ORIGINAL RESEARCH

Coffee Consumption and Coronary Artery Calcium Score: Cross-Sectional Results of ELSA-Brasil (Brazilian Longitudinal Study of Adult Health)

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Background—Available evidence for the relationship between coffee intake and subclinical atherosclerosis is limited and inconsistent. This study aimed to evaluate the association between coffee consumption and coronary artery calcium (CAC) in ELSA-Brasil (Brazilian Longitudinal Study of Adult Health).

Methods and Results—This cross-sectional study is based on baseline data from participants of the ELSA-Brasil cohort. Only participants living in São Paulo, Brazil, who underwent a CAC measurement (n=4426) were included. Coffee consumption was collected using a food frequency questionnaire. CAC was detected with computed tomography and expressed as Agatston units. CAC was further categorized as an Agatson score ≥100 (CAC ≥100). In multiple logistic regression analysis considering intake of coffee and smoking status interaction, significant inverse associations were observed between coffee consumption (>3 cups/d) and CAC≥100 (odds ratio [OR]: 0.85 [95% confidence interval, 0.58–1.24] for ≤1 cup/d; OR: 0.73 [95% confidence interval, 0.51–1.05] for 1–3 cups/d; OR: 0.33 [95% confidence interval, 0.17–0.65] for >3 cups/d). Moreover, there was a statistically significant interaction effect for coffee consumption and smoking status (*P*=0.028 for interaction). After stratification by smoking status, the analysis revealed a lower OR of coronary calcification in never smokers drinking >3 cups/d (OR: 0.37 [95% confidence interval, 0.15–0.91]), whereas among current and former smokers, the intake of coffee was not significantly associated with coronary calcification.

Conclusions—Habitual consumption of >3 cups/d of coffee decreased odds of subclinical atherosclerosis among never smokers. The consumption of coffee could exert a potential beneficial effect against coronary calcification, particularly in nonsmokers. **(*J Am Heart Assoc*. 2018;7:e007155. DOI: 10.1161/JAHA.117.007155.)**

Key Words: cardiovascular diseases • coffee consumption • coronary artery calcium • subclinical atherosclerosis

Cardiovascular diseases (CVD) are the leading global cause of death from noncommunicable diseases, accounting for 17.9 million deaths/y in 2015[1] and predicted to rise to >23.6 million by 2030.[2] From 2005 to 2013, the number of disability-adjusted life-years increased for CVD.[3] Reducing these numbers, with the consequent reduction in morbidity and mortality related to CVD, has been a main objective of public health policies worldwide.[1]

Lifestyle and dietary factors, such as a lack of physical activity, excess body weight, smoking, excessive alcohol intake, and unhealthy diet, are implicated in the etiology of CVD.[4,5] Coffee is one of the most popular and widely consumed nonalcoholic beverages in the world, and its role in CVD is still being debated and remains controversial.[5–7] In this context, some epidemiological studies suggested a positive association between coffee consumption and risk of CVD,[8,9] whereas others reported no association[6,10] or even an inverse association.[11–13]

Coffee is a complex mixture of several compounds including caffeine, minerals, fiber, and other biologically active components, such as diterpene alcohols, cafestol and kahweol, and phenolic acids, that influence human

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Clinical perspective

What Is New?

- We observed that the association between coffee consumption and coronary calcification was related to smoking status.
- Drinking >3 cups/d of coffee was associated with lower odds of subclinical coronary atherosclerosis in never smokers.

What Are the Clinical Implications?

- Based on our results and prior studies, consumption of coffee could exert a potential beneficial effect against coronary calcification and cardiovascular disease risk, particularly in nonsmokers.
- It is possible that deleterious effects of smoking overwhelm the benefits of coffee intake on early cardiovascular disease injury, so this impact of coffee may occur only in people who have never smoked.

homeostasis and metabolism, and they may have either harmful or beneficial cardiovascular effects.[14]

The presence of coronary artery calcium (CAC) is a well-known and independent marker of subclinical atherosclerosis and a good predictor of future risk of cardiovascular events and all-cause mortality in individuals with no previous history of CVD.[15–17] The CAC detected by cardiac computed tomography (CT) is an accurate noninvasive measurement for atherosclerosis in coronary arteries.[18,19] CAC provides information on underlying pathologic changes in coronary arteries, allowing for detailed assessment of the early stages of CVD.[20]

Although the relationship between coffee consumption and metabolic risk factors for CVD has been a topic of frequent interest, few studies have determined whether coffee drinking influences subclinical atherosclerosis. In fact, at this moment, only 4 studies have investigated the relationship between coffee consumption and CAC, with limited and inconsistent results.[21–24] Further investigation is needed regarding this issue.

We aimed to evaluate the association between habitual coffee consumption and subclinical atherosclerosis measured as CAC during the baseline examination of middle-aged participants in ELSA-Brasil (Brazilian Longitudinal Study of Adult Health).

Material and Methods

Study Design and Population

Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to Center for Clinical and Epidemiological Research, University Hospital, University of São Paulo at Av. Lineu Prestes nº 2565, 3° andar, São Paulo, SP, Brazil, CEP 05508-000.

ELSA-Brasil is a cohort study designed to identify risk factors for diabetes mellitus and CVD. Further details of the study, including design, eligibility criteria, sources and methods of recruitment, and measurements obtained, have been described elsewhere.[25,26] Briefly, the cohort comprises 15 105 civil servants, aged 35 to 74 years at baseline, who were sampled from universities located in 6 Brazilian cities (Belo Horizonte, Porto Alegre, Rio de Janeiro, Salvador, São Paulo, and Vitoria).

Baseline assessment was conducted from August 2008 to December 2010 and consisted of ≈7-hour evaluation, which included personal interviews conducted by trained personnel. These interviews focused on sociodemographic characteristics, health and medical history, occupational exposure, family history of disease, reproductive health, health care, psychosocial factors, body weight history and body image, food consumption, smoking, alcohol consumption, physical activity, medication use, cognitive function, mental health, and clinical and laboratory measurements. In addition, the participants at the ELSA-Brasil site in São Paulo (n=5061) were invited to perform a CT examination to quantify CAC.

For the current investigation, only participants of ELSA-Brasil at the São Paulo Research Center who underwent CAC determination (n=4549) were included. In addition, in the present analysis, we excluded individuals with missing data at baseline for coffee intake (n=2) and self-reported history of CVD, defined as prior myocardial infarction, angina, stroke, heart failure, or coronary revascularization (n=121). The final study sample comprised 4426 individuals who underwent CAC measurements and who did not fulfill exclusion criteria to participate in this subset of the study.

The ELSA-Brasil protocol was approved at all 6 centers by the institutional review boards addressing research in human participants. All participants signed a written informed consent form.

Assessment of Coffee Consumption

Dietary data were collected using a validated, semiquantitative, 114-item food frequency questionnaire to provide information on typical eating habits of participants (ie, foods and drinks) in the 12 months before the baseline examination of ELSA-Brasil. More details are available elsewhere.[27] For the assessment of habitual coffee intake, specifically, participants were asked to provide both the typical frequency with which they consumed coffee ("More than 3 times per day," "2–3

times per day," "once a day," "5–6 times per week," "2–4 per week," "once a week," "1–3 times a month" and "never or almost never") and the quantity of coffee consumed on each occasion in relation to a reference cup size of 50 mL, which is the household measure adopted in Brazil. Participants were further asked to specify the type of coffee normally consumed (filter, instant, espresso, moka pot), whether this coffee contained caffeine (caffeinated or decaffeinated), and whether additional items were typically added to the coffee (sugar, artificial sweetener, none). Daily coffee consumption (mL/d) was estimated and then classified into 4 categories (in cups/d): *never/almost never* or *≤1, 1 to 3*, or *>3 cups/d*. The *never/almost never* category was used as the reference group.

The Food Frequency Questionnaire ELSA-Brasil used the Nutrition Data System for Research software (University of Minnesota), which is mainly based on data from the food composition table published by the US Department for Agriculture and the *Tabela Brasileira de Composição de Alimentos* (http://www.unicamp.br/nepa/taco/) to obtain the nutritional information of the 114 items listed in the food frequency questionnaire, such as dietary nutrients, total energy, and other food components.

CAC Measurement

The ELSA-Brasil participants from the São Paulo site underwent noncontrast CT for CAC score evaluation.[28,29] The scans were performed using a 64-detector CT scanner (Brilliance 64; Philips Healthcare). The field of view was set to include the entire heart, and the *z*-axis direction included data from the bifurcation of the pulmonary arteries to the apex of the heart during an expiratory pause. The default settings included 120 kV, mA adjusted to body mass index, 1-phase prospective acquisition at 70% (mid-diastole) of the cardiac cycle and collimation of 2.5 mm, gantry rotation of 400 ms, and reconstruction with a standard filter. CT images were evaluated in blinded form by an experienced cardiologist using a semiautomatic software (Calcium Scoring; Philips Workstation). The measurement of the CAC score was calculated using a threshold of 130 Hounsfield units and expressed in Agatston units.[30] CAC severity was further categorized with a cutoff at 100 points because it is a better marker of worse prognosis than CAC >0.[31–33]

Covariate Assessment

Each participant was interviewed at his or her workplace and visited the research center for clinical examinations according to standard protocols.[34] Consequently, all covariates included in this analysis were self-reported through standardized questionnaires or obtained through clinical procedures or laboratory examination measurements, performed by trained personnel under strict quality control at ELSA-Brasil baseline assessment.[25,34,35]

Sociodemographic and lifestyle characteristics included monthly family per capita income (in US dollars), educational attainment, physical activity level, smoking status, alcohol drinking habits, and use of medications. Current educational attainment was assessed as the highest qualification attained and categorized as *undergraduate school or more, complete high school, complete elementary school*, and *incomplete elementary school*. Physical activity included energy expenditure in leisure time by reporting type and duration of activity according to predetermined questionnaire items from the long version of the International Physical Activity Questionnaire.[36] The physical activity level was categorized as *low, moderate* and *high*. Individuals were categorized according to smoking status as *never smoker, former smoker*, and *current smoker*. Never smoking status was defined as lifetime consumption of <100 cigarettes (5 packs of cigarettes). Former smokers were participants with past history of smoking who had not smoked cigarettes within the previous 30 days. Current smoking was defined as consumption of cigarettes within the previous 30 days. Average alcohol consumption was categorized as *nondrinker* and *alcohol drinker*. Medicaments use included hypertension, diabetes mellitus, and hypercholesterolemia treatment.

Physical examination included measurement of height, weight, and blood pressure using standard procedures. Body mass index was calculated by dividing weight (kg) by the square of height (m^2), expressed as kg/m^2. Blood pressure was measured using a validated oscillometric device (Omron HEM 705CP), handled by a nursing technician. Three measurements were performed at 1-minute intervals. The mean of the 2 latest blood pressure measurements was used as the high blood pressure definition.[34] Hypertension status was defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg, use of antihypertensive drug treatment, or both.[37]

The blood samples were collected by venipuncture after 12 hours of overnight fasting. All analyses were performed at the University of São Paulo. Serum total cholesterol and fractions, low- and high-density lipoprotein cholesterol, and triglycerides were determined by enzymatic colorimetric assay (ADVIA 1200 Chemistry Analyzer; Siemens). Fasting plasma glucose was measured by hexokinase method (enzymatic; ADVIA 1200 Chemistry Analyzer; Siemens). Diabetes mellitus status was defined as a medical history of diabetes mellitus with a physician diagnosis and/or the reported use of medications to treat diabetes mellitus (insulin or oral antidiabetic medication) and/or fasting plasma glucose >126 mg/dL, glycated hemoglobin ≥6.5%, or 2-hour plasma glucose after an overload of 75 g glucose in ≥200 mg/dL (5.17 mmol/L).[26] Other details on logistics of collection, processing,

transportation of biological samples, and organization of the central laboratory in ELSA-Brasil are available elsewhere.[35]

Statistical Analyses

Baseline characteristics of the sample were summarized using median and interquartile range for continuous variables and frequencies and percentages for categorical variables according to coffee consumption categories (never/almost never, ≤1, 1–3, and >3 cups/d). Differences between coffee consumption categories were performed using the χ^2 test for categorical variables and the Kruskall–Wallis test for continuous variables.

Multiple logistic regression analysis was performed to estimate odds ratios and 95% confidence intervals (95% CIs) for the association between the independent variable (categories of coffee consumption) and category of CAC score (<100 versus ≥100), as the dependent variable. The effect of interaction between smoking status and coffee consumption on subclinical coronary calcification was tested by including the respective multiplicative interaction terms in the logistic regression model. Thereafter, the multivariate model was adjusted for established risk factors for CVD that were also known to be associated with coffee consumption based on prior studies and theoretical considerations, according to the literature, as follows: age (years), sex (male and female), self-reported race/skin color (white and nonwhite), current educational attainment (complete elementary school, complete high school, and undergraduate school or more), physical activity level (low, moderate, and high), body mass index (kg/m^2), smoking status (never, former, and current smokers), alcohol consumption (nondrinker and drinker), saturated fat (g/d), consumption of fruit and vegetables (g/d), tea drinking (mL/d), total energy intake (kcal/d), blood pressure (mm Hg), fasting glucose (mg/dL), high-density lipoprotein cholesterol (mg/dL), low-density lipoprotein cholesterol (mg/dL), triglyceride (mg/dL), and use of antihypertensive, antidiabetic, or cholesterol-lowering medications. Because an interaction was found for smoking status (P=0.028), the analysis was performed after stratification of the sample by this variable.

All statistical analyses were conducted using the Stata statistical software package, version 13.0 (StataCorp), and P<0.05 was considered statistically significant. The P value for trend of continuous variables using ANOVA was also determined.

Results

The final study population had a median age of 50.0 years, was mostly female (54.2%), was self-declared white (58.9%), had a low physical activity level (78.7%), and was overweight or obese (65.4%). Of the participants, 2360 were never smokers (53.3%), 1356 were former smokers (30.7%), and 710 were current smokers (16.0%). The prevalence of CAC ≥100 was 9.9%. Most participants (≈56%) reported consuming coffee at least twice per day, with 515 (11.6% of the total) reporting consuming coffee >3 times per day. Most participants reported typically consuming coffee that was filtered (81.7%) and caffeinated (98.6%) and using added sugar (59.0%) or artificial sweetener (28.2%).

The baseline characteristics of the studied population according to coffee consumption categories are shown in Table 1. Coffee consumption was related to age, white race or skin color, educational level, physical activity level, smoking status, alcohol intake, tea consumption, fruit and vegetable consumption, saturated fat, and total energy intake.

The association between coronary calcification and coffee consumption categories, considering the coffee–smoking interaction, is depicted in Table 2. After multivariate adjustment, there was a statistically significant interaction effect for coffee consumption and smoking status on CAC ≥100 (P=0.028 for interaction). Moreover, significant inverse association was observed between coffee consumption (>3 cups/d) and CAC (≥100 Agatston units). The odds ratios for CAC ≥100 in participants who consumed coffee compared with those who never drank coffee were 0.85 (95% CI, 0.58–1.24), 0.73 (95% CI, 0.51–1.05), and 0.33 (95% CI, 0.17–0.65) for ≤1, 1 to 3, and >3 cups/d (P=0.015 for trend). Table 3 presents the results of the stratified analysis according to smoking status. The odds ratio of subclinical coronary atherosclerosis among current and former smokers was not significantly associated with coffee consumption, whereas among never smokers, the intake of coffee up to 3 cups/d was associated with lower odds of coronary calcification (odds ratio: 0.37 [95% CI, 0.15–0.91]; P=0.036 for trend).

Discussion

The current study found that habitual coffee consumption was inversely associated with coronary calcification, a marker of subclinical coronary atherosclerosis, even after adjustments for potential confounders, including cardiovascular risk factors; however, this protective role of coffee on coronary calcification was nullified by smoking habit.

The benefits of coffee consumption on the cardiovascular system have been investigated extensively, providing inconsistent and conflicting results according to different study designs.[5,6] In the 1980s, cross-sectional studies found a positive association between coffee consumption and serum total cholesterol concentrations, which might be related to the coffee-brewing method (ie, boiled or unfiltered coffee).

Table 1. Baseline Characteristics of ELSA-Brasil Participants (N=4426) By Categories of Coffee Consumption per Day, São Paulo, 2008–2010

Characteristics		Coffee Consumption, Number of 50-mL Cups/d				
	Total	Never/Almost Never	≤1	1–3	>3	*P* Value*,†
No. of participants	4426	971	959	1981	515	
Sociodemographic						
Age (y), median (IQR)	50 (44–57)	51 (45–58)	50 (44–56)	49 (45–55)	49 (44–55)	<0.001*
Sex, n (%)						
Male	2027 (45.8)	447 (46.0)	428 (44.6)	920 (46.4)	232 (45.0)	0.802†
Female	2399 (54.2)	524 (54.0)	531 (55.4)	1061 (53.6)	283 (55.0)	
Race/skin color, n (%)						
White	2574 (58.9)	635 (66.9)	514 (53.9)	1136 (58.2)	289 (56.3)	<0.001†
Other	1794 (41.1)	314 (33.1)	439 (46.1)	817 (41.8)	224 (43.7)	
Educational Attainment, n (%)						
Complete elementary school	655 (14.8)	86 (8.9)	194 (20.2)	301 (15.2)	74 (14.4)	
Complete high school	1819 (41.1)	278 (28.6)	411 (42.9)	872 (44.0)	258 (50.1)	<0.001†
Undergraduate school or more	1952 (44.1)	607 (62.5)	354 (36.9)	808 (40.8)	183 (35.5)	
Physical activity level, n (%)						
Low	3358 (78.7)	661 (70.7)	741 (79.6)	1567 (81.6)	389 (81.0)	
Moderate	554 (13.0)	151 (16.2)	126 (13.5)	212 (11.0)	65 (13.6)	<0.001†
High	356 (8.3)	123 (13.1)	64 (6.9)	143 (7.4)	26 (5.4)	
Smoking status, n (%)						
Never smoker	2360 (53.3)	584 (60.1)	579 (60.4)	939 (47.4)	258 (50.1)	<0.001†
Former smoker	1356 (30.7)	296 (30.5)	281 (29.3)	610 (30.8)	169 (32.8)	
Current smoker	710 (16.0)	91 (9.4)	99 (10.3)	432 (21.8)	88 (17.1)	
Clinical and physical characteristics						
Body mass index (kg/m^2), median (IQR)	26.8 (24.0–30.0)	26.5 (23.7–29.6)	26.7 (23.9–29.9)	26.7 (24.1–30.0)	27.4 (24.1–30.3)	0.174*
Hypertension, n (%)						
No	3068 (69.3)	695 (71.6)	643 (67.0)	1380 (69.7)	350 (68.0)	0.156†
Yes	1357 (30.7)	276 (28.4)	316 (33.0)	600 (30.3)	165 (32.0)	
Diabetes mellitus, n (%)						
No	3547 (80.1)	788 (81.1)	750 (78.2)	1595 (80.5)	414 (80.4)	0.380†
Yes	879 (19.9)	183 (18.9)	209 (21.8)	386 (19.5)	101 (19.6)	

Continued

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Table 1. Continued

Characteristics		Coffee Consumption, Number of 50-mL Cups/d				
	Total	Never/Almost Never	≤1	1–3	>3	*P* Value*,†
Biochemical						
LDL-C (mg/dL), median (IQR)	128 (108–150)	128 (108–150)	128 (107–149)	127 (107–151)	131 (111–152)	0.349*
HDL-C (mg/dL), median (IQR)	54 (46–64)	55 (47–67)	53 (46–64)	53 (46–63)	53 (46–63)	0.020*
TG (mg/dL), median (IQR)	115 (81–164)	113 (79–160)	117 (79–170)	114 (83–164)	121 (83–166)	0.325*
Daily dietary data						
Alcohol user, n (%)	3019 (68.2)	697 (71.8)	605 (63.1)	1377 (69.5)	340 (66.0)	<0.001*
Tea consumption (mL/d), median (IQR)	0 (0–87)	21 (0–174)	0 (0–87)	0 (0–87)	0 (0–44)	<0.001*
Fruit and vegetable consumption (g/d), median (IQR)	653.9 (437.5–940.1)	643.2 (423.7–952.1)	663.3 (436.4–917.7)	646.2 (440.6–915.2)	687.2 (461.7–1031.3)	0.019*
Saturated fat (g/d), median (IQR)	23.3 (19.6–27.2)	23.6 (20.3–27.5)	22.9 (19.8–26.9)	23.3 (19.3–27.4)	22.7 (18.5–27.1)	0.007*
Total energy intake (kcal/d), median (IQR)	2208.6 (1697.3–2888.7)	2070.9 (1558.3–2730.8)	2147.8 (1652.6–2767.7)	2234.1 (1758.4–2903.6)	2515.4 (1896.9–3452.9)	<0.001*

Values are median (IQR) for continuous variables and frequencies and percentages for categorical variables. $P<0.05$ was considered statistically significant. ELSA-Brasil indicates Brazilian Longitudinal Study of Adult Health; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides.

*Comparisons across categories were performed by using Kruskall–Wallis test.

†Comparisons across categories were performed by using χ^2.

Case–control studies, which are prone to recall and selection biases, tended to show a positive association, whereas cohort studies generally suggested a null association, although results varied substantially across studies and findings have remained inconsistent.[12]

More recent meta-analysis of prospective studies showed that moderate coffee consumption was associated with decreased CVD risk, all-cause mortality, and mortality attributed to CVD and neurologic disease in the overall population. High coffee consumption (>5 cups/d) was neither related to CVD risk nor to risk of mortality.[12,13] To corroborate this evidence, the 2015–2020 Dietary Guidelines for Americans show that consumption of 3 to 5 cups/d of coffee is associated with reduced risk of type 2 diabetes mellitus and CVD in adults.[38] Consequently, moderate coffee consumption can be incorporated into a healthy dietary pattern, along with other healthful behaviors.[38]

Although coffee consumption has been studied in relation to various risk factors of CVD, only 4 studies have investigated the association between coffee intake and subclinical atherosclerosis,[21–24] and the data available were limited and inconsistent.

According to Choi et al,[23] in the large sample of Korean men and women apparently free of clinically evident CVD (n=25 138), moderate coffee consumption (3 to <5 cups/d) was associated with 41% lower prevalence of CAC. The results from our study are comparable to this research. In the study by Choi et al, however, the average age of the study participants was 41 years, 84% of the participants were male, and ≈82% completed college graduation or higher, thus the results might not be generalizable to the other populations. In the Rotterdam study (n=1570), van Woudenbergh et al[21] showed that moderate (>3 to 4 cups/d) to high (>4 cups/d) coffee consumption was associated with decreased prevalence of severe calcification (CAC score >400) in women, but an increased risk was observed in nonsmoking men. These investigators were unable to explain why coffee appeared to be protective among women but harmful among nonsmoking men. Smoking behavior may wield a strong influence on an association between coffee consumption and CVD risk. Smokers are often more frequent coffee drinkers,[39] and they are also inherently at greater risk of coronary artery disease[39] and positively associated with subclinical atherosclerosis.[40,41] Smoking may also intercede in the pathways through which coffee constituents are hypothesized to mediate effects on this disease. If caffeine and coffee-derived antioxidants are important mediators of the association between coffee consumption and subclinical atherosclerosis, it is possible that deleterious effects of smoking overwhelm the influence of coffee intake on early CVD injury. Consequently, this impact of coffee may only be detectable in people who have never smoked. In stratified analysis, we are able to remove

Table 2. ORs and 95% CIs of Subclinical Coronary Calcification (CAC ≥100 vs <100) by Categories of Coffee Consumption Considering Smoking Status and Coffee Intake Interaction (ELSA-Brasil, São Paulo, 2008–2010).

CAC Score Category, OR (95% CI)	Coffee Consumption, Number of 50-mL Cups/d					
	Never/Almost Never	≤1	1–3	>3	*P* for Trend*	*P* for Interaction*,†
CAC ≥100 vs <100						
No. of cases	113	92	198	38		
Total population (without interaction term)						
Model 1 (crude)	1.00 (Ref.)	0.80 (0.60–1.07)	0.84 (0.66–1.08)	0.60 (0.41–0.89)	0.027	—
Model 2 (adjusted)	1.00 (Ref.)	0.89 (0.61–1.30)	0.86 (0.63–1.19)	0.51 (0.30–0.86)	0.039	—
Total population (with interaction term)						
Model 1 (crude)	1.00 (Ref.)	0.82 (0.61–1.11)	0.84 (0.61–1.13)	0.70 (0.40–1.23)	0.219	0.300
Model 2 (adjusted)	1.00 (Ref.)	0.85 (0.58–1.24)	0.73 (0.51–1.05)	0.33 (0.17–0.65)	0.015	0.028

Model 2: adjusted for age, sex, race or skin color, educational attainment, body mass index, physical activity level, smoking status, alcohol consumption, saturated fat, total energy intake, consumption of fruit, vegetable and tea intake, systolic and diastolic blood pressure, fasting glucose, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglyceride, and use of antihypertensive, antidiabetic, and cholesterol-lowering medications. CAC indicates coronary artery calcium; CI, confidence interval; ELSA-Brasil indicates Brazilian Longitudinal Study of Adult Health; OR, odds ratio; Ref., reference.

*$P<0.05$ was considered statistically significant.

†Interaction between coffee consumption and smoking status.

residual confounding by smoking status from our data; therefore, our results support the evidence that the beneficial effects of coffee intake on coronary artery calcification were observed only in never smokers.

Contrary to our findings, 2 other studies[22,24] have shown that there was no association between habitual coffee consumption and coronary atherosclerosis in adults. In the CARDIA (Coronary Artery Risk Development in Young Adults) study (N=5115),[22]

Table 3. ORs and 95% CIs of Subclinical Coronary Calcification (CAC ≥100 vs <100) in Never, Former, and Current Smokers by Categories of Coffee Consumption (ELSA-Brasil, São Paulo, 2008–2010)

CAC Score Category	Coffee Consumption, Number of 50-mL Cups/d				
(CAC ≥100 vs <100), OR (95% CI)	Never/Almost Never	≤1	1–3	>3	*P* for Trend*
Never smokers					
No. of participants	584	579	939	258	
No. of cases	54	39	68	17	
Model 1 (crude)	1.00 (Ref.)	0.90 (0.57–1.42)	0.71 (0.48–1.05)	0.44 (0.23–0.84)	0.007
Model 2 (adjusted)	1.00 (Ref.)	1.18 (0.63–2.20)	0.81 (0.47–1.37)	0.37 (0.15–0.91)	0.036
Former smokers					
No. of participants	296	281	610	169	
No. of cases	47	41	72	13	
Model 1 (crude)	1.00 (Ref.)	0.71 (0.46–1.09)	0.77 (0.53–1.11)	0.69 (0.39–1.22)	0.157
Model 2 (adjusted)	1.00 (Ref.)	0.82 (0.46–1.45)	0.86 (0.52–1.42)	0.55 (0.23–1.31)	0.276
Current smokers					
No. of participants	91	99	432	88	
No. of cases	12	12	58	8	
Model 1 (crude)	1.00 (Ref.)	0.91 (0.38–2.13)	1.02 (0.52–1.98)	0.66 (0.25–1.70)	0.634
Model 2 (adjusted)	1.00 (Ref.)	0.75 (0.25–2.29)	1.19 (0.50–2.83)	0.68 (0.21–2.16)	0.976

Models 2: adjusted for age, sex, race or skin color, educational attainment, body mass index, physical activity level, alcohol consumption, saturated fat, total energy intake, consumption of fruit, vegetable and tea intake, systolic and diastolic blood pressure, fasting glucose, high density lipoprotein cholesterol, low density lipoprotein cholesterol, triglyceride, and use of antihypertensive, antidiabetic, and cholesterol-lowering medications. CAC indicates coronary artery calcium; CI, confidence interval; ELSA-Brasil indicates Brazilian Longitudinal Study of Adult Health; OR, odds ratio; Ref., reference.

*$P<0.05$ was considered statistically significant.

caffeinated and decaffeinated coffee consumption was not associated with coronary calcification or with progression over 5 years of follow-up. Participants in the CARDIA study were younger (mean age: 26 years) and consumed less coffee (16% reported consuming ≥3 cups/d). In the NHLBI Family Heart Study (n=1929),[24] prevalence ratios for CAC ≥100 were 1.0 (reference), 0.92 (95% CI, 0.57–1.49), 1.34 (95% CI, 0.86–2.08), 1.30 (95% CI, 0.84–2.02), and 0.99 (95% CI, 0.60–1.64) for coffee consumption of almost never, <1, 1, 2 to 3, and ≥4 cups/d, respectively, in adult men and women.

These controversial findings across studies could also be attributable to different types of studies and methodological issues, including differences in sample size, statistical adjustments for potential confounding factors, measures and different coffee-brewing methods, daily consumption, distinct characteristics of study populations (age, sex, ethnicity, educational level), and prevalence of CAC.

Regarding the biological mechanisms, several pathways have been suggested for the potential beneficial relationship between coffee consumption and cardiovascular risk. It might be possible that the protective effect of coffee consumption comes through different physiology that reduces the long-term effects of traditional risk factors responsible for CVD. Habitual coffee consumption has been associated with a significantly lower risk of type 2 diabetes mellitus,[42,43] a major risk factor for atherosclerosis. In addition, coffee drinking might improve insulin sensitivity, apparently because of the presence of antioxidant compounds in the coffee.[44] Despite the fact that acute coffee consumption might increase blood pressure, this effect seems to disappear with long-term coffee consumption, and large prospective studies do not support the hypothesis that high coffee consumption increases the risk of hypertension.[45,46] Coffee is a beverage with very complex chemical composition, rich in phenolic compounds, predominantly hydroxycinnamic acids, which demonstrate protective roles in the cardiovascular system.[4] This cardiovascular protection has been confirmed in vivo and can be explained by various mechanisms, including their anti-inflammatory properties,[47] strong antioxidant activity[48,49] that might prevent low-density lipoprotein oxidation,[49] and antithrombotic capacities associated with improved endothelial function and nitric oxide bioavailability,[50,51] protecting against thrombus formation or atherosclerotic lesion development. Conversely, coffee, particularly unfiltered coffee, has been associated with alterations in circulating lipids, because it is rich in cholesterol-raising compounds (diterpenes, kahweol, and cafestol) that contribute significantly to the increase in total cholesterol, low-density lipoprotein cholesterol, and triglycerides.[52–54] Consumption of filtered coffee, however, had no substantial effects on blood lipids,[52,55] because the brewing releases oil droplets containing diterpenes from ground coffee beans, and the oil is retained by a paper filter.[52,54] In Brazil, filtering is the traditional method of coffee preparation, so our study corroborated and supported this information. Besides, the antioxidants included in coffee might reduce lipid oxidation, as mentioned earlier.

Some limitations of this study should be considered when interpreting results. Although ELSA-Brasil is a prospective cohort study, at this moment, we only have available data from the baseline examination; therefore, the cross-sectional design limits the possibility of establishing causal inferences, because we cannot rule out reverse causation or residual confounding. Nevertheless, to minimize the problem of reverse causality, we excluded participants with previously diagnosed CVD from the analyses. Finally, our results were based on a sample of relatively healthy middle-aged participants with a high educational level, thus they might not be generalizable to other populations. Further research is warranted to confirm our findings and to establish the biological basis of coffee's potential preventive effects on coronary artery disease.

Our study, however, has several strengths. The large sample size provides sufficient power to detect the association between coffee drinking and CAC scores while controlling for several potential confounders. Data collection in ELSA-Brasil is subject to carefully standardized protocols and rigorous quality control. In addition, we had information on a large number of CVD risk factors that could be used to adjust for potential confounders in multivariable models. Moreover, we used the CAC measurement to assess coronary atherosclerosis, a method with good reproducibility and correlation with the extent of coronary artery disease.

In conclusion, the current study showed that the association between coffee consumption and coronary calcification was related to smoking status. Habitual coffee drinking of >3 cups/d was associated with lower odds of subclinical coronary atherosclerosis among never smokers in a Brazilian population. Our findings suggest that coffee consumption could exert a potential beneficial effect against coronary calcification and CVD risk, particularly in nonsmokers.

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Disclosures

None.

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