Prevalence and Correlates of Coronary Calcification in Black and White Young Adults

The Coronary Artery Risk Development in Young Adults (CARDIA) Study

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Abstract—Whereas cardiovascular risk factor levels are substantially different in black and white Americans, the relative rates of cardiovascular disease in the 2 groups are not always consistent with these differences. To compare the prevalence of coronary calcification, an indicator of coronary atherosclerosis, in young adult blacks and whites, we performed electron-beam computed tomography of the heart in 443 men and women aged 28 to 40 years recruited from a population-based cohort. The presence of calcium, defined as at least 1 focus of at least 2.05 mm^2 in area and >130 Hounsfield units in density within the coronary arteries, was identified in 16.1% of black men, 11.8% of black women, 17.1% of white men, and 4.6% of white women ($P=0.04$ for comparison across groups). Coronary calcium was associated with age and male sex, and after adjustment for age, race, and sex, coronary calcium was positively associated with body mass index, weight, systolic blood pressure, total cholesterol, low density lipoprotein cholesterol, triglycerides, and fasting insulin and negatively associated with education (all $P<0.05$). Independent risk factors included male sex, body mass index, and low density lipoprotein cholesterol. Race was not significantly associated with coronary calcium in men or women, before or after adjustment for risk factors. Coronary calcification is associated with increased levels of cardiovascular risk factors in young adults, and its prevalence is not significantly different in blacks and whites. **(*Arterioscler Thromb Vasc Biol.* 2001;21:852-857.)**

Key Words: coronary heart disease ■ risk factors ■ race ■ coronary artery calcification

Relative levels of coronary risk factors in blacks and whites suggest that blacks would be at higher risk for coronary heart disease (CHD).[1–6] CHD mortality rates appear to reflect higher risk factor levels in blacks,[7] but CHD incidence is lower in black men than in white men.[8] Clues to possible racial differences in rates of CHD may be found by identifying subclinical disease for which treatment has not been instituted and which is not subject to the biases of disease ascertainment or death certificate coding.[9–12] To compare the prevalence of a marker of coronary atherosclerosis in a population-based sample of young adult blacks and whites, to examine risk factor correlates, and to determine whether any racial differences in prevalence might be explained by risk factor differences, we measured coronary calcification by using electron-beam computed tomography (EBCT) of the heart and risk factors in men and women aged 28 to 40 years who have participated in an ongoing epidemiological study of the coronary disease risk factors. Coronary calcium is a specific marker for coronary atherosclerosis[13] and can be quantified by EBCT.[14–16]

Methods

Participants

Participants in the present study were from the Coronary Artery Risk Development in Young Adults (CARDIA) Study. The baseline CARDIA examination took place from 1985 to 1986 and included 5115 women and men from 4 centers (Birmingham, Ala; Chicago, Ill; Minneapolis, Minn; and Oakland, Calif). Participants had been sampled from the total community or from selected census tracts, except for participants in Oakland, for whom a health plan membership was used. Fifty-two percent of participants were black, and 55% were women. Details of the study design have been published previously.[17] At the conclusion of a reexamination of the cohort between June 1995 and June 1996 (year 10), at which 78.5% of the surviving cohort participated, 443 individuals from the Chicago and Oakland centers were recruited to participate in a substudy of coronary calcification. Sampling was designed to achieve approximately equal numbers of black and white men and women. Women

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were scanned during the 2 weeks after the beginning of their menstrual cycles to avoid radiation during pregnancy. Participants who weighed >280 pounds were not included, because the scanning apparatus could not accommodate them. Scans were performed between May 1996 and January 1997. The time between the year-10 examination, during which risk factors were measured, and EBCT scanning was 347±103 days (mean±SD). The protocol was approved by the institutional review boards of both medical centers, and informed consent was obtained from all participants.

Scanning Protocol

EBCT scanners (Imatron C-100) were used to obtain 40 contiguous 3-mm-thick transverse images from the root of the aorta to the apex of the heart. Images were obtained at 80% of the ECG RR interval. Scan acquisition time was 100 ms. Two scans were obtained for each participant, 1 to 2 minutes apart. Participants remained supine between scans.

Reading Protocol

Each image was examined by a radiological technologist who removed bony structures from the images and identified a region of interest around each potential focus of coronary calcium. A focus was defined as a region ≥6 adjacent pixels with a computed tomography (CT) number >130 Hounsfield units (HU). Because the field of view was 30 cm^2 and a 512×512 reconstruction matrix was used, a focus was at least 2.05 mm^2. Lesions of this size have been found to be reproducible.[18,19] One of the authors (J.R.) read each scan without knowledge of participant characteristics. Care was taken to ensure that only foci within coronary arteries were identified. A total calcium score was calculated for each scan by multiplying the area of the focus by a coefficient based on the peak CT number in the focus. This coefficient ranged from 1 to 4, where 1=131 to 200 HU, 2=201 to 300 HU, 3=301 to 400 HU, and 4=≥401 HU.[14] The scan with the higher score was used for analysis. The presence of calcium was defined as a score ≥2.05 (at least 1 focus of calcium ≥6 pixels in size).

Risk Factor Measurements

Risk factor measurements were made at the baseline and year-10 examinations. Years of education and history of smoking were self-reported. Weight and height were measured with subjects in light clothing and without shoes. Body mass index (BMI) was calculated as weight (kilograms) divided by height^2 (meters squared). Standard methods for measuring blood pressure, fasting total cholesterol, HDL cholesterol, triglycerides, alcohol intake, and physical activity were used, as previously described.[17,20–23] LDL cholesterol was calculated by using the Friedewald equation.[24] Insulin was measured by radioimmunoassay (Linco). Diabetes was defined as having been told by a physician that the participant had diabetes, other than during pregnancy. Smoking history was defined by questionnaire as current, former, or never. Current and former smokers were grouped together as ever smokers. Participants were also asked if they had ever had a heart attack or angina.

Statistical Methods

Distributions of year-10 risk factors and coronary calcium scores and the prevalence of coronary calcification were determined for each race-sex group. ANOVA and χ^2 contingency table analysis were used to test for differences in risk factors across the 4 race-sex groups. Risk factor variables with marked skewness were logarithmically transformed to normalize their distributions for statistical testing, but untransformed variables are displayed. Logistic regression was used to estimate the odds of having coronary calcification in relation to each baseline and year-10 risk factor, with adjustment for age, race, and sex.

Additional multivariable logistic regression models were constructed to predict calcium presence by first adjusting for all variables with significant age-, race-, and sex-adjusted associations with coronary calcium in the entire sample and by then identifying a set of independent variables with the use of backward stepwise regression. Race was forced into a model with the remaining variables to examine its relation to coronary calcification independent of other risk factors. Systolic blood pressure and BMI were used to represent blood pressure and obesity, respectively. All models were constructed by using baseline and year-10 risk factor variables. Areas under receiver operator characteristic (ROC) curves were estimated to assess the performance of the models. Areas may range from 0.50 (no discrimination between participants with and without coronary calcium by model) to 1.00 (100% discrimination between participants with and without coronary calcium by model).

TABLE 1. Characteristics of Study Sample at Year 10

	Black Men (n=118)	Black Women (n=127)	White Men (n=111)	White Women (n=87)	*P*
Age, y	34.5±3.6	34.9±3.9	35.2±3.4	35.8±3.4	0.07
Education, y	13.4±1.9	13.6±2.0	15.5±2.8	15.2±2.6	<0.0001
Weight, kg	86.9±17.5	83.5±21.8	83.3±12.2	68.0±15.4	<0.0001
BMI, kg/m^2	27.5±5.4	30.8±8.1	26.2±3.6	24.8±5.7	<0.0001
Systolic blood pressure, mm Hg	115.9±11.0	111.6±13.7	112.9±9.8	105.4±9.4	<0.0001
Diastolic blood pressure, mm Hg	76.5±9.5	74.1±11.4	74.5±8.4	69.6±7.7	<0.0001
Hypertension, %	12.0	14.3	3.6	1.1	0.0007
Smoking history, %					
Never	60.2	52.8	69.4	64.4	0.06
Ever	39.8	47.2	30.6	35.6	
Total cholesterol, IU	4.76±1.02	4.46±0.82	4.71±0.97	4.68±0.88	0.06
LDL cholesterol, IU	2.96±0.88	2.62±0.69	3.01±0.87	2.81±0.79	0.0012
HDL cholesterol, IU	1.28±0.37	1.39±0.38	1.16±0.25	1.44±0.35	<0.0001
Triglycerides, IU	1.08±1.07	0.78±0.45	1.17±0.94	0.89±0.71	<0.0001
Insulin, pmol/L	87.2±60.0	86.3±52.1	70.1±28.3	64.7±24.9	0.006
Alcohol intake, mL/d	16.6±21.4	8.6±23.0	15.2±21.2	7.1±12.0	<0.0001
Diabetes, %	4.3	3.1	0.9	1.2	0.32
Physical activity score	441±294	236±194	442±290	347±233	<0.0001

Values are mean±SD, except for hypertension, smoking, and diabetes (percentages). *P* values indicate comparison across the 4 race-sex groups.

TABLE 2. Distribution of Coronary Calcium

	Black Men (n=118)	Black Women (n=127)	White Men (n=111)	White Women (n=87)
Prevalence (95% CI)	16.1 (9.5–22.7)*	11.8 (6.2–17.4)	17.1 (10.1–24.1)	4.6 (0.2–9.0)
Calcium score				
Mean±SD	12.2±106.4†	2.6±18.0	5.8±25.8	0.4±2.7
75th percentile	0	0	0	0
90th percentile	4.8	2.8	2.8	0
Maximum	1148.4	199.5	191.6	24.7

*χ^2 $P=0.04$ comparing prevalence across the 4 race-sex groups (χ^2 test).

†After excluding the highest score of 1148, the mean±SD was 2.5±13.8. The next to highest score was 143.5.

There were 443 participants with complete EBCT data. At year 10, 2 participants were excluded from analyses of lipids because they were on lipid-lowering medication; 6 participants were excluded from analyses of blood pressure because they were on antihypertensive medication and their blood pressure was below the 90th percentile for those not on medication; and 35 participants were excluded from analyses of LDL cholesterol, triglycerides, and insulin because they had not fasted for at least 9 hours. Because of missing variables, the sample for multivariable analysis with all covariates included 392 participants. At baseline, the same exclusions resulted in a final sample of 427.

Analyses were performed by using SAS, version 6.10. Statistical significance was set at $P<0.05$ for 2-sided tests.

Results

Mean age was ≈35 years across the race-sex groups (Table 1). Significant differences across the groups were found for all variables except age, smoking, total cholesterol, and diabetes. No participant reported ever having had a heart attack or angina. These characteristics were generally similar to the race-sex group characteristics of the whole CARDIA cohort (data not shown).

The prevalence of coronary calcium was highest (17.1%) in white men and lowest (4.6%) in white women ($P=0.04$ for comparison across groups, Table 2). The distributions of calcium scores indicate skewness toward higher values. There were no significant differences by race in either men or women ($P=0.84$ and 0.07, respectively) or by sex group among blacks ($P=0.33$). However, the prevalence was significantly higher among white men than women ($P=0.006$)

The presence of calcium was significantly positively associated with age, male sex, BMI, weight, systolic blood pressure, and total and LDL cholesterol at baseline and year 10 (Table 3) and was significantly associated with year-10 fasting triglycerides and fasting insulin. Education was significantly inversely associated with the presence of calcium.

In the model including year-10 risk factors that were associated with calcium, only male sex (odds ratio [OR] 3.94, 95% CI 1.62 to 9.57; $P=0.003$) and BMI (OR for a 5-U difference 1.61, 95% CI 1.16 to 2.25; $P=0.005$) were significantly associated with coronary calcium prevalence (Table 4, model 1). After backward stepwise regression, male sex (OR 4.06, 95% CI 1.76 to 9.38; $P=0.001$), BMI (OR for a 5-U difference 1.68, 95% CI 1.30 to 2.17; $P<0.0001$), and LDL cholesterol (OR for a 0.78-IU difference 1.39, 95% CI

TABLE 3. ORs of Presence of Coronary Calcium in Relation to Coronary Risk Factors

	Baseline Risk Factors			Year-10 Risk Factors		
Variable (Difference)	OR	95% CI	*P*	OR	95% CI	*P*
Age (3.5 y)	1.52	1.13–2.06	0.006	1.54	1.14–2.07	0.005
Black race	1.42	0.79–2.53	0.24	1.43	0.80–2.54	0.23
Male sex	2.25	1.24–4.09	0.008	2.25	1.24–4.08	0.008
Education (2 y)	0.74	0.56–0.98	0.04	0.76	0.59–0.97	0.03
BMI (5.0 kg/m^2)	1.64	1.24–2.18	0.0006	1.61	1.28–2.03	<0.0001
Weight (17.0 kg)	1.87	1.33–2.63	0.0003	1.86	1.41–2.45	<0.0001
Systolic blood pressure (10 mm Hg)	1.33	1.03–1.73	0.03	1.29	1.02–1.64	0.04
Diastolic blood pressure (9 mm Hg)	1.15	0.88–1.51	0.31	1.18	0.91–1.54	0.21
Total cholesterol (0.91 IU)	1.63	1.20–2.22	0.002	1.54	1.18–2.00	0.002
LDL cholesterol (0.78 IU)	1.71	1.29–2.28	0.0002	1.57	1.16–2.11	0.003
HDL cholesterol (0.31 IU)	0.76	0.56–1.03	0.08	0.81	0.61–1.09	0.16
Triglycerides (0.66 IU)	1.37	0.96–1.95	0.08	1.33	1.08–1.63	0.008
Fasting insulin (36 pmol/L)	1.20	1.00–1.44	0.05	1.34	1.10–1.63	0.004
Alcohol intake (20 mL/d)	1.21	0.99–1.48	0.06	1.17	0.94–1.47	0.17
Physical activity (250 U)	0.95	0.76–1.18	0.63	0.94	0.71–1.24	0.67
Ever smoker	1.40	0.79–2.51	0.25	1.55	0.87–2.76	0.14

Adjustments were made for race, sex, and age (except for race, sex, and age adjusted for the other 2 variables). Differences in risk factors in parentheses represent ~1 SD.

TABLE 4. Multivariable-Adjusted ORs of Presence of Coronary Calcium in Relation to Coronary Risk Factors

	Baseline Risk Factors			Year-10 Risk Factors		
Variable (Difference)	OR	95% CI	*P*	OR	95% CI	*P*
Model 1						
Black race	0.87	0.44–1.73	0.69	0.91	0.42–2.00	0.81
Male sex	2.24	1.11–4.53	0.02	3.94	1.62–9.57	0.003
Education (2 y)	0.77	0.57–1.02	0.07	0.80	0.60–1.07	0.14
Age (3.5 y)	1.38	0.97–1.94	0.07	1.28	0.89–1.85	0.18
BMI (5 U)	1.68	1.18–2.40	0.004	1.61	1.16–2.25	0.005
Systolic blood pressure (10 mm Hg)	1.31	0.98–1.74	0.07	0.99	0.72–1.38	0.97
LDL cholesterol (0.78 IU)	1.67	1.24–2.26	0.0008	1.29	0.93–1.78	0.13
Triglycerides (0.66 IU)	0.93	0.61–1.44	0.75	1.27	0.85–1.90	0.24
Fasting insulin (36 pmol/L)	0.91	0.71–1.18	0.49	1.03	0.76–1.40	0.86
Area under ROC curve	0.76	...	...	0.78	...	...
Model 2						
Male sex	2.49	1.30–4.76	0.005	4.04	1.76–9.38	0.001
BMI (5 U)	1.68	1.28–2.21	0.0002	1.68	1.30–2.17	<0.0001
LDL cholesterol (0.78 IU)	1.71	1.28–2.28	0.0003	1.38	1.01–1.89	0.04
Area under ROC curve	0.73	...	...	0.76	...	...
Model 3						
Black race	1.01	0.54–1.89	0.97	0.98	0.49–1.99	0.96
Male sex	2.56	1.33–4.90	0.005	3.77	1.68–8.49	0.001
BMI (5 U)	1.68	1.27–2.23	0.003	1.66	1.29–2.15	<0.0001
LDL cholesterol (0.78 IU)	1.71	1.28–2.28	0.0003	1.46	1.08–1.97	0.01
Area under ROC curve	0.73	...	...	0.76	...	...

Model 1 includes significant variables from Table 3. Model 2 is the result of backward stepwise regression, initially including variables from Model 1. Model 3 includes variables from Model 2 plus race. Differences in risk factors in parentheses are ≈1 SD.

1.02 to 1.89; $P=0.04$) were associated with coronary calcium (model 2). When race was reintroduced into the analysis, there was no association between black race and the presence of calcium (OR 0.98, 95% CI 0.49 to 1.99; $P=0.96$), but male sex, BMI, and LDL cholesterol retained significant associations with the presence of calcium (model 3). Results were similar with the use of baseline risk factors. Among all models in Table 4, areas under the ROC curves ranged from 0.73 to 0.78.

Discussion

In this population-based sample of young black and white men and women, coronary calcium was associated with traditional coronary risk factors, as expected. Race was not associated with the presence of coronary calcium before or after adjustment for sex, BMI, and LDL cholesterol.

Pathological studies have found more extensive fatty streaks in the aortas and coronary arteries of blacks than of whites[25–27] but similar amounts of raised lesions,[26] which are more likely to include calcium. However, these data are limited because they include individuals of African heritage outside the United States, who may not be representative of blacks in the United States, and because autopsied decedents may not be representative of the living population.

Studies of subclinical cardiovascular disease are important for understanding whether racial differences in clinical disease and mortality have a biological basis or are due to differences in access to care or disease presentation and treatment. Two large studies have found that blacks have thicker common carotid intimal-medial thickness (IMT) than do whites but that black men have thinner internal carotid IMT do white men,[28,29] with 1 of the studies[28] also finding that black women had thinner internal carotid IMT than did white women. A third study found no difference in maximum internal carotid artery plaque thickness between blacks and whites.[30]

A fluoroscopic study conducted in persons at high risk for coronary disease identified coronary calcium in only 36% of blacks compared with 60% of whites and Asian Americans.[31] This difference remained after adjustment for risk factors. However, the selection of participants and the small number of blacks (n=87), particularly black women, raises concern about the validity of this finding. Another study from this group of investigators found a lower prevalence of coronary calcium in blacks by use of EBCT, but there were only 2 black women in the study.[32] In a study of persons enrolled in a large health plan, black race, compared with white race, was significantly associated with a 35% higher prevalence of aortic calcification in women, but there was no significant association in men.[33] The present study did not find a significantly greater prevalence of coronary calcium among blacks. However, the inconsistency of findings among different studies suggests that more research is needed on subclinical cardiovascular disease among different racial groups.

In the present study, age, male sex, systolic blood pressure, weight, BMI, total and LDL cholesterol, fasting triglycerides, and fasting insulin were each related to coronary calcium, as expected, given that coronary calcium appears to be an excellent marker of atherosclerosis. Several other studies, including a study in young adults,[34] have found relationships between EBCT-measured coronary calcium and coronary risk factors.[34–36] Coronary calcium has also been found to predict mortality[37] and CHD events.[37–39] These findings confirm that coronary calcium is a marker of atherosclerosis and suggest that it is a useful tool in studying the origins of atherosclerotic heart disease. Of additional interest, hostility has been found to be associated with coronary calcification in this population.[40]

Body weight and BMI were relatively strong risk factors in the present study and in the Muscatine Study,[34] which included a similar age group, and were also associated with atherosclerosis in the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study.[41] However, obesity may be associated with more artifacts on EBCT scans, which could lead to false-positive readings, particularly if a sensitive definition for coronary calcium is used. A 3-pixel definition from only 1 scan was used in the Muscatine study, which may be responsible for the particularly high ORs for weight and obesity, ranging from 6.4 to 19.6, comparing the highest with the lower 9 deciles for body size. We found that the lower the pixel level in the definition of a focus, the stronger was the association between BMI and calcium score (data not shown). We believe that the 3-pixel definition may be overly sensitive in younger populations, in whom the amount of coronary calcium is relatively low with respect to the amount of artifacts.

Finally, we examined the association of risk factors measured concurrently with coronary calcium and measured 10 years before coronary calcium measurement and found remarkably similar risk factor–calcium relationships. We chose not to focus on baseline risk factors because we do not know when coronary calcium developed and, thus, cannot imply that risk factors preceded coronary calcification. It is likely that the fibrous lesions into which calcium is incorporated were present many years before the detection of calcium.

There are several limitations to the present study. First, the sample consisted of volunteers from the original cohort, who might have had particular concern about their risks of coronary disease. However, none of the participants provided a history of heart attack or angina. Also, their characteristics were similar to the entire CARDIA cohort at year 10. Second, small amounts of calcium, as found in this cohort, may not be assessed reliably.[18] We chose a more specific definition for coronary calcium to reduce the possibility of false-positive readings. Third, the present study did not have sufficient power to address the relationship between race and coronary calcification in each sex group. A larger study of coronary calcium in this cohort is currently planned; this upcoming study will allow the issue of race-sex interaction to be addressed. Finally, there are undoubtedly other unmeasured factors that are associated with calcium deposition in coronary atherosclerosis, including other risk factors,[35,36] inflammatory and thrombotic factors,[42] hormonal factors, and genetic factors.[43] Our intent was not to completely explain the presence of coronary calcium but rather to demonstrate its association with known risk factors in young adults.

In conclusion, coronary calcium was associated with male sex and with CHD risk factors, particularly obesity and LDL cholesterol, in these young adults. The prevalence of calcium did not appear to be higher in blacks than in whites before or after adjusting for CHD risk factors.

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References

1. Hypertension prevalence and the status of awareness, treatment, and control of high blood pressure: final report of the Subcommittee on Definition and Prevalence of the 1984 Joint National Committee. *Hypertension*. 1985;7:457–468.
2. Burt VL, Cutler JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Roccella EJ. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population. *Hypertension*. 1995;26:60–69.
3. Harris MI, Hadden WC, Knowler WC, Bennett PH. Prevalence of diabetes and impaired glucose tolerance and plasma glucose levels in U. S. population aged 20–74 yr. *Diabetes*. 1987;36:523–534.
4. Liu K, Ruth KJ, Flack JM, Jones-Webb R, Burke G, Savage PJ, Hulley SB. Blood pressure in young blacks and whites: relevance of obesity and lifestyle factors in determining differences: the CARDIA Study. *Circulation*. 1996;93:60–66.
5. Folsom AR, Burke GL, Byers CL, Hutchinson RG, Heiss G, Flack JM, Jacobs DR, Caan B. Implications of obesity for cardiovascular disease in blacks: the CARDIA and ARIC studies. *Am J Clin Nutr*. 1991;53: 1604S–1611S.
6. Marcovina SM, Albers JJ, Wijsman E, Zhang Z, Chapman NH, Kennedy H. Differences in Lp(a) concentrations and apo(a) polymorphs between black and white Americans. *J Lipid Res*. 1996;37:2569–2585.
7. National Heart, Lung, and Blood Institute. *Morbidity and Mortality: 2000 Chartbook on Cardiovascular, Lung, and Blood Diseases*. US Department of Health and Human Services. Available at http://www.nhlbi.nih.gov/resources/docs/cht-book.htm. Accessed May 2000.
8. Gillum RF, Mussolino ME, Madans JH. Coronary heart disease incidence and survival in African-American women and men. *Ann Intern Med*. 1997;127:111–118.
9. Lee MH, Borhani NO, Kuller LH. Validation of reported myocardial infarction mortality in blacks and whites: a report from the Community Cardiovascular Surveillance Program. *Ann Epidemiol*. 1990;1:1–12.
10. Gillum RF. Coronary heart disease in black populations, I: mortality and morbidity. *Am Heart J*. 1982;104:839–851.
11. Wenneker MB, Epstein AM. Racial inequalities in the use of procedures for patients with ischemic heart disease in Massachusetts. *JAMA*. 1989; 261:253–257.
12. Peterson ED, Shaw LK, DeLong ER, Pryor DB, Califf RM, Mark DB. Racial variation in the use of coronary-revascularization procedures. *N Engl J Med*. 1997;336:480–486.
13. Blankenhorn DH. Coronary calcification, a review. *Am J Med Sci*. 1961; 242:1–9.
14. Agatston AR, Janowitz WR, Hildner FJ, Zusmer NR, Viamonte M, Detrano R. Quantification of coronary artery calcium using ultrafast computed tomography. *J Am Coll Cardiol*. 1990;15:827–832.
15. Rumberger JA, Simons DB, Fitzpatrick LA, Sheedy PF, Schwartz RS. Coronary artery calcium area by electron-beam computed tomography and coronary atherosclerotic plaque area: a histopathologic correlative study. *Circulation*. 1995;92:2157–2162.
16. Budoff MJ, Georgiou D, Brody A, Agatston AS, Kennedy J, Wolkfiel C, Stanford W, Shields P, Lewis RJ, Janowitz WR, et al. Ultrafast computed tomography as a diagnostic modality in the detection of coronary artery disease: a multicenter study. *Circulation*. 1996;93:898–904.
17. Friedman GD, Cutter GR, Donahue RP, Hughes GH, Hulley SB, Jacobs DR, Liu K, Savage PJ. CARDIA: study design, recruitment, and some characteristics of the examined subjects. *J Clin Epidemiol*. 1988;41: 1105–1116.
18. Bielak LF, Kaufmann RB, Moll PP, McCollough CH, Schwartz RS, Sheedy PF. Small lesions in the heart identified at electron beam CT: calcification or noise? *Radiology*. 1994;192:631–636.

19. Kaufmann RB, Sheedy PF, Breen JF, Kelzenberg JR, Kruger BL, Schwartz RS, Moll PP. Detection of heart calcification with electron beam CT: interobserver and intraobserver reliability for scoring quantification. *Radiology*. 1994;190:347–352.
20. Warnick GR. Enzymatic methods for quantification of lipoprotein lipids. *Methods Enzymol*. 1986;129:101–123.
21. Warnick GR, Benderson J, Albers JJ. Dextran sulphate-Mg^{+} precipitation procedure for quantification of high density lipoprotein cholesterol. *Clin Chem*. 1982;28:1379–1388.
22. Dyer AR, Cutter GR, Liu KQ, Armstrong MA, Friedman GD, Hughes GH, Dolce JJ, Raczynski J, Burke G, Manolio T. Alcohol intake and blood pressure in young adults: the CARDIA Study. *J Clin Epidemiol*. 1990;43:1–13.
23. Jacobs DR, Hahn LP, Haskell WL, Pirie P, Sidney S. Validity and reliability of short physical activity history: CARDIA and the Minnesota Heart Health Program. *J Cardiopulm Rehabil*. 1989;9:448–459.
24. Friedewald WT, Levy RI, Frederickson DS. Estimation of the concentration of low density lipoprotein cholesterol in plasma. *Clin Chem*. 1972;18:499–501.
25. McGill HC, Strong JP. The geographic pathology of atherosclerosis. *Ann N Y Acad Sci*. 1968;149:923–927.
26. Strong JP, Malcom GT, McMahan CA, Tracy RE, Newman WP, III, Herderick EE, Cornhill JF. Prevalence and extent of atherosclerosis in adolescents and young adults: implications for prevention from the Pathobiological Determinants of Atherosclerosis in Youth Study. *JAMA*. 1999; 281:727–735.
27. Freedman DS, Newman WP III, Tracy RE, Voors AE, Srinivasan SR, Webber LS, Restrepo C, Strong JP, Berenson GS. Black-white differences in aortic fatty streaks in adolescence and early adulthood: the Bogalusa Heart Study. *Circulation*. 1988;77:856–864.
28. Howard G, Sharrett AR, Heiss G, Evans GW, Chambless LE, Riley WA, Burke GL. Carotid artery intimal-medial thickness distribution in general populations as evaluated by B-mode ultrasound. *Stroke*. 1993;24: 1297–1304.
29. Manolio TA, Burke GL. Black-white differences in subclinical cardiovascular disease among older adults: the Cardiovascular Health Study: CHS Collaborative Research Group. *J Clin Epidemiol*. 1995;48: 1141–1152.
30. Sacco RL, Roberts JK, Boden-Albala B, Gu Q, Lin IF, Kargman DE, Berglund L, Hauser WA, Shea S, Paik MC. Race-ethnicity and determinants of carotid atherosclerosis in a multiethnic population: the Northern Manhattan Stroke Study. *Stroke*. 1997;28:929–935.
31. Tang W, Detrano R, Brezden O, Georgiou D, French W, Wong N, Doherty T, Brundage B. Racial differences in coronary calcium prevalence among high-risk adults. *Am J Cardiol*. 1995;75:1088–1091.
32. Doherty TM, Tang W, Dascalos S, Watson KE, Demer LL, Shavelle RM, Detrano R. Ethnic origin and serum levels of 1α,25-hydroxymvitamin D_3 are independent predictors of coronary calcium mass measured by electron-beam computed tomography. *Circulation*. 1997;96:1477–1481.
33. Iribarren C, Sidney S, Sternfeld B, Browner WS. Calcification of the aortic arch: risk factors and association with coronary heart disease, stroke, and peripheral vascular disease. *J AMA*. 2000;283:2810–2815.
34. Mahoney LT, Burns TL, Stanford W, Thompson BH, Witt JD, Rost CA, Lauer RM. Coronary risk factors measured in childhood and young adult life are associated with coronary artery calcification in young adults: the Muscatine Study. *J Am Coll Cardiol*. 1996;27:277–284.
35. Wong ND, Kouwabunpat D, Vo AN, Detrano RC, Eisenberg H, Goel M, Tobis JM. Coronary calcium and atherosclerosis by ultrafast computed tomography in asymptomatic men and women: relation to age and risk factors. *Am Heart J*. 1994;127:422–430.
36. Maher JE, Raz JA, Bielak LF, Sheedy PF, Schwartz RS, Peyser PA. Potential of quantity of coronary artery calcification to identify new risk factors for asymptomatic atherosclerosis. *Am J Epidemiol*. 1996;144: 943–953.
37. Detrano R, Hsiai T, Wang S, Puentes G, Fallavollita J, Shields P, Stanford W, Wolfkiel C, Georgiou D, Budoff M, et al. Prognostic value of coronary calcification and angiographic stenoses in patients undergoing coronary angiography. *J Am Coll Cardiol*. 1996;27:285–290.
38. Arad Y, Spadaro LA, Goodman K, Lledo-Perez A, Sherman S, Lerner G, Guerci AD. Predictive value of electron beam computed tomography of the coronary arteries: 19-month follow-up of 1173 asymptomatic subjects. *Circulation*. 1996;93:1951–1953.
39. Raggi P, Callister TQ, Cooil B, He Z, Lippolis NJ, Russo DJ, Zelinter A, Mahmarian JJ. Identification of patients at increased risk of first unheralded acute myocardial infarction by electron-beam computed tomography. *Circulation*. 2000;101:850–855.
40. Iribarren C, Sidney S, Bild DE, Liu K, Markovitz JH, Roseman JM, Matthews K. Association of hostility with coronary artery calcification in young adults: the CARDIA study: Coronary Artery Risk Development in Young Adults. *JAMA*. 2000;283:2546–2551.
41. McGill HC, McMahan A, Zieske AW, Tracy RE, Malcom GT, Herderick EE, Strong JP. Association of coronary heart disease risk factors with microscopic qualities of coronary atherosclerosis in youth. *Circulation*. 2000;102:374–379.
42. Bielak LF, Klee GG. Association of fibrinogen with quantity of coronary artery calcification measured by electron beam computed tomography. *Arterioscler Thromb Vasc Biol*. 2000;20:2167–2171.
43. Peyser PA. Genetic epidemiology of coronary artery disease. *Epidemiol Rev*. 1997;19:80–90.