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Red meat consumption and cardiovascular target organ damage (from the Strong Heart Study)

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Abstract

Objective—The aim of this study was to investigate whether red meat consumption is related to changes in left ventricular mass (LVM), left atrial diameter and carotid atherosclerosis in American Indians.

Methods—We prospectively analyzed echocardiographic and carotid ultrasound data of 1090 adults aged 40 years and older enrolled in the Strong Heart Family Study who were free of cardiovascular disease at baseline – 535 (49%) were hypertensive and 555 (51%) participants were nonhypertensive. Processed and unprocessed red meat intake was ascertained by using a Block food-frequency questionnaire at baseline. Cardiac and vascular biomarkers were assessed at baseline and 4 years later. Marginal models with multivariate adjustment were used to assess the associations of red meat intake with LVM, left atrial diameter, intima–media thickness and presence and extent of carotid atherosclerosis.

Results—Participants with hypertension were older, had a higher BMI, were more likely to be diabetic and less physically active. Processed and unprocessed red meat consumption was related to an increase in the presence of atherosclerotic plaques in male and female hypertensive individuals. In male hypertensive participants, processed meat intake was further observed to be associated with an increase in intima–media thickness, atrial diameter but not LVM. In nonhypertensive participants, neither unprocessed nor processed red meat intake was associated with changes in cardiac parameters or carotid atherosclerosis.

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Conflicts of interest

There are no conflicts of interest.

Conclusion—Over a 4-year period, red meat consumption was related to cardiovascular target organ damage in hypertensive American Indians. These findings emphasize the importance of dietary measures for cardiovascular disease prevention.

Keywords

carotid atherosclerosis; echocardiography; left ventricular mass; red meat; ultrasonography

INTRODUCTION

Red meat consumption has been identified to be a major dietary risk factor for cardiovascular disease (CVD) [1–4]. To this point, several issues remain unresolved. Despite the availability of several endpoint studies on the association of red meat intake with incident cardiovascular events, surprisingly little is known about the relation between red meat intake and preclinical CVD (target organ damage) [5]. Second, evidence suggests that among meat products, higher risk of coronary heart disease or diabetes is seen with processed meat consumption, whereas a smaller increase or no risk is seen with unprocessed meat intake [1,2,6,7]. Processed and unprocessed red meats differ most notably in their contents of preservatives that promote blood pressure (BP) elevation and vascular inflammatory processes [1,2,6]. Individuals already at high risk for CVD may be particularly vulnerable to these dietary effects as the association between processed meat products, coronary artery disease and stroke can be explained by BP-driven changes of the left ventricle (LV) predisposing to greater myocardial oxygen demand and demand-side ischemia. On the other hand, processed meat consumption may increase local and systemic inflammatory vascular processes that influence the formation of atherosclerotic plaques predisposing to blood flow reduction or plaque rupture. Unfortunately, studies examining these pathophysiological mechanisms are unavailable, and longitudinal population-based samples are needed to elucidate cardiac and vascular changes related to processed and unprocessed meat intake. Such data will help elucidate the role of key dietary intakes for the development and progression of cardiovascular risk to CVD.

The aim of this study was to explore changes in left ventricular mass (LVM), left atrial diameter and measures of carotid atherosclerosis related to red meat intake in individuals with or without hypertension. We hypothesized that red meat intake would be associated with cardiovascular target organ damage.

METHODS

The Strong Heart Study (SHS) is a longitudinal population-based survey of cardiovascular risk factors and disease in American Indians from 13 communities in Arizona, Oklahoma and South and North Dakota that was initiated in 1988. The SHS design and methods have been described previously [8]. In brief, the Strong Heart Family Study (SHFS) was conducted between 2001 and 2003 (SHS IV exam) with a follow-up visit in 2007–2009 (SHS V exam). It enrolled 1468 men and 2197 women from 96 large families of SHS participants. All participants of the SHFS received extensive examinations including a transthoracic echo-cardiogram and carotid ultrasonography at both visits.

For this analysis, we included individuals aged 40 years or older. Participants with a self-reported history of any CVD [i.e. myocardial infarction, angina pectoris, heart failure, coronary bypass surgery, angioplasty, carotid endarterectomy, valve replacement and significant valve disease (aortic or mitral stenosis or more than mild regurgitation) or history of stroke at SHS IV exam] were excluded (N=118). Furthermore, we excluded participants who reported having extreme caloric intakes (intakes of <600 or >6000 kcal/ day for women and <600 or >8000 kcal/day for men were used as thresholds) (N=189) [7]. Our final study population consisted of 1090 study participants. Participants were followed up for an average of 4 years.

The institutional review boards (Cornell University, Med-Star Health and University of Oklahoma), Indian Health Service IRB (Phoenix, Oklahoma City and Aberdeen) and each participating tribe approved the study. Written informed consent was obtained from all participants at enrollment.

Dietary assessment

An interviewer-administered Block 119-item food-frequency questionnaire (FFQ) was applied to all participants at baseline to measure usual food intake of participants [9,10]. The Block FFQ has demonstrated good reliability and validity [11–14]. For the purpose of our study population of American Indians, the standard Block FFQ was modified, i.e. questions about the frequency of consumption and the portion sizes of foods such as ‘SPAM’ commonly consumed among American Indians were added [7,15]. SPAM is a term that refers to a canned processed meat product that consists of a combination of beef or pork shoulder, salt, sodium nitrate, potato starch and water. SPAM is provided free of charge to many American Indians as part of the United States Department of Agriculture food assistance/commodity food program. For this analysis, our dietary exposures of interest were processed meat intake (e.g. breakfast sausage, hot dogs, lunch meat and bacon and SPAM) and unprocessed meat intake (e.g. porkchops, pork roast, dinner ham, veal, lamb, deer, ribs, hamburger, cheeseburger, roast beef, steak and liver) [7]. Serving and portion sizes were assessed by using photographs of various portions as visual aids. Each participant was asked how often, on average, a particular food was consumed during the past year. As previously described, we considered 50 g (1.8 oz) and 100 g (3.5 oz) as one serving of processed meat and unprocessed meat, respectively [7].

Cardiovascular target organ damage

Echocardiographic measures were collected in all participants at SHS IV and SHS V exams by expert sonographers and reviewed offline by a highly experienced investigator following the American Society of Echocardiography recommendations [16]. For this analysis, the following parameters were included: left atrial diameter was measured at end-systole, and LVM was calculated using a necropsy-validated formula and normalized to height in meters$^{2.7}$ (LVM index) [17,18].

For the assessment of carotid atherosclerosis, the extracranial carotid arteries were examined using a standardized protocol in all participants at SHS IV and SHS V exams following previously described procedures [19,20]. In brief, carotid ultrasonography with simultaneous

ECG was performed by field sonographers following central training and reviewed offline by a highly experienced investigator. Intima–media thickness (IMT) measurements were obtained from the far wall of the distal common carotid artery approximately 1 cm proximal to the carotid bulb at end-diastole. All carotid arteries were also scanned for evidence of atherosclerosis. A carotid artery plaque was defined as a localized protrusion of the vessel wall, which extended into the lumen at least 1.5 mm, or had a thickness exceeding the IMT of the adjacent portion of the vessel wall by more than 50% [19,21]. Plaque score, a semiquantitative measure of the extent of atherosclerosis, was calculated by the number of left and right segments (common carotid, bulb, internal carotid and external carotid) containing plaque; thus, plaque score ranged from 0 to 8 [19,21].

Covariate assessment

Covariates were assessed by standardized protocols or self-report using a standardized questionnaire at baseline [8]. BP status was assessed by the average of two blood pressure readings at baseline examination. Hypertension was defined as SBP at least 140 mmHg or DBP at least 90 mmHg, or taking hypertension medication [22]. Diabetes was diagnosed if fasting plasma glucose was at least 126 mg/dl or if the participant was on diabetes medications [23]. BMI was calculated as body weight divided by height squared (kg/m^2). Physical activity was assessed by measuring the number of steps taken per day [24,25].

Statistical analyses

Echocardiographic and carotid ultrasound measures by hypertension status at baseline (SHS-phase IV) and follow-up exam (SHS-phase V) were compared using *t* test, logistic or marginal models [26]. Marginal models were used to assess the association of red meat intake with echocardiographic and carotid artery measures in SHS V exam separately for nonhypertensive and hypertensive groups stratified by sex. Models were adjusted for the respective baseline echocardiographic/ultrasound measurement, age, field center, smoking status, BMI, diabetes, average steps per day, alcohol intake (drinks/week), total energy intake and relatedness among family members. Similar to previous analyses from the SHFS, the impact of relatedness among family members was considered by using standard kinship coefficients (i.e. 0.25 for parent/offspring, 0.25 for full siblings, 0.125 for half siblings and 0 for no consanguinity) [26]. Furthermore, for dichotomous measures (i.e. plaque score), we calculated the odds ratio (OR) for a 10 g increase in total meat consumption as exponential of the respective estimate coefficient of total meat. Sensitivity analyses were undertaken by excluding BMI from our modeling as well as by additionally adjusting for education level and antihypertensive or cardiovascular medication. All *P* values were two-tailed. A *P* value less than 0.05 was considered significant. Data were analyzed with SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

Characteristics of study participants by BP status at baseline (SHS IV exam) are presented in Table 1. Participants with hypertension were significantly older, more likely to be diabetic, had higher BMI and were less physically active.

Measures of LVM, left atrial diameter and carotid atherosclerosis of nonhypertensive and hypertensive individuals at baseline and the follow-up exam (SHS V exam) are presented in Table 2. At baseline, there were significant mean differences among the groups in LVM, left atrial diameter, IMT and presence and extent of carotid plaques. Between the follow-up and baseline exams, the presence and extent of carotid plaques as well as left atrial diameter but not IMT increased in all groups. LVM and LVM index increased significantly only in hypertensive individuals.

Associations of red meat intake with changes in LVM, left atrial diameter and carotid atherosclerosis by hypertension status, stratified by sex, are presented in Tables 3 and 4. In nonhypertensive male or female participants, neither unprocessed nor processed red meat intake was associated with changes in any echocardiographic measure or presence of atherosclerotic plaques (Table 3). In male and female hypertensive individuals, processed and unprocessed red meat consumption was related to an increase in the presence of atherosclerotic plaques but not LVM (Table 4). In addition, in male hypertensive participants, processed meat intake was also significantly associated with an increase in IMT and atrial diameter. To complement the information provided in Table 4, we calculated easier-to-interpret measures of significant effect sizes (OR) for dichotomous variables (plaque score): in female hypertensive participants, the OR for an increase in plaque score for a 10 g increase in consumption of total red meat was estimated to be 1.11 (95% confidence interval 1.01; 1.22).

To consider possible overadjustment for BMI, we excluded BMI from our modeling in sensitivity analyses (data not shown). The significant or insignificant associations shown in Tables 3 and 4 were not changed. Finally, additional adjustment for education level and antihypertensive medication did not affect the significant associations of unprocessed/processed/total meat with atherosclerotic plaque or plaque score as shown in Table 4.

DISCUSSION

In this prospective community-based study of American Indians with 4 years of follow-up, processed and unprocessed red meat consumption was associated with an increase in the presence of carotid plaques in hypertensive individuals. Although no relationship between processed and unprocessed red meat intake and LVM was found, processed meat intake was related to an increase in left atrial size in male hypertensive participants. In nonhypertensive individuals, red meat consumption was not associated with changes in cardiac parameters or with measures of carotid atherosclerosis.

Carotid plaque burden is a strong predictor for future coronary heart disease and ischemic stroke [19,27]. Dietary factors may influence the formation of carotid plaques, but data on the relationship between red meat consumption and carotid atherosclerosis are sparse. A cross-sectional analysis of Korean adults with metabolic syndrome reported higher meat consumption to be related to a higher carotid IMT [5]. However, as longitudinal measurements were not undertaken as well as other vascular biomarkers such as atherosclerosis were not assessed, the role of meat consumption for atherosclerotic disease progression remains largely unclear. Moreover, results of dietary pattern analysis are

inconclusive. A Mediterranean dietary pattern, which limits red meat consumption, has been shown to be beneficial for cardiovascular risk reduction, but current evidence on its effects on carotid atherosclerosis is sparse [28–31]. In the PREDIMED randomized controlled trial, 175 individuals at high risk for CVD were randomized to receive a Mediterranean diet supplemented with extra virgin olive oil, nuts or a control diet (low-fat diet) [29]. Compared with a low-fat diet, consumption of a Mediterranean diet supplemented with nuts was associated with a delayed progression of atherosclerotic plaques. On the other hand, the Dietary Intervention Randomized Controlled Trial-Carotid study (a dietary weight loss intervention study) found neither a low-fat diet, nor a Mediterranean or a low-carbohydrate diet to be superior in relation to vascular biomarkers over the course of a two-year follow-up [30]. However, unfortunately, the statistical power to detect moderate differences in the effect of the three diets was limited in this trial [30]. Although pattern analysis may very often reveal stronger associations when the effects of multiple components are synergistic, pattern analysis may also dilute an association with diet if only a few components are truly related to the outcome. Our individual dietary component analysis based on longitudinal data indicates that among selected food items, red meat plays a key role as its consumption may accelerate atherosclerotic plaque progression in carotid arteries. This is consistent and in line with previous endpoint studies linking red meat intake to incident stroke [4,32].

Explanations for the differences of red meat consumption on carotid atherosclerosis by BP status can be derived from the underlying pathophysiology. Hypertensive individuals face higher levels of both distending pressure and pulsatile forces on their arterial structure resulting on the hand in hypertrophy of the media layer of the vessel wall, on the hand in greater susceptibility to endothelial damage and to a proinflammatory vascular state [33–35]. Thus, they are more vulnerable to environmental factors that predispose them to atherosclerotic disease progression (i.e. plaque formation). The specific adverse effects of red meat consumption on cardiovascular risk have been attributed to its constituents such as saturated fat, heme iron, sodium and other preservatives. In addition to increasing BP, these enfold oxidative stress and lead to a proinflammatory body response [1,2,36]. Recent basic science findings further indicate that the intestinal metabolism of L-carnitine, a trimethylamine abundant in red meat, accelerates atherosclerosis by modulating cholesterol and sterol metabolism [37].

Among other mechanisms that relate meat intake to coronary heart disease and stroke, changes in LVM and left atrial diameter are of key interest. To this date, evidence for such a mechanism is largely missing. Previous cross-sectional investigations suggest that individuals most closely conforming to a Mediterranean-type or DASH-type dietary pattern have a modestly better LV structure, including lower LVM, than persons with less conformity do [38–40]. Although our longitudinal data revealed significant alterations of cardiac phenotype by hypertension status, our regression analyses did not show any association between meat consumption and changes in LVM or left atrial size except for a singular finding between processed meat intake and increase in atrial diameter in male hypertensive American Indians. Although the latter finding may indeed point to the harmful role of preservatives (e.g. sodium) included in processed meats [41], the lack of a stronger relationship between red meat intake and LVM or left atrial size across female and male hypertensive participants can be explained by several factors. Most importantly, red meat

consumption largely mediates its effect on LVM and left atrial size by BP elevation, and the effect size seems to be dependent on the duration of exposure. This is in part supported by recent prospective findings from the Nurses' Health and Health Professionals Follow-up Study showing an increased risk of hypertension after long-term meat intake [42]. Thus, our study period may not have been long enough to observe pronounced changes in LVM or left atrial size.

Our findings have implications for dietary choices with respect to consumption of specific food items. This study showed for the first time the harmful effects of red meat consumption on cardiovascular target organs in hypertensive individuals that already occurred over a relatively short period (i.e. 4 years). Thus, these results emphasize that, among measures of cardiovascular risk management, the implementation of lifestyle and dietary changes is of foremost importance [43–45]. Our data support current lifestyle management guidelines that recommend a limitation of red meat consumption as one step to maintain and promote cardiovascular health [43].

Strengths of our analysis include the sample size of our study population, a prospective design, a wide range of covariates and standardized assessment of echocardiographic and ultrasound measures. For statistical analysis, we used marginal methods modeling with different dependent and independent variables, which avoids the need of multitesting correction such as Bonferroni. However, several limitations remain. Our study may lack generalizability as our cohort was limited to American Indians. Dietary intake was determined using FFQs at baseline. Hence, some participants may not have adequately recalled dietary information on specific foods or portion sizes (recall bias). This bias may have reduced our observed associations potentially causing an underestimation of true associations [2]. On the other hand, as the SHFS included supplementary questions on dietary intake of foods common in American Indians such as SPAM, we may have been able to better estimate dietary intake in this population. We also adjusted for energy intake in our statistical modeling, which partly corrects for potential overreporting or under-reporting [46]. Finally, due to the observational character of our study, we cannot exclude the influence of residual confounding.

In conclusion, over a 4-year period, red meat consumption was related to cardiovascular target organ damage in hypertensive American Indians. These findings emphasize the importance of dietary measures for CVD prevention.

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Abbreviations

BP blood pressure

CVD	cardiovascular disease
FFQ	food-frequency questionnaire
LVM	left ventricular mass
SHFS	Strong Heart Family Study
SHS	Strong Heart Study

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TABLE 1

Characteristics of study participants at baseline (Strong Heart Study IV exam)

Variable	Nonhypertension, *n* = 555		Hypertension, *n* =535		
	Mean	SD	Mean	SD	*P* value*
Age (years)	50.93	9.02	57.58	11.64	<0.0001
Women (rate)	0.39	0.49	0.34	0.47	0.4160
SBP (mmHg)[a]	119	11	139	18	
DBP (mmHg)[a]	76	8	80	13	
Diabetes (FPG) (rate)	0.16	0.36	0.42	0.49	<0.0001
BMI (kg/m^2)	30.41	5.99	32.92	6.8	<0.0001
Average steps/day	5493	3687	4361	3369	0.0215
Total fat (% of energy)	39.04	7.05	38.53	7.5	0.3665
Saturated fat (% of energy)	12.07	2.40	11.86	2.62	0.7281
Carbohydrates (% of energy)	48.03	8.72	48.56	9.11	0.9710
Unprocessed red meat (g/1000 kcal)	60.13	57.77	53.34	65.43	0.8684
Processed red meat (g/1000 kcal)	33.57	34.59	29.79	29.29	0.9923
Total red meat (g/1000 kcal)	93.71	78.62	83.14	79.81	0.8925
Alcohol intake (drinks/week)	2.82	10.10	2.61	7.72	0.0768
Fruit (servings/day)	1.02	0.84	1.06	0.84	0.9169
Vegetables (servings/day)	2.80	2.25	2.55	1.87	0.2591
Total energy intake (kcal/day)	2323	1249	2096	1132	0.2881
LDL cholesterol (mg/dl)	106	31	103	32	0.2903

Variable	Nonhypertension, n = 555		Hypertension, n =535		P value*
	Mean	SD	Mean	SD	
Field center					
Arizona (rate)	0.09		0.11		
Oklahoma (rate)	0.50		0.58		
South/North Dakota (rate)	0.41		0.30		

* P value from testing the means differences among different hypertension status.

[a] From those without on hypertension medications.

TABLE 2

Echocardiographic and carotid ultrasound measures of study participants at the baseline and follow-up exams

	Baseline exam (phase IV)					Follow-up exam (phase V)					
	Nonhypertension		Hypertension			Nonhypertension			Hypertension		
Variable	**Mean**	**SD**	**Mean**	**SD**	***P****	**Mean**	**SD**	***P****	**Mean**	**SD**	***P****
Echocardiography											
Left atrial diameter (cm)	3.60	0.44	3.8	0.43	<0.0001	3.69	0.45	<0.0001	3.9	0.48	<0.0001
LVM (g)	155.46	38.35	172.06	38.39	<0.0001	155.46	39.04	0.6211	174.35	42.3	0.0012
LVM index (g/m^2)	80.13	17.35	87.77	17.97	<0.0001	80.00	15.97	0.6038	88.94	19.37	0.0001
Carotid ultrasound											
IMT (mm)	0.71	0.14	0.80	0.17	<0.0001	0.70	0.15	0.2609	0.79	0.20	0.1546
Atherosclerotic plaque (%)	0.86	1.20	1.75	1.79	<0.0001	1.41	1.51	<0.0001	2.28	1.92	<0.0001
Plaque score	0.44	0.50	0.69	0.46	<0.0001	0.62	0.49	<0.0001	0.79	0.4	<0.0001

IMT, intima–media thickness; LV, left ventricular mass.

*P value from testing difference of means between nonhypertension and hypertension groups after adjusting for age, sex and center.

**P value from testing measure difference between follow-up and baseline exams.

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TABLE 3

Regression of phase V cardiac and carotid ultrasound measures on phase IV meat intakes in nonhypertensive participants stratified by sex

		Female participants			Male participants		
Variable	**Meat intake**	**Estimated Coeff.[a]**	**SE**	***P***	**Estimated Coeff.[a]**	**SE**	***P***
Left atrial diameter (cm)	Unprocessed	−0.0003	0.0004	0.3875	−0.0003	0.0003	0.3436
	Processed	−0.0006	0.0009	0.4923	−0.0002	0.0006	0.6648
	Total	−0.0004	0.0003	0.2626	−0.0003	0.0003	0.3041
LVM (g)	Unprocessed	0.0317	0.0249	0.2037	−0.0296	0.0301	0.3266
	Processed	−0.0180	0.0575	0.7544	0.0016	0.0496	0.9736
	Total	0.0229	0.0221	0.3000	−0.0214	0.0260	0.4120
LVM index (g/m^2)	Unprocessed	−0.0010	0.0137	0.9410	−0.0196	0.0150	0.1913
	Processed	−0.0107	0.0317	0.7362	0.0241	0.0248	0.3320
	Total	−0.0027	0.0121	0.8222	−0.0083	0.0131	0.5265
IMT (mm)	Unprocessed	−0.0001	0.0002	0.4490	−0.0003	0.0002	0.1882
	Processed	0.0007	0.0004	0.0659	−0.0002	0.0003	0.5565
	Total	0.0000	0.0001	0.9048	−0.0003	0.0002	0.1568
Atherosclerotic plaque (%)	Unprocessed	−0.0011	0.0015	0.4661	−0.0014	0.0018	0.4263
	Processed	−0.0009	0.0034	0.7811	−0.0026	0.0030	0.3933
	Total	−0.0010	0.0013	0.4224	−0.0017	0.0015	0.2732
Plaque score	Unprocessed	−0.0053	0.0041	0.2022	−0.0057	0.0042	0.1810
	Processed	−0.0091	0.0102	0.3722	−0.0074	0.0081	0.3595
	Total	−0.0059	0.0036	0.1038	−0.0061	0.0037	0.1035

Coeff., coefficient; IMT, intima–media thickness; LVM, left ventricular mass; SE, standard error.

[a] Adjusted for the respective baseline echocardiographic/carotid ultrasound measure, age, field center, smoking status, BMI, diabetes, average steps/day, alcohol intake (drinks/week), relatedness among family members and total energy intake.

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TABLE 4

Regression of phase V cardiac and carotid ultrasound measures on phase IV meat intakes in hypertensive participants stratified by sex

		Female participants			Male participants		
Variable	**Meat intake**	**Estimated Coeff.[a]**	**SE**	***P***	**Estimated Coeff.[a]**	**SE**	***P***
Left atrial diameter (cm)	Unprocessed	−0.0004	0.0003	0.1649	0.0000	0.0004	0.9353
	Processed	−0.0001	0.0009	0.9373	0.0023	0.0010	0.0222
	Total	−0.0004	0.0003	0.1810	0.0004	0.0004	0.3404
LVM (g)	Unprocessed	−0.0216	0.0221	0.3303	0.0218	0.0320	0.4970
	Processed	0.0038	0.0662	0.9541	0.0484	0.0736	0.5123
	Total	−0.0199	0.0216	0.3582	0.0258	0.0296	0.3846
LVM index (g/m^2)	Unprocessed	−0.0174	0.0132	0.1885	−0.0005	0.0159	0.9771
	Processed	0.0092	0.0393	0.8146	0.0249	0.0362	0.4941
	Total	−0.0157	0.0129	0.2243	0.0036	0.0147	0.8085
IMT (mm)	Unprocessed	0.0001	0.0002	0.4636	0.0004	0.0002	0.0425
	Processed	0.0000	0.0005	0.9714	0.0011	0.0005	0.0185
	Total	0.0001	0.0002	0.4980	0.0005	0.0002	0.0067
Atherosclerotic plaque (%)	Unprocessed	0.0029	0.0013	0.0277	0.0035	0.0020	0.0850
	Processed	0.0090	0.0038	0.0178	0.0067	0.0045	0.1335
	Total	0.0034	0.0013	0.0084	0.0040	0.0019	0.0338
Plaque score	Unprocessed	0.0087	0.0051	0.0884	0.0051	0.0058	0.3835
	Processed	0.0158	0.0090	0.0803	0.0066	0.0093	0.4795
	Total	0.0105	0.0046	0.0248	0.0054	0.0054	0.3127

Coeff., coefficient; IMT, intima–media thickness; LVM, left ventricular mass; SE, standard error.

[a] Adjusted for the respective baseline echocardiographic/carotid ultrasound measure, age, field center, smoking status, BMI, diabetes, average steps/day, alcohol intake (drinks/week), relatedness among family members and total energy intake.