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Association Between a Social-Business Eating Pattern and Early Asymptomatic Atherosclerosis

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ABSTRACT

BACKGROUND The importance of a healthy diet in relation to cardiovascular health promotion is widely recognized. Identifying specific dietary patterns related to early atherosclerosis would contribute greatly to inform effective primary prevention strategies.

OBJECTIVES This study sought to quantify the association between specific dietary patterns and presence and extent of subclinical atherosclerosis in a population of asymptomatic middle-aged adults.

METHODS The PESA (Progression of Early Subclinical Atherosclerosis) study enrolled 4,082 asymptomatic participants 40 to 54 years of age (mean age 45.8 years; 63% male) to evaluate the presence of subclinical atherosclerosis in multiple vascular territories. A fundamental objective of this cohort study was to evaluate the life-style-related determinants, including diet, on atherosclerosis onset and development. We conducted a cross-sectional analysis of baseline data, including detailed information on dietary habits obtained as part of the overall life-style and risk factor assessment, as well as a complete vascular imaging study that was performed blinded to the clinical information.

RESULTS Most PESA participants follow a Mediterranean (40% of participants) or a Western (41%) dietary pattern. A new pattern, identified among 19% of participants, was labeled as a social-business eating pattern, characterized by a high consumption of red meat, pre-made foods, snacks, alcohol, and sugar-sweetened beverages and frequent eating-out behavior. Participants following this pattern presented a significantly worse cardiovascular risk profile and, after adjustment for risk factors, increased odds of presenting subclinical atherosclerosis (odds ratio: 1.31; 95% confidence interval: 1.06 to 1.63) compared with participants following a Mediterranean diet.

CONCLUSIONS A new social-business eating pattern, characterized by high consumption of red and processed meat, alcohol, and sugar-sweetened beverages, and by frequent snacking and eating out as part of an overall unhealthy life-style, is associated with an increased prevalence, burden, and multisite presence of subclinical atherosclerosis. (Progression of Early Subclinical Atherosclerosis [PESA]; NCT01410318) (J Am Coll Cardiol 2016;68:805–14)

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ABBREVIATIONS AND ACRONYMS

BMI = body mass index

CAC = coronary artery calcification

cIMT = carotid intima-media thickness

CT = computed tomography

CVD = cardiovascular disease

DH-E = Dietary History-Enrica

Cardiovascular disease (CVD) is responsible for about 32% and 47% of all deaths in the United States (1) and Europe (2), respectively. Smoking, physical inactivity, and unhealthy dietary habits (3) are the main targets for effective population-based primary prevention strategies to decrease CVD's high prevalence (1). Evidence suggests that studying the overall quality of diet, rather than focusing on single nutrients and foods, enables identification of dietary patterns associated with CVD risk (2-5).

SEE PAGE 815

Several studies have investigated the association between dietary patterns and presence of atherosclerosis. However, most studies have evaluated the presence of atherosclerosis by measuring carotid intima-media thickness (cIMT) and/or coronary artery calcification (CAC) (4-6), with no study directly evaluating the presence of plaques, a hallmark of atherosclerosis. There is accumulating evidence that cIMT is a vascular process different from atherosclerosis, which calls into question its validity for individual cardiovascular risk stratification (7-9). Conversely, although CAC is clearly linked to atherosclerosis progression, it appears at later stages of the disease. Moreover, given atherosclerosis' systemic nature, rather than focusing on a single vascular bed, a more extensive analysis including multiple sites and a direct assessment of plaques may potentially provide a more accurate estimation of the presence, extent, and factors related to subclinical atherosclerosis.

The PESA (Progression of Early Subclinical Atherosclerosis) study, which aims to understand the determinants of the onset and progression of subclinical atherosclerosis diagnosed by noninvasive vascular imaging in multiple vascular sites (10), offers a unique opportunity to further define the association between dietary patterns and early atherosclerosis in a sample of middle-aged adults who may be optimal targets for primary prevention.

METHODS

STUDY POPULATION. PESA is an ongoing observational prospective cohort study. Details of the study design and methodology have been previously described (11). The PESA cohort consists of 4,082 employees of the Santander Bank in Madrid. Male and female subjects 40 to 54 years of age, free of known CVD, were examined at baseline by vascular ultrasound and noncontrast computed tomography (CT) and will be followed at 3 and 6 years. Additionally, each visit includes clinical interviews, physical examination, a fasting blood draw, urine sample, and a 12-lead electrocardiogram. Of the 4,082 participants recruited at baseline, 26 subjects with missing data on diet, psychosocial factors, physical activity, ultrasound, or CT, and 4 participants reporting extreme values of total energy intake (<800 or >4,200 kcal and <500 or >3,500 kcal for men and women, respectively) (12) were excluded. Therefore, the final sample available for cross-sectional analysis was 4,052 participants. The study was approved by the ethics committee of the Instituto de Salud Carlos III, and all study participants provided written informed consent (11).

ASSESSMENT OF DEMOGRAPHIC, LIFE-STYLE, AND CVD RISK FACTORS. During the baseline visit, per PESA protocol (11), traditional risk factors such as family history of CVD, smoking habits, hypertension, dyslipidemia, and diabetes, as well as the use of any medication, were documented as part of the participant's medical history. At physical examination, blood pressure at rest was measured using OMRON HEM-907 automatic oscillometric sphygmomanometer (OMRON Healthcare, Kyoto, Japan). The anthropometric measurements were performed by standardized procedures, and obesity was defined as body mass index (BMI) ≥30 kg/m². Physical activity was assessed through triaxial accelerometers (Acti Trainer, Actigraph, Pensacola, Florida) that were placed on each participant's waist for 1 week. Venous blood was collected after 8 h of fasting, and samples were tested for high-density lipoprotein cholesterol, total cholesterol, low-density lipoprotein cholesterol, triglycerides, glucose, whole blood hemoglobin A_{1C}, and markers of inflammation. Additionally, blood aliquots were processed and stored at −80°C for further analysis. Participants also completed questionnaires to assess dietary habits and sleep patterns. Depression and perceived stress at home and at work were

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evaluated using CES-D (Center for Epidemiological Studies Depression) and PSS (Perceived Stress Scale) questionnaires. All interviews were conducted blinded to clinical, laboratory, and imaging results by trained technicians.

DIETARY ASSESSMENT. Habitual food intake was assessed by trained dieticians using the computerized Dietary History-Enrica (DH-E) questionnaire developed and validated for the Spanish population within the ENRICA (Estudio de Nutrición y Riesgo Cardiovascular) study (13). Briefly, during an approximately 1-h interview, participants were asked to report all of the foods usually consumed in the previous year, taking into consideration 6 eating occasions (on waking up, breakfast, mid-morning, lunch, mid-afternoon, and dinner). A food was considered to be "usually consumed" when it was eaten at least once every 15 days, and participants were guided to report foods that represented a typical week. Conversion factors were then used to transform the weekly frequency to year frequency depending on the number of months in which the food was consumed (13). The DH-E questionnaire can collect standardized information on 861 foods (including 127 sets of digitized photographs to help participants estimate portion size). Additionally, the DH-E includes 184 recipes for traditional or commonly consumed dishes in Spain. Finally, for quality control during the interview, the DH-E generates warnings when registering unrealistic energy intake or when foods that are usually part of the main eating occasions are not reported (13).

DEFINITION OF DIET CLUSTERS. Foods reported during the dietary assessment were classified into 21 food groups on the basis of nutrient content and submitted to factor analysis to identify common underlying dimensions (factors or patterns) of food consumption by deriving factor loadings for each predefined food group. Factors were subsequently rotated using a Varimax procedure to maintain uncorrelated factors. Analysis of eigenvalues, scree plot, and the interpretability of the factor solution were used to support a final decision on retaining a 3-factor solution, where each factor had an eigenvalue >0.3. A factor score for each participant was calculated by summing the daily intake of each food group weighted by their factor loadings. Derived factor scores were then analyzed for clustering on the basis of Euclidean distances between observations by using the K-mean method, allowing study participants to be grouped into nonoverlapping, mutually exclusive clusters reflecting their dietary patterns. We explored solutions with 2 to 4 clusters to evaluate which set of clusters was more meaningful to define dietary patterns. The 3-cluster solution was determined most appropriate on the basis of power requirements and sufficient representation of interpretable dietary patterns. As per protocol, diet and life-style evaluation was performed independently and blinded to risk factor assessment and subclinical atherosclerosis findings.

TABLE 1 Energy-Adjusted* Daily Intake of Selected Foods

	Total (N = 4,052)	Cluster 1 (Mediterranean) (n = 1,615)	Cluster 2 (Western) (n = 1,668)	Cluster 3 (Social-Business) (n = 769)
Energy, kcal	2,314 ± 468	2,087 ± 399†‡	2,421 ± 421§‡	2,562 ± 492†§
Vegetable products, g				
Vegetables	204 ± 102	253 ± 110†‡	168.0 ± 75.8§‡	179 ± 91.1†§
Refined grains	194.0 ± 66.8	179.0 ± 67.1†	214.0 ± 63.0§‡	184.0 ± 63.7†
Fruits	177 ± 138	217 ± 157†‡	162 ± 120§‡	128 ± 107†§
Legumes	37.7 ± 46.9	43.2 ± 60.8†‡	36.1 ± 34.8§‡	29.7 ± 32.2†§
Potatoes	32.4 ± 19.3	27.8 ± 18.4†‡	36.1 ± 18.6§	34.3 ± 20.6§
Whole grains	9.40 ± 22.10	16.9 ± 28.9†‡	4.10 ± 13.70§	5.50 ± 14.50§
Nuts	6.60 ± 9.50	6.80 ± 9.70†	5.80 ± 8.20§‡	7.80 ± 11.20†
Pickled olives	3.90 ± 5.90	3.69 ± 5.12†‡	2.78 ± 3.72§‡	7.00 ± 9.44†§
Animal products, g				
Whole-fat dairy	171 ± 120	134 ± 105†	227 ± 125§‡	126.0 ± 84.2†
Low-fat dairy	83.3 ± 119.0	137 ± 144†‡	36.2 ± 68.4§‡	72.3 ± 102.0†§
Lean meat	62.1 ± 30.9	74.4 ± 37.5†‡	55.0 ± 23.0§	53.6 ± 23.6§
Fish	61.1 ± 34.0	72.3 ± 36.3†‡	52.0 ± 28.9§‡	57.2 ± 32.6†§
Red meat	52.1 ± 27.6	46.8 ± 26.5†‡	53.7 ± 26.5§‡	59.7 ± 29.8†§
Processed meat	35.9 ± 23.0	33.5 ± 22.5‡	35.4 ± 22.1‡	42.2 ± 24.5†§
Eggs	19.2 ± 12.3	21.5 ± 14.4†‡	17.5 ± 10.0§	18.3 ± 11.3§
Shellfish	8.70 ± 8.40	7.90 ± 7.60‡	7.30 ± 7.00‡	13.3 ± 10.6†§
Oils and fats, g				
Olive oil	26.9 ± 11.0	31.7 ± 11.5†‡	23.40 ± 9.40§	24.20 ± 9.60§
Other vegetables oils	4.60 ± 4.90	4.52 ± 5.03	4.65 ± 4.89	4.69 ± 4.46
Animal fat	2.20 ± 3.80	2.20 ± 4.10	2.30 ± 3.80‡	1.90 ± 3.40†
Processed foods, g				
Commercial bakery	59.1 ± 37.4	49.5 ± 33.8†‡	71.0 ± 38.7§‡	53.3 ± 34.4†§
Pre-cooked meals	40.3 ± 29.6	34.1 ± 27.3†‡	44.1 ± 29.0§	45.1 ± 32.8§
Fast food	7.00 ± 10.40	6.01 ± 9.31†‡	7.79 ± 11.20§	7.24 ± 10.70§
Chips	5.30 ± 7.10	4.64 ± 5.95†‡	3.68 ± 4.74§‡	10.2 ± 10.6†§
Beverages, servings‖				
Beer	0.27 ± 0.42	0.19 ± 0.30‡	0.20 ± 0.31‡	0.61 ± 0.63†§
Wine	0.05 ± 0.19	0.05 ± 0.16†‡	0.03 ± 0.12§‡	0.10 ± 0.31†§
Distilled spirits	0.08 ± 0.17	0.05 ± 0.13‡	0.06 ± 0.14‡	0.17 ± 0.26†§
SSB	0.41 ± 0.57	0.39 ± 0.58‡	0.39 ± 0.52‡	0.49 ± 0.66†§

Values are mean ± SD. *Energy adjusted = g/2,000 kcal. †p < 0.5 versus cluster 2. ‡p < 0.5 versus cluster 3. §p < 0.5 versus cluster 1. ‖Servings/2,000 kcal: beer = 12 oz, ~350 ml; wine = 5 oz, ~150 ml; distilled spirits = 1.5 oz, ~45 ml; sugar-sweetened beverages (SSB) = 12 oz, ~330 ml.

ASSESSMENT OF SUBCLINICAL ATHEROSCLEROSIS. Presence and significance of atherosclerotic plaques in carotids, infrarenal aorta, and both iliofemoral territories were assessed using vascular ultrasound (Philips iU22 ultrasound, Philips Healthcare, Bothell, Washington) as previously described (11). Plaque was

JACC VOL. 68, NO. 8, 2016
AUGUST 23, 2016:805-14

TABLE 2 Demographic and Life-Style-Related Characteristics

	Total (N = 4,052)	Cluster 1 (Mediterranean) (n = 1,615)	Cluster 2 (Western) (n = 1,668)	Cluster 3 (Social-Business) (n = 769)
Demographics				
Male	2,564 (63.3)	713 (44.1)*†	1,224 (73.4)‡	627 (81.5)*‡
Age, yrs	45.80 ± 4.27	45.60 ± 4.19†	45.70 ± 4.28†	46.50 ± 4.36*‡
Marital status				
Married	3,081 (76.0)	1,204 (74.6)	1,293 (77.5)	584 (75.9)
Divorced	207 (5.1)	89 (5.5)	70 (4.2)	48 (6.2)
Separated	74 (1.8)	27 (1.7)	31 (1.9)	16 (2.1)
Single	306 (7.6)	138 (8.5)	113 (6.8)	55 (7.2)
Education level				
High school degree	1,013 (25.2)	326 (20.4)*†	441 (26.6)†‡	246 (32.2)*‡
Graduate degree	604 (15.0)	242 (15.1)	250 (15.1)	112 (14.7)
Post-graduate degree	2,405 (59.8)	1,033 (64.5)*†	966 (58.3)‡	406 (53.1)‡
Income level				
Low	1,430 (35.5)	624 (38.6)†	596 (35.7)†	210 (27.3)*‡
Medium	1,191 (29.4)	437 (27.1)†	500 (30.0)	254 (33.0)‡
High	1,431 (35.3)	554 (34.3)†	572 (34.3)†	305 (39.7)*‡
Job category				
Technicians/ operators/security	1,362 (34.2)	579 (36.5)	543 (33.0)	240 (31.7)
Administrative staff	154 (3.9)	69 (4.3)	63 (3.8)	22 (2.9)
Managers	1,113 (27.9)	431 (27.1)	487 (29.6)	195 (25.8)
Executives	1,359 (34.1)	509 (32.1)†	550 (33.5)†	300 (39.6)*‡
Years working for the company	18.50 ± 9.08	17.90 ± 8.60†	18.60 ± 9.30	19.30 ± 9.60‡
Physical activity, min/day				
Moderate	43.5 ± 16.6	42.5 ± 16.7†	43.6 ± 16.3†	45.3 ± 17.1*‡
Vigorous	3.80 ± 7.10	3.80 ± 7.00	3.70 ± 7.00	3.90 ± 7.20
MVPA	47.3 ± 19.6	46.3 ± 19.8†	47.3 ± 19.1	49.3 ± 20.1‡
Resting (sleeping) patterns, h				
<7	2,121 (52.3)	809 (50.1)†	885 (53.1)	427 (55.5)‡
7-8	1,630 (40.2)	678 (42.0)	662 (39.7)	290 (37.7)
>8	301 (7.40)	128 (7.90)	121 (7.30)	52 (6.80)
Insomnia	40 (1.00)	17 (1.10)	13 (0.80)	10 (1.30)
Obstructive apnea	78 (1.90)	21 (1.30)†	32 (1.90)	25 (3.30)‡
Smoking status				
Nonsmokers	1,574 (38.8)	660 (40.9)†	707 (42.4)†	207 (26.9)*‡
Active smokers	833 (20.6)	284 (17.6)*†	356 (21.3)‡	193 (25.1)‡
Social smokers	340 (8.39)	138 (8.54)	124 (7.43)	78 (10.1)
Former smokers	1,305 (32.2)	533 (33.0)*	481 (28.8)†‡	291 (37.8)*
Cigarettes/day§	8.23 ± 11.40	7.27 ± 10.30†	7.67 ± 11.10†	11.5 ± 13.3*‡
Frequency of eating out, lunch‖				
Rare	581 (14.3)	232 (14.4)	264 (15.8)†	85 (11.1)*
Sometimes	332 (8.2)	130 (8.0)	142 (8.5)	60 (7.8)
Often	3139 (77.5)	1253 (77.6)	1262 (75.7)†	624 (81.1)*

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defined as any focal protrusion into the arterial lumen >0.5 mm of thickness or >50% of the surrounding intima-media thickness, or a diffuse thickness >1.5 mm measured between the media-adventitia and intima-lumen interfaces (14). CAC score was obtained by noncontrast electrocardiogram-gated prospective acquisition with a 16-slice CT scanner and quantified using Agatston scoring (15). Subclinical atherosclerosis was defined as any plaque in at least 1 explored territory (right/left carotid, aorta, right/left iliofemoral) and/or a CAC score ≥1. Extension of atherosclerosis was classified as focal (1 site affected), intermediate (2 to 3 sites), or generalized (4 to 6 sites) disease (10). All imaging acquisitions were performed at the PESA examination center (11), and imaging analysis was centralized in the Central Imaging Core laboratory at the Centro Nacional de Investigaciones Cardiovasculares (CNIC) Carlos III.

STATISTICAL ANALYSIS. All statistical analyses were performed with STATA version 12 (StataCorp LLP, College Station, Texas). Baseline characteristics of the study population are presented as counts and percentages for categorical variables and as mean ± SD for continuous variables. Analysis of variance with multiple-testing correction (Bonferroni) for continuous variables or chi-square test (for categorical variables) was used to compare participants' characteristics across dietary clusters. A forward-stepwise regression was used to identify life-style-related determinants of adherence to a dietary pattern among the factors identified by the American Heart Association as main targets for CVD prevention. The strength of these relationships was assessed using categorical covariates and odds ratios (ORs). Adjusted logistic regression models were used to assess the relationship among dietary patterns, the presence of plaque in the carotid or iliofemoral territories, and CAC score. Age (years), sex (male or female), energy intake (kcal), education (high school, college, or university degree), income, physical activity (compliance with World Health Organization recommendations), CVD risk factors (dyslipidemia, current smoking, hypertension, and diabetes), other life-style factors (sleep duration, use of discretionary salt, and frequency of eating out [lunch or dinner]), and frequency of traveling for business were considered as potential confounding factors and, therefore, were used to adjust models. Additionally, to assess the potential differential effect by sex, a stratified analysis was performed using Poisson regression (using the same progressive adjustment of the models), reporting the results as prevalence ratios to provide a more conservative estimate of the association.

RESULTS

DIETARY PATTERNS, FOODS, AND NUTRIENTS. Factor and cluster analyses identified 3 mutually exclusive dietary patterns among the PESA participants. The main food items characterizing each of these clusters are shown in **Table 1** and Online Table 1.

Participants in cluster 1 (n = 1,615; 40%) had the highest consumption of fruits and vegetables, as well as whole grains and olive oil. They also showed the highest intake of low-fat dairy products, lean meat, and fish, and the lowest consumption of processed food (Table 1). Coffee and tea consumption was also highest in this group. On a nutrient basis, this group was strongly correlated with dietary fiber, potassium, magnesium, carotenoids, and vitamins (except for retinoids), and was negatively correlated with saturated fat (Online Table 2).

Participants within cluster 2 (n = 1,668; 41%) were characterized by the highest consumption of refined cereal products, legumes, and dairy products as well as sweets and desserts (Table 1). Participants in this cluster also showed high intakes of red meat and pre-made foods. This dietary pattern was strongly correlated with total and saturated fat, carbohydrates (including sugars and polysaccharides), dietary fiber, iron, and sodium (Online Table 2).

Finally, cluster 3 (n = 769; 19%) grouped participants with the highest consumption of red meat and shellfish, pre-made foods, appetizers, and snacks (including pickled olives and salted nuts), and alcoholic and sugar-sweetened beverages (Table 1). This diet correlated positively with total and animal protein, fat (including saturated, monounsaturated, and polyunsaturated fatty acids), cholesterol, alcohol, iron, sodium, phosphorus, and vitamins B3 and B12 (Online Table 2).

CHARACTERISTICS ACCORDING TO DIETARY PATTERNS. Per the demographic characteristics and life-style-related variables for each dietary pattern (Table 2), sex was almost equally distributed within cluster 1, whereas participants in clusters 2 and 3 were predominantly men. A small but significant difference in age was observed for participants in cluster 3 (approximately 1 year older than clusters 1 or 2). No difference in relation to marital status was observed between clusters. Regarding education, mostly post-graduate participants formed all 3 clusters, reflecting the overall sample, but cluster 3 included the highest percentage of individuals with a high school degree. Participants in cluster 3 also had the highest level of income, on average worked 1.5 years longer in the company, and were more likely to hold director and executive positions within the company.

Cluster 3 showed marked differences in life-style factors compared with the other clusters. For example, 76% of cluster 3 participants were current, social, or former smokers, and they dedicated more time to moderate or moderate-to-vigorous physical activity. This group (cluster 3) also had the highest proportion of participants reporting short sleep (<7 h) and obstructive sleep apnea, more frequent business trips, and the highest frequency of eating out. Cluster 3 also included the highest percentage of individuals using discretionary salt (Table 2).

TABLE 2 Continued

	Total (N = 4,052)	Cluster 1 (Mediterranean) (n = 1,615)	Cluster 2 (Western) (n = 1,668)	Cluster 3 (Social-Business) (n = 769)
Frequency of eating out, dinner‖				
Rare	2,731 (67.4)	1,071 (66.3)*	1,186 (71.1)†‡	474 (61.6)*
Sometimes	1,221 (30.1)	508 (31.5)*	457 (27.4)†‡	256 (33.3)*
Often	100 (2.5)	36 (2.2)†	25 (1.5)†	39 (5.1)*‡
Work travel¶				
Never	3,106 (76.7)	1,261 (78.1)†	1,316 (78.9)†	529 (68.8)*‡
Sometimes	501 (12.4)	194 (12.0)	194 (11.6)	113 (14.7)
Often	445 (11.0)	160 (9.9)†	158 (9.5)†	127 (16.5)*‡
Frequency use of discretionary salt				
Always on salads	722 (17.8)	264 (16.3)†	277 (16.6)†	181 (23.5)*‡
Always on vegetables	493 (12.2)	185 (11.5)†	182 (10.9)†	126 (16.4)*‡
Always on other dishes	495 (12.2)	168 (10.4)†	199 (11.9)†	128 (16.6)*‡

Values are n (%) or mean ± SD (Bonferroni correction was applied for categorical variables [$p < 0.017$]). *$p < 0.5$ versus cluster 2. †$p < 0.5$ versus cluster 3. ‡$p < 0.5$ versus cluster 1. §For both active and former smokers. ‖Rare: <3 times/month; sometimes: 1 to 2 times/week; often: >3 times/week. ¶Sometimes: 1 time/year to 2 times/trimester; often: >1 time/month.

MVPA = moderate-to-vigorous physical activity.

The relationships between the identified clusters and the American Heart Association targets for CVD prevention are summarized in Table 3. Although adherence to cluster 1 was associated with female sex, moderate consumption of alcohol, and nonsmoker status, adherence to cluster 2 was associated with male sex, normal weight, and moderate consumption of alcohol. Finally, adherence to cluster 3 was associated with alcohol consumption above the recommended intake as well as male sex, obesity, and smoker status.

DIETARY PATTERNS AND CARDIOVASCULAR RISK FACTORS. The relationship between adherence to the identified diet clusters and markers of CVD risk is presented in Table 4. Hypertension, dyslipidemia, and diabetes were most prevalent among participants in cluster 3. Accordingly, the values of systolic and diastolic blood pressure, as well as the plasma lipid profile and indicators of glycemia homeostasis, were worse among participants adhering to the cluster 3 pattern, and a trend in the same direction was observed for those in cluster 2. Also, obesity was more prevalent among cluster 3 participants. Furthermore, inflammation markers, such as C-reactive protein and P-selectin, were higher in clusters 2 and 3. These differences in individual markers of CVD risk were also reflected in a lower score on the classical algorithms for CVD risk classifications of cluster 1 participants (Framingham 10-year risk score: 4.71 ± 3.77%)

compared with those in cluster 3 (7.75 ± 5.13%). No significant differences in psychosocial factors were observed between clusters (**Table 4**).

DIETARY PATTERNS AND SUBCLINICAL ATHEROSCLEROSIS. Participants belonging to cluster 1 showed a lower prevalence and extent of subclinical atherosclerosis compared with the overall sample mean values (**Table 5**). Stratifying by sex, these differences persisted and were more pronounced among men (Online Table 3). In contrast, participants in cluster 3 presented a higher prevalence of plaques in any of the explored vascular territories using vascular ultrasound and higher values of CAC score. Almost one-half (48.7%) of participants in cluster 3 presented plaques in the femoral territory versus 35.5% in cluster 2 and 29.3% in cluster 1. Using logistic regression and after adjustment for potential confounders including CVD risk factors (dyslipidemia, current smoking, hypertension, diabetes, BMI, and life-style and dietary habits), participants adhering to a cluster 3 pattern had a significantly higher prevalence (OR: 1.31; 95% confidence interval [CI]: 1.06 to 1.63) of subclinical atherosclerosis and a borderline significant higher prevalence of plaques in the iliofemoral territory (OR: 1.22; 95% CI: 0.99 to 1.50) (**Table 6**). Nonsignificant associations were observed for the presence of carotid plaques (OR: 1.18; 95% CI: 0.96 to 1.45) and abdominal aorta (OR: 1.06; 95% CI: 0.85 to 1.33). These results also held true when using Poisson regression to estimate prevalence ratios using the same covariates for adjustment (Online Table 4). Finally, the extent of subclinical atherosclerosis was also associated with adherence to a particular diet (**Central Illustration**). Participants who were free of disease (43%) concentrated in cluster 1, whereas participants with generalized atherosclerosis (more than 3 territories affected) were more frequently included in cluster 3 (**Central Illustration**). A similar association was observed after stratification by sex (Online Figures 1 and 2).

DISCUSSION

We report a new dietary pattern that we have labeled the "social-business eating pattern," characterized by eating away from home more frequently, either as a job requirement or due to busier schedules. This eating pattern is followed by 19% of the PESA cohort participants, among whom a higher prevalence and extent of subclinical atherosclerosis was observed. This social-business eating pattern was characterized by a low consumption of vegetables and fruits and high increased consumption of red and processed meat, pre-made meals, snacks, and alcoholic and sugar-sweetened beverages. Although there have been reports identifying a dietary pattern with high intake of alcoholic beverages (16) labeled as a drinker pattern in other studies (17), to the best of our knowledge, this social-business eating pattern has not been singled out before. The sociability aspect of the newly described social-business dietary pattern, as well as the high degree of correlation with other life-style factors, made it different from other unhealthy patterns reported previously. This dietary pattern was characterized by more frequent eating outside of the home (restaurants, cafeterias, convenience food, and so on). Participants following this pattern were less likely to eat homemade meals and more likely to engage in unhealthy habits, such as smoking, excess salt consumption, and alcohol intake beyond moderation. Taking into consideration the

TABLE 3 Determinants of Dietary Patterns

	Categories	Cluster 1 (Mediterranean) OR (95% CI)	p Value	Cluster 2 (Western) OR (95% CI)	p Value	Cluster 3 (Social-Business) OR (95% CI)	p Value
Sex	Women (ref)	–	–	–	–	–	–
	Men	0.25 (0.21–0.28)	<0.001	2.53 (2.18–2.95)	<0.001	2.57 (2.06–3.21)	<0.001
Smoking status	Nonsmoker (ref)	–	–	–	–	–	–
	Current smoker	0.76 (0.66–0.89)	<0.001	–	–	1.35 (1.12–1.62)	0.001
BMI	Normal—weight (ref)	–	–	–	–	–	–
	Overweight	–	–	0.79 (0.68–0.92)	0.002	1.69 (1.36–2.10)	<0.001
	Obese			0.61 (0.49–0.75)	<0.001	2.77 (2.14–3.59)	<0.001
Alcohol intake	≤1 and ≤2 servings/day for women and men (ref)	–	–	–	–	–	–
	>1 and >2 servings/day for women and men	0.47 (0.37–0.61)	<0.001	0.27 (0.20–0.35)	<0.001	7.95 (6.28–10.06)	<0.001

Determinants made on the basis of a forward stepwise regression model. All variables are categorical.
BMI = body mass index; CI = confidence interval; OR = odds ratio; ref = reference.

sociocultural characteristics of eating in Spain, this pattern might reflect the consumption of small amounts of food accompanied by an alcoholic beverage, frequently wine or beer, and mainly consumed in a social-related environment, hence the name social-business eating pattern.

A closer look at the energy intake of participants adhering to this group revealed that this group consumed approximately 475 more kcal/day compared with cluster 1 and 140 more kcal/day compared with cluster 2. Although this caloric excess might partially explain the higher prevalence of obesity and overweight in this group, which may lead to worse levels of CVD risk markers (18), the data reported here pointed to an overall unhealthy life-style and, in particular, a low-quality diet as potentially the main reason responsible for the observed association. Indeed, participants in this social-business eating group presented increased values of CVD risk markers and increased presence and extent of subclinical atherosclerosis, including plaques in the carotid and the iliofemoral territories and calcification in the coronaries, independently of other risk factors. The association was significantly modified after adjusting for CVD risk factors, such as hypertension, dyslipidemia, diabetes, and smoking, indicating that these were the main potential mediators of the dietary effect. The fact that this association held after adjusting for the previously mentioned CVD risk factors, as well as BMI and several life-style determinants, points to this eating pattern—which was a combination of dietary intake and eating habits—as an important life-style to be avoided and as an appealing target for primary prevention strategies.

The social-business dietary pattern characterized in this sample serves as a proxy for an overall life-style, with the "business" component as an essential part of this group's behavior. To understand the possible underlying cause of this behavior, we analyzed other life-style characteristics, such as marital status, job situation, stress, and depression. This cluster of participants included the highest proportion of directors and higher-income staff. The prevalence of stress in this cluster was not different from that of the other clusters, nor was the prevalence of depression, which was overall low. Cluster 3 participants reported shorter sleeping times, which has been associated with increased BMI in some studies (19). However, these observations did not fully support the idea of this eating behavior being a reaction to psychosocial conditions; therefore, we can only hypothesize that the higher status within the company entailed obligations (e.g., lunch meetings, frequent travel) that affected and limited dietary

TABLE 4 CVD Risk Factors

	Total (N = 4,052)	Cluster 1 (Mediterranean) (n = 1,615)	Cluster 2 (Western) (n = 1,668)	Cluster 3 (Social-Business) (n = 768)
Family history of CVD	641 (15.8)	263 (16.3)	241 (14.4)	137 (17.8)
Obesity	594 (14.7)	181 (11.2)†	218 (13.1)†	195 (25.4)*‡
BMI, kg/m^2	26.20 ± 3.83	25.40 ± 3.63*†	26.10 ± 3.69†‡	27.8 ± 4.0*‡
Hypertension	480 (11.8)	139 (8.61)*†	200 (12.0)†‡	141 (18.3)*‡
Systolic BP, mm Hg	116.0 ± 12.5	114.0 ± 12.5*†	117.0 ± 12.1†‡	121.0 ± 12.3*‡
Diastolic BP, mm Hg	72.50 ± 9.44	70.9 ± 9.1*†	72.60 ± 9.35†‡	75.6 ± 9.53*‡
Dyslipidemia	1,681 (41.5)	561 (34.7)*†	741 (44.4)‡	379 (49.3)‡
Total cholesterol, mg/dl	201.0 ± 33.3	199.0 ± 32.0†	199.0 ± 33.0†	209.0 ± 35.2*‡
LDL-C mg/dl	132.0 ± 29.7	130.0 ± 29.0†	132.0 ± 29.3†	139.0 ± 31.1*‡
HDL-C mg/dl	49.0 ± 12.2	51.9 ± 12.4*†	47.0 ± 11.5‡	47.5 ± 11.9‡
TG, mg/dl	95.0 ± 57.2	83.7 ± 48.7*†	98.8 ± 58.4†‡	110.0 ± 65.9*‡
Inflammation				
C-reactive protein, mg/dl	0.18 ± 0.37	0.16 ± 0.30†	0.19 ± 0.50	0.20 ± 0.30‡
P-selectin, ng/ml	131.0 ± 40.1	126.0 ± 39.1*†	133.0 ± 40.3‡	137.0 ± 40.3‡
Urinary isoprostanes-to-creatinine ratio	1.17 ± 6.30	1.07 ± 0.70	1.27 ± 9.80	1.16 ± 0.70
Diabetes	79 (1.95)	24 (1.49)†	30 (1.80)	25 (3.25)‡
Fasting glucose, mg/dl	90.6 ± 13.7	89.0 ± 13.9*†	90.4 ± 12.0†‡	94.2 ± 16.0*‡
HbA_{1c}, %	5.44 ± 0.48	5.40 ± 0.44†	5.44 ± 0.47†	5.52 ± 0.51*‡
CVD risk scales				
FRS-10	5.94 ± 4.45	4.71 ± 3.77*†	6.30 ± 4.36†‡	7.75 ± 5.13*‡
FRS-30	18.0 ± 11.9	14.7 ± 10.5*†	18.8 ± 11.6†‡	23.1 ± 13.1*‡
EU-SCORE	0.57 ± 0.61	0.42 ± 0.51*†	0.59 ± 0.56†‡	0.82 ± 0.77*‡
REGICOR	2.07 ± 1.52	1.69 ± 1.28*†	2.17 ± 1.50†‡	2.65 ± 1.79*‡
Psychosocial characteristics				
CES-D score§	6.07 ± 6.23	6.12 ± 6.15	5.99 ± 6.21	6.14 ± 6.45
Being depressed (CES-D score ≥16)	298 (7.4)	124 (7.7)	114 (6.8)	60 (7.8)
PSS‖	21.90 ± 5.79	22.1 ± 5.8	21.7 ± 5.8	21.7 ± 5.9
Being stressed (PSS ≥25)	1,199 (29.6)	495 (30.7)	474 (28.4)	230 (29.9)

Values are n (%) or mean ± SD (Bonferroni correction was applied for categorical variables [p < 0.017]). *p < 0.5 versus cluster 2. †p < 0.5 versus cluster 3. ‡p < 0.5 versus cluster 1. §Score range: 10 to 60; the higher the score, the greater the depression. ‖Score range: 10 to 50; the higher the score, the greater the stress.

BP = blood pressure; CES-D = Center for Epidemiological Studies Depression; EU-SCORE = European Systematic Coronary Risk Evaluation; FRS = Framingham risk score; HbA_{1c} = glycosylated hemoglobin; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; PSS = perceived stress scale; REGICOR = Registre Gironi del Cor; TG = triglycerides; other abbreviations as in Table 3.

TABLE 5 Cardiovascular Imaging

	Total (N = 4,052)	Cluster 1 (Mediterranean) (n = 1,615)	Cluster 2 (Western) (n = 1,668)	Cluster 3 (Social-Business) (n = 769)
Coronary calcium (Agatston score)	14.8 ± 84.5	12.8 ± 82.8†	11.7 ± 69.9†	25.4 ± 111.0*‡
CAC score ≥1	734 (18.1)	225 (13.9)*†	294 (17.6)†‡	215 (28)*‡
CAC score >100	142 (3.5)	47 (2.90)†	49 (2.90)†	46 (6.00)*‡
CAC score >400	29 (0.71)	13 (0.80)	7 (0.42)	9 (1.17)
Presence of any plaque	2,407 (60.3)	880 (55.1)*†	1,011 (61.4)†‡	516 (69.0)*‡
Aorta	992 (24.6)	384 (23.8)†	388 (23.4)†	220 (28.9)*‡
Carotid arteries	1,276 (31.5)	448 (27.7)*†	538 (32.3)†‡	290 (37.8)*‡
Femoral artery	1,437 (35.5)	471 (29.3)*†	592 (35.5)†‡	374 (48.7)*‡
Iliac arteries	840 (21.0)	316 (19.7)†	334 (20.2)†	190 (25.3)*‡
Any plaque and CAC score ≥1	2,496 (62.5)	906 (56.7)*†	1,047 (63.6)†‡	543 (72.6)*‡

Values are mean ± SD or n (%) (Bonferroni correction was applied for categorical variables [p < 0.017]). *p < 0.5 versus cluster 2. †p < 0.5 versus cluster 3. ‡p < 0.5 versus cluster 1.

CAC = coronary artery calcification.

TABLE 6 Prevalent Subclinical Atherosclerosis*

	Cluster 1 (Mediterranean)	Cluster 2 (Western) Adjusted OR (95% CI)	Cluster 3 (Social-Business) Adjusted OR (95% CI)
Plaque in Carotids			
Model 1	Ref	1.10 (0.94–1.30)	1.28 (1.04–1.56)†
Model 2	Ref	1.07 (0.91–1.26)	1.19 (0.97–1.46)
Model 3	Ref	1.06 (0.90–1.26)	1.20 (0.98–1.47)
Model 4	Ref	1.07 (0.90–1.26)	1.18 (0.96–1.45)
Plaque in Iliofemoral Territories			
Model 1	Ref	1.00 (0.96–1.17)	1.36 (1.11-1.65)‡
Model 2	Ref	0.95 (0.81-1.12)	1.22 (1.00-1.50)
Model 3	Ref	0.94 (0.80-1.11)	1.23 (1.00-1.51)†
Model 4	Ref	0.95 (0.80-1.11)	1.22 (0.99-1.50)
Any Plaque or CAC >1			
Model 1	Ref	1.10 (0.94-1.29)	1.46 (1.18-1.80)‡
Model 2	Ref	1.05 (0.89-1.24)	1.33 (1.07-1.65)‡
Model 3	Ref	1.05 (0.89-1.23)	1.33 (1.07-1.65)‡
Model 4	Ref	1.05 (0.89-1.23)	1.31 (1.06-1.63)†

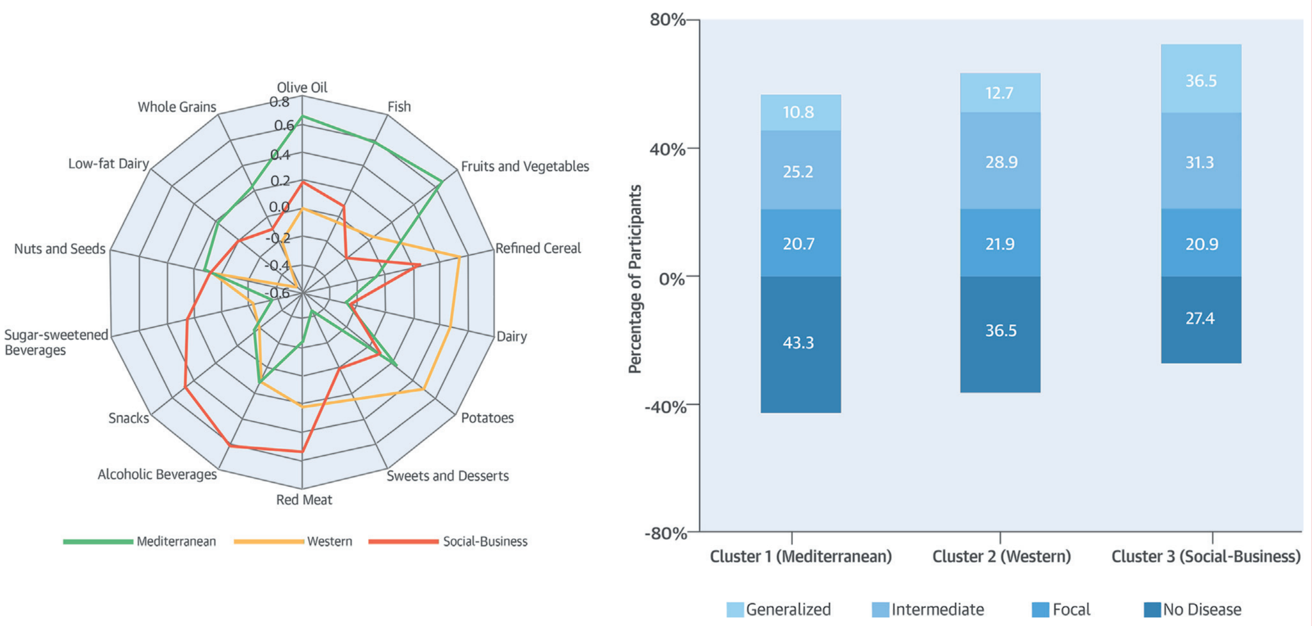
*Models were adjusted as follows: Model 1: sex, age, energy intake, education, income, and physical activity (compliance with recommendations). Model 2: Model 1 plus prevalent dyslipidemia, hypertension, diabetes, and current smoking. Model 3: Model 2 plus BMI. Model 4: Model 3 plus sleep duration, use of discretionary salt, frequency of eating out (lunch and dinner), and frequency of traveling. †$p < 0.05$ versus cluster 1. ‡$p < 0.01$ versus cluster 1.

Abbreviations as in Tables 3 and 5.

choices. Restaurants do not always provide healthy meals and, in fact, eating out was reported to be associated with on average excess intake of 200 kcal/day (20). Participants clustering around this eating pattern exercised slightly more but also were more likely to smoke and had a higher consumption of alcoholic beverages than participants in other clusters, possibly as a consequence of networking events.

The majority (81%) of PESA participants were classified into either cluster 1 or 2. These 2 dietary patterns have been observed in previous studies in Spain (16,21-23), including the Spanish AWHS (Aragon's Workers Health Study) cohort (24), and have been respectively labeled as a "Mediterranean diet" (characterized by a higher intake of vegetables, fruits, legumes, whole grains, fish, and olive oil) and a "Western diet" (characterized by a higher intake of processed meat, red meat, butter, high-fat dairy products, eggs, and refined grains). As suggested in previous reports in Spain (16,21,22), the Western pattern (cluster 2), which was present in 41% of the PESA population, might represent a shift from the traditional Mediterranean diet toward a more

CENTRAL ILLUSTRATION Social Eating and Atherosclerosis: Comparison of Mediterranean Pattern, Western Pattern, and Social-Business Pattern



Peñalvo, J.L. et al. J Am Coll Cardiol. 2016;68(8):805-14.

(Left) A representation of the main food items characterizing each dietary cluster. Values correspond to factor loadings (the higher the value, the more a particular food item contributes to the dietary cluster). **(Right)** The distribution of the extent of atherosclerosis within each identified cluster is represented. The group of participants (19% of the PESA population) following the social-business dietary pattern presents the highest proportion of individuals with generalized (>3 territories affected) or intermediate (2 to 3 territories) atherosclerosis, whereas the majority of individuals (43%) classified into the Mediterranean pattern present no sign of disease.

Westernized diet, characterized by higher consumption of refined cereal products and other processed food, red meat, full-fat dairy, and sweets (e.g., pastries and ice cream). To an extent, it represents a step away from the CVD-protective traditional Mediterranean diet and, in fact, is associated with higher rates of hypertension, dyslipidemia, and diabetes compared with the Mediterranean diet cluster in our population sample. The evidence of a relationship between a Western dietary pattern and an increased risk of CVD has been reported to be inconsistent (23). In our study, participants classified as following this Western pattern (cluster 2) presented a higher cardiovascular risk as per risk-stratification scales, together with higher CAC scores and plaque presence (compared with cluster 1), although no statistical association with subclinical atherosclerosis was found when adjusting for traditional risk factors, suggesting that the effect of this dietary pattern on atherosclerosis is mediated by traditional cardiovascular risk factors. In MESA (Multi-Ethnic Study of Atherosclerosis), a diet characterized by high intakes of processed meat, fat, sweets, fried foods, and sugar-sweetened beverages was positively associated with CAC score and cIMT (4). Similarly, a diet high in sugar-sweetened beverages, red meat, desserts, and saturated fat, but low in vegetables, fruits, fiber, and micronutrient density, was associated with a 2-fold increased prevalence of carotid atherosclerosis in the Framingham cohort (6).

The beneficial association between the Mediterranean diet, evaluated by this approach (factor- and cluster-derived dietary patterns), and lower prevalence of subclinical atherosclerosis has not been previously reported in observational studies. In MESA, a diet high in whole grains, fruits, and nuts was associated with neither cIMT thickness nor CAC score (25). Similarly, no significant association between a healthier (greater intakes of fruits and vegetables, rye, legumes, and nuts) diet and cIMT thickness was observed in an analysis from the Cardiovascular Risk in Young Finns study (26). Considering the depreciated value of cIMT for improving CVD risk prediction (9), the lower prevalence of plaques and coronary calcification found in participants following a Mediterranean-type diet in our study helped to better understand the clinical benefit attributed to this dietary pattern. This is of interest as recent systematic reviews of epidemiological studies assessed using cluster or factor analysis concluded that, although limited, dietary patterns characterized by vegetables, fruits, whole grains, fish, and low-fat dairy products are associated with decreased risk of CVD in adults (23). Moreover, most randomized controlled trials on diet interventions showed that a Mediterranean/prudent diet may be effective in atherosclerosis regression in subjects with an initially moderate or severe burden of coronary heart disease (27,28).

STUDY LIMITATIONS. Middle- to high-income office workers with somewhat unique dietary habits constituted the PESA cohort; therefore, generalizability of our observations is limited. This can be regarded as a limitation but also as a strength, because this characteristic allowed us to identify a specific dietary pattern that might be shared by other populations in the same socioeconomic stratum and can help target preventive strategies toward this collective. Factor and cluster analyses are data-driven approaches in which the consolidation of food items into food groups, the number of factors or clusters to extract, and the labeling of components are subjective. Patterns derived from either factor or cluster analysis may not be reproducible across studies because elements of dietary patterns and analytic decisions differ. Also, due to the cross-sectional nature of our study, causality cannot be addressed. Furthermore, the use of ORs may overestimate the strength of the association due to the relatively high prevalence of plaques in the PESA population. Finally, because of the multicausal etiology of atherosclerosis, residual confounding cannot be ruled out despite of the use of fully adjusted models.

CONCLUSIONS

Approximately 1 in 5 participants enrolled in the PESA cohort followed a social-business eating pattern that, as a part of an overall unhealthy life-style, was associated with increased CVD risk and a higher prevalence and extension of subclinical atherosclerosis. These results suggested that diet and overall life-style habits were important in early atherosclerosis and could inform strategies to reduce the burden of CVD in similar populations after the results are validated when prospective data become available in the PESA cohort.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: Identification of dietary patterns associated with specific socioeconomic strata may help targeting strategies for prevention of CVD.

TRANSLATIONAL OUTLOOK: Randomized trials of strategies that address dietary and other life-style habits for primordial and primary prevention of CVD should include assessments of the presence and severity of subclinical atherosclerosis.

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KEY WORDS cardiovascular disease, dietary patterns, plaque, subclinical atherosclerosis

APPENDIX For supplemental tables and figures, please see the online version of this article.