Association of ideal cardiovascular health and calcified atherosclerotic plaque in the coronary arteries: The National Heart, Lung, and Blood Institute Family Heart Study

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Background The American Heart Association (AHA) established recommendations based on 7 ideal health behaviors and factors with the goal of improving cardiovascular health (CVH) and reducing both morbidity and mortality from cardiovascular disease by 20% by 2020. Few studies have investigated their association with subclinical coronary heart disease. We sought to examine whether the 7 AHA CVH metrics were associated with calcified atherosclerotic plaque in the coronary arteries.

Methods In a cross-sectional design, we studied 1,731 predominantly white men and women from the National Heart, Lung, and Blood Institute Family Heart Study without prevalent coronary heart disease. Diet was assessed by a semiquantitative food frequency questionnaire. Coronary artery calcium (CAC) was measured by cardiac computed tomography. We defined prevalent CAC using an Agatston score of 100+ and fitted generalized estimating equations to calculate prevalence odds ratios of CAC.

Results Mean age was 56.8 years, and 41% were male. The median number of ideal CVH metrics was 3, and no participant met all 7. There was a strong inverse relationship between number of ideal CVH metrics and prevalent CAC. Odds ratios (95% CI) for CAC of 100+ were 1.0 (reference), 0.37 (0.29-0.45), 0.35 (0.26-0.44), and 0.27 (0.20-0.36) among subjects with 0 to 1, 2, 3, and 4+ ideal CVH metrics, respectively ($P = .0001$), adjusting for sex, age, field center, alcohol, income, education, and energy consumption.

Conclusions These data demonstrate a strong and graded inverse relationship between AHA ideal CVH metrics and prevalent CAC in adult men and women. (Am Heart J 2015;169:371-378.e1.)

Cardiovascular disease (CVD) remains a major public health burden in the United States with total costs in excess of $315 billion.[1] Epidemiological studies have demonstrated inverse relation between number of cardiovascular health (CVH) behaviors or factors met and CVD events.[2-4]

The American Heart Association (AHA) published recommendations for the general population aimed at reducing CVD incidence and mortality by achieving 7 specific CVH metrics.[5] These include 3 health factors (blood pressure, total cholesterol, and blood glucose) and 4 health behaviors (physical activity, not smoking, body mass index [BMI], and healthy diet), categorized as ideal, intermediate, or poor.

Although several studies have examined the relationship between these CVH metrics and CVD events,[6-8] few have investigated the joint effects of all 7 AHA metrics with subclinical coronary heart disease (CHD).[9,10] Such quantification could be used by clinicians to convey potential benefits of modifiable behaviors and factors. The prognosis of patients with CHD is closely related to the burden of atherosclerotic disease and its stability,[11]

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and coronary artery calcification (CAC) is a well-described marker for subclinical atherosclerotic disease that can help stratify CHD risk and predict future events.[12-14] Conversion of no CAC to any measurable CAC confers a continuously increased risk of CVD and underscores the importance of identifying and targeting modifiable risk factors for the development of coronary atherosclerosis.[15] We sought to investigate this relationship in men and women sampled from 4 regions of the United States.

Methods

Study population

The National Heart, Lung, and Blood Institute Family Heart Study (NHLBI FHS) is a multicenter, population-based study designed to identify and evaluate genetic and nongenetic determinants of CHD, preclinical atherosclerosis, and cardiovascular risk factors.[16,17] Briefly, families in the study had been chosen randomly (random group) or based on a higher than expected risk of CHD (high-risk group) from previously established population-based cohort studies. A total of 588 families were chosen at random (with 2,673 subjects), and 566 families were selected based on higher than expected risk of CHD (3,037 subjects). Of the 5,710 subjects, 265 were African American. The high-risk group was defined based on a family risk score, which compares the family's age and sex-specific incidence of CHD to that expected in the general population.[18] All family members were invited for a clinical evaluation (between 1993 and 1995), which included a detailed lifestyle and medical history and laboratory measurements including blood glucose and cholesterol levels. Between 2002 and 2003, about one third of the NHLBI FHS participants were invited to participate in a clinical examination that included measurement of CAC. In addition to the initial study centers, an African American center—University of Alabama at Birmingham—was recruited from the Hypertension Genetic Epidemiology Network study, where subjects underwent cardiac computed tomography (CT) but did not have dietary assessments.

Of the 3,360 subjects who had data on cardiac CT, we excluded 389 subjects with prevalent CHD and 62 subjects with extreme energy intake (>17.58 kilojoules (kJ) and 14.65 kJ or <3.35 kJ and 2.51 kJ calories for men and women, respectively). A total of 993 participants were missing diet information; 185 additional participants had incomplete or missing data on total cholesterol (n = 122), blood pressure (n = 37), glucose (n = 19), education (n = 3), alcohol consumption (n = 2), and physical activity (n = 2). Thus, current analyses are based on the remaining 1,731 subjects. Each participant gave informed consent, and the study protocol was reviewed and approved by all participating institutions.

Assessment of baseline characteristics

Dietary assessment. Dietary information was collected through a staff-administered semiquantitative food frequency questionnaire (FFQ) developed by Willett et al.[19] The reproducibility and validity of the FFQ have been documented elsewhere.[20] Nutrients (including sodium) were computed using the food composition database from the Harvard School of Public Health and manufacturer information, and this technique has been described previously.[21] Subjects were asked how often on average they consumed a typical portion size of each respective food in the questionnaire, with answers ranging from 0 to >6 per day.

Laboratory assays. Fasting triglyceride concentrations were measured using triglyceride GB reagent on the Roche COBAS FARA centrifugal analyzer (Boehringer Mannheim Diagnostics, Indianapolis, IN). Serum total cholesterol was measured using a commercial cholesterol oxidase method on a Roche COBAS FARA centrifugal analyzer (Boehringer Mannheim Diagnostics). For samples with triglyceride concentrations <4.5 mmol/L (400 mg/dL), low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula[22]; otherwise, LDL was measured by ultracentrifugation.

Other variables. Resting blood pressure was measured 3 times on seated participants after a 5-minute rest, and we used the average systolic and diastolic blood pressures from the second and third measurements for analyses. Information on alcohol consumption, education, exercise, and cigarette smoking was obtained by interview during the initial clinic visit. Total physical activity was assessed using a questionnaire that captured average minutes per day of strenuous, moderate, and light leisure-time activities; frequency of sweating with exercise; miles walked and steps climbed; and level of occupational activity.[23] Anthropometric data were collected with subjects wearing scrub suits. Comorbidities including diabetes mellitus, CHD, and hypertension were assessed via questionnaires and current medications. All variables used in these analyses were ascertained during the initial examination (1993-1995) except for CAC scores, which were obtained during a follow-up examination (2002-2003).

Definition of CVH metrics

Cardiovascular health factors and behaviors were classified according to AHA definitions[5] as follows: (*a*) smoking – ideal (never), intermediate (not currently smoking but smoked ≥100 cigarettes), and poor (current) because of a lack of information about time since quitting; (*b*) BMI – ideal (<25 kg/m^2), intermediate (25 to <30 kg/m^2), and poor (≥30 kg/m^2); (*c*) physical activity – ideal (≥150 min/wk moderate intensity, ≥75 min/wk vigorous intensity, or equivalent combination), intermediate (1-149 min/wk moderate intensity, 1-74 min/wk vigorous intensity, or equivalent combination), and poor (no moderate and vigorous activity); (*d*) diet – ideal (4-5 healthy components), intermediate (2-3 healthy components), and poor (0-1 healthy component) based on 5 health dietary metrics (≥4.5 cups of fruits and vegetables a day, ≥2 3.5-oz servings of fish a week, ≥3 1-oz equivalent