hypertension	1.10* (1.04–1.17)	1.15* (1.04–1.27)	1.19* (1.08–1.31)	1.23* (1.09–1.40)
Cholesterol medication	1.22* (1.14–1.30)	1.16* (1.05–1.28)	1.23* (1.10–1.36)	1.11 (0.96–1.29)
Area under ROC curve	0.82	0.77	0.81	0.76

RR indicates relative risk per increment in risk factor estimated from nonlinear least squares regression, adjusted for all variables listed and for center; ROC, receive-operator curve for overall model.

*RR significant at $P<0.05$.

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tive effect in Hispanics, compared with an inverse effect in blacks (data not shown).

Discussion

In this cohort of men and women aged 45 to 84 years who did not have clinical CVD, we found coronary calcification in 70.4% of white men and 44.6% of white women, and the prevalence of coronary calcification was significantly lower in each of the other ethnic groups after adjustment for coronary risk factors. In particular, in blacks and Hispanics, the prevalence was 22% and 15% lower, respectively, than in whites, whereas in Chinese, it was 8% lower than in whites. Similarly, whites had the highest amounts of calcification among those with detectable calcification, as measured by Agatston score, and the relative amounts of calcification in the other ethnic groups compared with whites were substantially lower in blacks, Hispanics, and Chinese (31%, 26%, and 23% lower, respectively). The present study confirms several other studies that have found ethnic differences in the prevalence of coronary calcification but is the largest comparison of multiple ethnic groups and includes a population-based sample, as opposed to one based on clinical or self-referral for cardiac CT scanning.

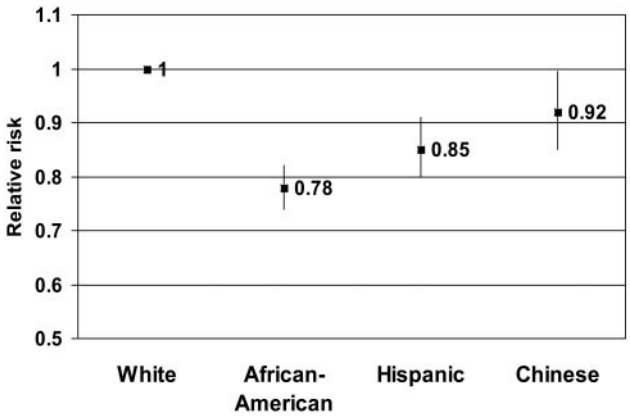

Figure 3. Relative risk for presence of coronary calcification by ethnicity, compared with whites: MESA. 95% CIs shown. Adjusted for age, gender, education, BMI, LDL cholesterol, HDL cholesterol, smoking, hypertension, diabetes, reported treatment for high cholesterol, and center.

The observation that blacks have less calcification of coronary atherosclerosis than whites was first described in a large autopsy series in 1965.[22] That study, which included 777 autopsies in Louisiana, found the relative prevalence of calcified lesions in the 3 major coronary arteries for decedents who did not die of atherosclerotic heart disease to be 20% to 75% higher in white than in black decedents. More recently, using fluoroscopy[7] or rapid CT, several studies have found a lower prevalence of coronary calcification in blacks than in whites.[8–10] One study found a lower prevalence in Hispanics and a similar prevalence in Asians compared with whites,[9] and another found a lower prevalence in Asians and whites compared with Asian Indians.[23] The present findings are generally consistent with and extend these studies by quantifying these effects in population-based samples and adding information about the amount and not just presence of calcification.

Recently, the Dallas Heart Study (DHS), another population-based study, found no differences in the prevalence of coronary artery calcification between black and white men and women.[11] There were several differences in the populations studied and methods used in the DHS and MESA that might explain these disparate findings, which were more pronounced in women than men: DHS did not exclude participants with CVD as MESA did, DHS participants were younger, there were more exclusions in the DHS due to weight (8% of blacks and 3% of whites in DHS versus 1% of blacks and 5% of whites in MESA), and different reading methods were used. The DHS defined coronary calcium prevalence as an Agatston score >10, whereas

TABLE 4. Multivariable Estimates of Relative Difference in Coronary Calcification Associated With Each Unit Difference in Risk Factors Among Persons With Detectable Coronary Calcification in MESA

	White (n=1480) RD (95% CI)	Black (n=816) RD (95% CI)	Hispanic (n=657) RD (95% CI)	Chinese (n=402) RD (95% CI)
Age, 10 years	2.14* (1.94–2.35)	1.84* (1.61–2.10)	1.71* (1.48–1.97)	1.48* (1.25–1.76)
Male gender	2.42* (2.03–2.89)	1.55* (1.22–1.97)	2.18* (1.66–2.87)	1.37 (0.94–2.01)
Education less than high school	1.00 (0.71–1.42)	1.37 (0.98–1.93)	0.68* (0.52–0.89)	0.78 (0.54–1.14)
Triglycerides, 1.59 mmol/L (100 mg/dL)	1.09* (1.001–1.20)	1.05 (0.91–1.22)	1.12 (0.95–1.31)	0.97 (0.81–1.17)
Current smoking	1.56* (1.17–2.10)	1.22 (0.87–1.71)	1.74* (1.15–2.65)	0.83 (0.43–1.61)
Former smoking	1.37* (1.14–1.64)	1.19 (0.91–1.55)	1.15 (0.86–1.53)	1.23 (0.80–1.89)
Diabetes	1.37* (1.03–1.81)	1.58* (1.20–2.09)	1.38* (1.02–1.87)	2.37* (1.59–3.53)
Hypertension	1.36* (1.14–1.63)	1.34* (1.03–1.74)	1.62* (1.24–2.13)	1.16 (0.84–1.59)
R^2, %	21.1	15.3	15.4	12.7

RD indicates relative difference in Agatston score per increment in risk factor estimated from linear regression with Ln(Agatston score) as the dependent variable, adjusted for all risk factors listed and center. An RD of 1.50 represents a 50% increase.

*RD significant at $P<0.05$.

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MESA used an Agatston score >0; however, the ethnic differences in MESA remained after we used a cutpoint of >10 Agatston units (data not shown). It is possible that the greater obesity of black women in the DHS compared with MESA (BMI 33 versus 31 kg/m^2) may have produced more artifact that was read as calcification; however, it is not possible to determine whether these methodological differences explain the different findings in the 2 studies or whether there is a difference in the underlying populations studied.

Faced with significant ethnic differences in coronary calcification that are not explained by traditional coronary risk factors, several important questions remain: Do these differences in coronary calcification represent differences in the amount of underlying coronary atherosclerosis? What factors contribute to differences in calcification, particularly if they are not due to differences in atherosclerosis? Finally, what implications might these differences have for the clinical interpretation of coronary calcium scores?

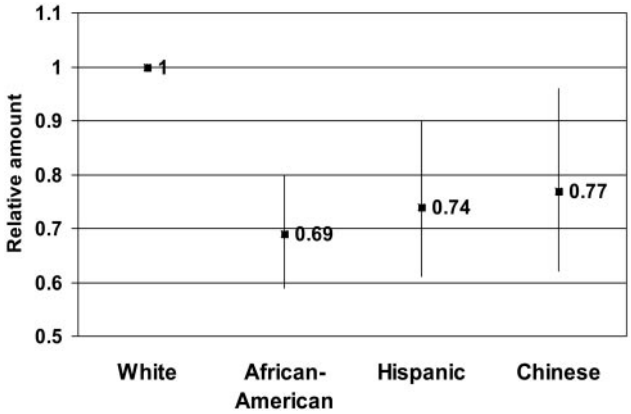

Figure 4. Relative coronary calcium amount, as measured by Agatston score, by ethnicity compared with whites, among those with detectable calcification: MESA. Relative amounts measured by Agatston scores. 95% CIs shown. Adjusted for age, gender, education, BMI, LDL cholesterol, triglycerides, smoking, hypertension, diabetes, reported treatment for high cholesterol, and center.

The most convincing evidence that coronary calcification is a quantitative indicator of the presence and extent of coronary atherosclerotic plaques comes from pathology studies that have consistently found strong correlations between histological plaque and calcium area.[2,3] Unfortunately, ethnicity is not accounted for in the analyses of the calcium-atherosclerotic relationship in these studies. Burke et al[24] have recently suggested that plaque is less often calcified in blacks than whites. Further studies should be conducted in substantial numbers of nonwhite ethnic groups to determine the relationship between histological calcification and plaque.

Ethnic differences have also been found in carotid artery wall thickness, another subclinical CVD marker. Nondiabetic black participants had greater common carotid artery intima-media thicknesses than their white counterparts in the Insulin Resistance Atherosclerosis Study, whereas Hispanic participants had thinner common carotid artery intima-media thicknesses.[25] Internal carotid artery intima-media thickness did not differ by ethnicity. Data from the Atherosclerosis Risk in Communities Study also suggest that common carotid artery intima-media thickness is greater in blacks than in whites, but internal carotid artery intima-media thickness was not greater in blacks than in whites.[26] These data raise questions about whether the internal carotid artery and common carotid artery similarly reflect atherosclerosis. Another possibility is that these disparate findings support the concept that differences in coronary calcification reflect differences in the propensity for plaque to calcify in different ethnic groups.

Coronary risk factors were related to coronary calcium as expected in each ethnic group. The only unexpected relationship was that education appeared to be positively associated with coronary calcification in Hispanics. This could reflect the fact that recent Hispanic immigrants, who tend to have lower education levels than the US population, may also have lower cardiovascular risk than their US-born counterparts,[27] but this finding deserves more exploration.

We found that although traditional coronary risk factors were associated with coronary calcification, these variables left much variability in the presence or amount of coronary

calcification to be explained. If the differences in calcification do not purely reflect differences in atherosclerosis, what other factors might explain them? First, calcified plaque represents only a small proportion of total plaque burden.[2] Second, it has been suggested that vitamin D metabolism explains some but not all of the difference between whites and blacks,[28] and there is accumulating evidence that other aspects of calcium metabolism or bone regulatory factors, inflammatory markers, hemostasis, fibrinolysis, or genetic factors are related to calcification.[29] A recent report identified a relationship between a common polymorphism for the soluble epoxide hydrolase gene and coronary calcification in blacks but not whites.[30] Another possible clue that ethnic differences in tissue calcification may play a role is the difference in bone mineral density between whites and blacks. Bone density tends to be greater and osteoporosis less common in blacks than in whites,[31] whereas bone density is inversely related to vascular calcification.[32] The present study serves as a basis for exploration of other factors, including environmental, behavioral, biochemical, and genetic factors, to determine causes of coronary calcification and to explain the observed group differences in coronary calcification.

Coronary calcification measured with CT scanning has been identified as a promising screening tool for subclinical coronary artery disease. The prevalence of coronary calcification appears to follow a pattern similar to that of coronary heart disease, with a strongly increasing prevalence with age and much higher prevalence in men than in women.[18] It has been shown to be related to traditional coronary risk factors, as expected,[33–35] and it predicts future coronary heart disease events.[4–6] Nevertheless, Doherty et al[36] have reported that coronary calcification does not have the same prognostic value for blacks as for whites. If confirmed, the accumulating data that blacks have less coronary calcification suggest that ethnicity, or the underlying physiological explanation for differences in propensity to calcify atherosclerotic plaque, must be taken into account in the clinical interpretation of calcium scores. For example, an Agatston score of 400, advocated by some as a trigger for further workup,[37] may be too high for some nonwhite ethnic groups.

The present study has several limitations that could affect its results. The participation rate was ≈30% of those contacted, which is low enough that bias could have been introduced, although similar recruitment methods were used in all ethnic groups, and the participation among those screened (for whom ethnicity was collected) was 70% of whites, 61% of blacks, 59% of Hispanics, and 48% of Chinese. Although MESA is broadly representative of the groups studied, compared with 2000 US Census data, whites and blacks in MESA were older, better educated, and had higher incomes. Hispanics in MESA were also older and slightly better educated but had similar incomes. The Chinese in MESA were older and had lower incomes. The Chinese men had slightly more education in MESA, whereas the Chinese women had less education. Although an in-depth consideration of how representative the MESA population is of ethnic groups in the United States is beyond the scope of this paper, it is not clear that the differences mentioned could explain the results found. Another consideration is that the exclusion of persons with symptomatic CVD could have operated differentially across ethnic groups owing to differences in access to care and diagnosis of disease.

In summary, we observed a substantially lower prevalence of coronary calcification in blacks and Hispanics compared with whites and a slightly lower prevalence in Chinese compared with whites. We also found a similar pattern in the amount of calcification among those with detectable calcification. These differences persisted after adjustment for coronary risk factors. Explanations for these differences should be sought, which may inform clinical interpretation and our understanding of the pathophysiology of coronary calcification. Follow-up data from MESA will address whether the relationship between coronary calcification and CVD outcomes differs by ethnicity.

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