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ORIGINAL ARTICLE

Dietary patterns and risk of nonfatal acute myocardial infarction in Costa Rican adults

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Objective: To investigate the association between dietary patterns and risk of a first nonfatal acute myocardial infarction (MI) in Costa Rican adults.
Design: Population-based case–control study.
Subjects: A total of 496 incident MI cases and 518 population-based randomly selected controls matched to the cases by age ($\pm$5 years), gender, and county of residence. Subjects were interviewed with a validated food frequency questionnaire. Dietary patterns were identified by factor analysis. Odds ratios (OR) and 95% confidence intervals (CI) were obtained using multivariate conditional logistic regression adjusted for several recognized risk factors for MI.
Results: Two diet patterns were identified, 'vegetable' characterized by increased intake of vegetables and fruits, and 'staple', characterized by an increased use of palm oil for cooking, and intake of refined grains (mostly white rice and white bread), legumes, coffee, added sugar, and red meat. Compared to the lowest quintile of the staple diet pattern, the highest quintile was associated with an increased risk of MI (OR: 3.70, 95% CI: 2.30–5.97). Adjusting for potential confounders did not change the results (OR: 3.53, 95% CI: 1.98–6.31). Consistently, an increasing staple pattern score was associated with lower HDL cholesterol (P for trend <0.02) and α-linolenic acid in adipose tissue (P for trend <0.0001). The vegetable pattern was not associated with MI.
Conclusions: The staple dietary pattern of Costa Rican adults is associated with low plasma HDL cholesterol, low α-linolenic acid in adipose tissue, and increased risk of MI.
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Introduction

Cardiovascular disease (CVD) has become an important public health problem in transition countries in Latin America (Medina and Kaempffer, 2000; Cubillos-Garzón *et al*., 2004; Ventura and Mehra, 2004; World Health Organization, 2004). Because changes in dietary intake are, in part, likely responsible for the increase in CVD during the past 20–30 years (Popkin, 2001), it is essential to identify foods that could play a role on CVD in developing countries. Food pattern analysis has become a valuable tool to examine the effects of diet on chronic disease (Jacques and Tucker, 2001; Hu, 2002). A major advantage of this procedure is that it takes into account multiple dietary factors, including nutrient and non-nutrient components, which could have complex effects on disease risk (Hu, 2002). In the context of Western countries, two main patterns that relate to CVD have been identified. In one study in men (Hu, 2002), a Western dietary pattern consisting primarily of red and processed meat, refined grains, sweets and desserts, French fries, and high-fat dairy products was associated with

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increased risk of coronary heart disease. In Denmark, a prudent dietary pattern consisting of whole meal bread, fruit, and vegetables was protective against all cause and cardiovascular mortality (Osler *et al*., 2001). In the same study, no association with mortality was found for a Western pattern characterized by high intake of meat products, potatoes, white bread, butter, and lard. Consistently, a Mediterranean style diet which includes olive oil, fiber, fruits, vegetables, fish and alcohol, and reduced in meat and meat products was also protective against myocardial infarction (MI) (Martinez-Gonzalez *et al*., 2002). The purpose of our study is to identify dietary patterns that are associated with risk of incident MI in Costa Rica, a Latin American country in transition (Reddy, 2004).

Subjects and methods

A total of 1062 subjects were recruited in a case–control study of diet and heart disease in Costa Rica. Participation was 97% for cases and 90% for controls. The cases were survivors of a first acute MI between 1994 and 1998. They were recruited from any of three national hospitals in the metropolitan area of San José, the capital of Costa Rica. All cases were diagnosed by two independent cardiologists according to the World Health Organization criteria for MI which require typical symptoms plus either elevations in cardiac enzymes or typical electrocardiographic changes (Tunstall-Pedoe *et al*., 1994). Cases were ineligible if they (a) died during hospitalization, (b) were $\geqslant$75 years on the day of their first acute MI, or (c) were physically or mentally unable to answer the questionnaire.

One free-living control subject was randomly selected to match the case for age ($\pm$5 years), gender, and county of residence using information available at the Costa Rican National Census and Statistic Bureau. Control subjects were ineligible if they ever had an MI or were physically or mentally unable to answer the questionnaire. All subjects gave written informed consent on forms approved by the Human Subjects Committee of the Harvard School of Public Health and the Ethics Committee of the University of Costa Rica.

Data collection

The data collection procedures have been described in detail elsewhere (Campos and Siles, 2000; Sen-Banerjee *et al*., 2000; Baylin *et al*., 2002). In brief, trained fieldworkers visited the study participants at their homes in the morning and collected information about sociodemographic characteristics, smoking status, household income, dietary intake, medical history (including a self-reported history of diabetes and hypertension), anthropometric measurements, venous blood sample after an overnight fast and subcutaneous adipose sample. Data collection was conducted as close as possible to the hospital discharge to minimize recall errors. On average, data collection for cases were completed 26 ± 10 (mean$\pm$s.d.) days after the MI. Data for controls were collected as close as possible to their match case, on average 31 ± 15 (mean$\pm$s.d.) days after the matched case MI event (El-Sohemy *et al*., 2002b). Measurements were performed in duplicate with subjects wearing light clothing and no shoes. Self-reported history of diabetes and hypertension were validated as previously described (Campos and Siles, 2000).

Dietary information was obtained using a validated semiquantitative food frequency questionnaire (FFQ) that inquired about foods consumed during the previous year (Kabagambe *et al*., 2001; Baylin *et al*., 2002; El-Sohemy *et al*., 2002a, b). There were nine possible responses to categorize the frequency of intake of any food item ranging from never or less than once per month to six or more times per day. All frequencies were converted to number of times per day. The questionnaire, administered by trained interviewers in the subjects' home, included specific items from the Costa Rican diet (Campos *et al*., 1991), such as rice, beans, plantains, corn tortillas, white bread, salads, chopped vegetables, meat, eggs, cheese, and sugar-sweetened tropical fruit beverages. Subjects selected only one type of fat that was used most frequently for cooking at home.

Plasma triacylglycerol, total cholesterol, and HDL cholesterol concentrations were measured by using enzymatic reagents (Boehringer-Mannheim, Indianapolis, IN, USA) in a Roche Cobas Mira Plus autoanalyzer (Roche Diagnostic Systems, Somerville, NJ, USA). Cholesterol and triglyceride determinations in our laboratory follow guidelines specified by the Centers for Disease Control and Prevention and the National Heart, Lung, and Blood Institute. LDL cholesterol levels were estimated for all subjects with triacylglycerol levels under 4.51 mmol/l, using the Friedewald equation (Friedewald *et al*., 1972); gluteus adipose tissue α-linolenic acid was quantified by gas–liquid, chromatography as previously described (Baylin *et al*., 2002).

Statistical analysis

Of the 1062 subjects that participated in the study, a total of 496 cases and 518 controls had complete information on all variables analyzed. For the application of the conditional logistic regression analysis, the 22 controls in excess of existing case–control pairs were matched to existing case–control pairs according to the matching criteria used. Data were analyzed with the SAS software version 8 (SAS Institute, Cary, NC, USA). Food items were classified into 42 food groups on the basis of nutrient profile, culinary use, or were left on their own in an attempt to minimize within-person variation in intakes of individual foods (Hu *et al*., 2000). The forty-two foods or food groups used in this study are shown in Table 1. Raw daily frequencies of food items on the FFQ were aggregated in food groups, square root transformed to improve normality, adjusted by total energy intake by the residual method (Willett and Stampfer, 1986) and back transformed for use as input into the principal components factor analysis. The factors obtained were rotated by an

Table 1 Selected food groups common to the Costa Rican diet

Foods or food groups	*Food items*
Beverages, alcoholic, liquor	Whiskey, rum, gin, vodka, 'guaro' (a local sugar cane colorless distilled spirit)
Beverages, alcoholic	Red and white wine, beer
Beverages, coffee	Caffeinated coffee
Beverages, high energy	Regular type beverages with and without caffeine (such as Coke and Pepsi, Fanta), instant powdered drinks, and fruit drinks (packaged or fresh)
Beverages, no energy	Diet type beverages with and without caffeine (such as Coke, Pepsi, Ginger-Ale, 7-Up)
Beverages, tea and water	Tea (regular, not herbal) and water (tap and bottled)
Cereal, cold breakfast	Refined grain-based cold breakfast cereals (such as cornflakes)
Condiment	Ketchup, salt, mayonnaise, hot chili sauce (added to foods at the table)
Condiment, fresh	Celery, parsley, sweet peppers, onions, cilantro, garlic
Condiment, sweet	Jam, jelly, honey
Dairy products, high fat	Whole and 2% dairy fat milk, sour cream, ice cream, fresh white cheese, cream cheese, white and yellow processed cheese
Dairy products, low fat	Skim milk, yogurt, cottage cheese
Dressings	Olive oil (as salad dressing, added to bread or food at the table), lemon & vinegar, and other dressings
Eggs	Hen eggs
Fruit	Pineapple, papaya, bananas, cantaloupe, avocado, apples, pears, mangos, oranges, watermelon, cashew pulp, tangerins, sweet lemon, grapefruit, lychee, medlars, 'jocotes' (*Spondias purpúrea*), apricots, peaches, plums
Fruit juices	Orange, other fruits
Grains, refined	White bread, white rice, macaroni, spaghetti, pancakes
Grains, whole	Oat meal, corn-based products, whole wheat bread
Grains, whole, other	Bran (oats and wheat), wheat germ
Legumes	Black beans, string beans, and peas
Meat, chicken	With skin and fat
Meat, chicken, lean	With skin and/or fat removed
Meat, fish	Canned tuna fish, sardine, white Pacific fish, shrimp, lobster
Meat, organ	Liver (beef, pork, chicken)
Meat, processed	Ham, salami, bologna, 'mortadella' sausage, hotdog
Meat, red	Beef, pork, bacon, fried pork rind
Nuts	Peanuts, cashews
Oil, unsaturated[a]	Soybean, corn, olive, and other used for cooking
Oil, palm[b]	Hardened palm oil (manteca) used for cooking
Pizza	
Saccharin	Saccharin (pills and drops)
Snacks	Saltine-type crackers, popcorn, chips (potatoes, cassava, plantain)
Soup, thick	Thick and cream soups
Spread	Butter, margarine, hydrogenated vegetable oil–butter blend ('lactocrema')
Sugar	Sugar added to hot and cold beverages and cereals
Sweets and desserts	Chocolate bars, chocolate confectionery, candy, cookies, brownies, donuts, chocolate drink (hot or cold), homemade and commercial, cookies, cakes, and pastry
Tomatoes	Raw, tomato sauce dishes
Vegetables, cruciferous	Broccoli, cabbage, cauliflower
Vegetables, dark-yellow	Carrots (raw, cooked), peach palm (*Bactris gasipaes*), yellow squash (*Cucurbita moschata*)
Vegetables, green, leafy	Cooked spinach, lettuce, mustard, and other green leafy vegetables
Vegetables, other	Cucumber, plantain, chayote (*Sechium edule*), tender squash, corn on the cob, beet, eggplant
Vegetables, root starchy	Potatoes (baked, boiled, mashed, French fries), yam ('ñame'; *Dioscorea alata*), sweet potato ('camote'; *Ipomoea batatas*), cassava ('yuca'; *Manihot esculenta*), 'tiquisque' (a root vegetable; *Xanthosoma sagittifolium*)

[a]Sixty-three percent of controls reported using unsaturated oils for cooking. The most commonly used unsaturated oils were soybean (75%), corn (19%), and olive (2%).
[b]Thirty-seven percent reported the use of palm oil.

orthogonal transformation to achieve a simpler structure that facilitates interpretability. To determine the number of factors to retain, we considered eigenvalues>1, Scree test, and interpretability of factors (Hair *et al*., 1998). We did not emphasize on the percentage of variance explained by each factor since this criterion depends largely on the total number of variables included in the analysis (Hu *et al*., 2000). In secondary analysis to test the robustness of the reported results, we generated patterns by different methods (principal factor analysis and maximum-likelihood), used different inputs (intake weights, intake energy each with and without oils used in cooking), and obtained similar results.

The factor scores produced in the principal components factor analysis were used in multivariate conditional logistic regression analysis to calculate the point estimates of the odds ratios (ORs) and 95% confidence interval (CI). To test for differences in means or distributions of lifestyle and dietary variables between cases and the controls, we used the *t*-test for continuous variables, and the χ^2 test for categorical variables. We assessed variables for confounding by distributing participants across quintiles of factor scores of each dietary pattern, and by investigating the change in point estimates when a given variable was entered into the conditional logistic regression model. Only significant confounders and risk factors were included in the final models. To test for linear trends in continuous variables, the median intake of each quintile was set to each subject in the same quintile and treated as a continuous variable in the regression analysis. For dichotomous variables, we used the Cochran–Armitage trend test to test for linear trend (Stokes *et al.*, 2000) of proportions across quintiles of the identified dietary patterns. All tests were two-sided and the significance level of the *P*-values was 0.05.

Results

The characteristics of the cases and controls are presented in Table 2. Smokers, self-reported history of diabetes and hypertension were significantly greater in cases than controls. Cases had larger waist-to-hip ratio and lower income than controls.

Table 3 shows the factor-loading matrix for the two major diet patterns identified in Costa Rica; vegetable and staple. The factor-loadings for the identified dietary patterns are depicted in a two-dimensional plane (Figure 1) showing the relative contribution of each of the food groups to each dietary pattern. The vegetable pattern was characterized mainly by a higher intake of all vegetables, fruits, skinless and lean chicken, and saccharin, and lower intake of added sugar, chicken, and coffee. The staple pattern was characterized by increasing intake of palm oil, legumes, refined grains, fresh condiments, coffee, red meat, added sugar, and organ meat, and decreasing intake of other oils, fruit juices, dressings, cold breakfast cereals, pizza, skinless and lean chicken, and low-fat dairy products. The variance explained by the vegetable and the staple dietary patterns was 9.12 and 5.44%, respectively. The variance explained after the patterns were orthogonally rotated by the varimax method, which makes the two factors independent, was very similar (7.32 and 7.24%).

Table 4 shows the general characteristics and potential confounders of control subjects across the lowest, middle, and highest quintiles of diet pattern scores. Compared to men, women controls were more likely to follow the vegetable pattern. Higher scores in the vegetable dietary pattern were associated with a higher percentage in the self-reported history of diabetes, higher family income, plasma HDL cholesterol, and adipose tissue α-linolenic acid. Controls with higher vegetable pattern scores also had lower waist-to-hip ratio and were less likely to be current smokers.

Table 2 Characteristics of cases of a first acute myocardial infarction and controls from the Central Valley of Costa Rica

	Cases (n = 496)	*Controls (n = 518)*
Age[a] (years)	57 ± 11[b]	57 ± 11
Gender[a] (%women)	26	26
Waist-to-hip ratio	0.95 ± 0.07	0.93 ± 0.07[c]
Self-reported history of diabetes (%)	23	11[d]
Self-reported history of hypertension (%)	43	26[d]
Current smokers[e] (%)	44	28[d]
Physical activity (METs[f])	1.41 ± 0.73	1.49 ± 0.82
Income, household $/month	458 ± 425	558 ± 485[c]

[a]Matching variable.
[b]$X \pm$ s.d.
[c,d]Significantly different from cases: [c]$P < 0.001$; [d]$P < 0.0001$.
[e]Smoked at least one cigarette/day.
[f]METs, metabolic equivalent tasks: average daily total energy expenditure relative to the basal energy expenditure (the energy expended by sitting quietly, equivalent to 3.5 ml of oxygen intake per kilogram of body weight per minute or 1 kcal/kg of weight/h). Multiply kcal by 4.19 to obtain kJ.

Table 3 Factor-loading matrix for the major factors (diet patterns) obtained by principal component analysis[a]

Food or food groups	*Vegetable*	*Staple*
Vegetables, other	0.65	
Vegetables, green, leafy	0.59	
Vegetables, dark-yellow	0.58	
Vegetables, cruciferous	0.56	
Fruit	0.44	
Tomatoes	0.37	
Meat, chicken, lean	0.36	−0.26
Vegetables, root starchy	0.34	
Saccharin	0.30	
Beverages, tea and water	0.29	
Snacks	0.25	
Grains, whole	0.22	
Beverages, liquor	−0.23	
Meat, chicken	−0.28	0.24
Sugar	−0.37	0.30
Oil, palm		0.73
Legumes		0.58
Grains, refined	−0.20	0.51
Condiments, fresh	0.25	0.44
Beverages, coffee	−0.25	0.33
Meat, red		0.30
Meat, organ		0.27
Beverages, high energy		0.22
Nuts		−0.21
Grains, other whole		−0.23
Beverages, no energy		−0.23
Dairy products, low fat		−0.26
Pizza		−0.31
Cereal, cold breakfast		−0.33
Dressings		−0.39
Fruit juices	0.22	−0.41
Oil, unsaturated		−0.42
Variance explained by factor (%)[b]	9.12	5.44

[a]Factors obtained by principal component analysis were identified using food consumption data, in servings/day, from a validated semiquantitative food-frequency questionnaire. Absolute factor loading values <0.195 are not listed for clarity; 42 food or food groups entered in the factor analysis.
[b]The variance explained by each factor after they were orthogonally rotated by the varimax method was 7.32% for the vegetables pattern and 7.24% for the staple pattern.

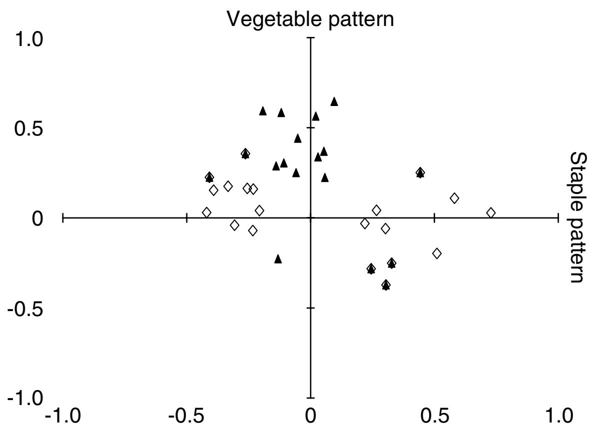

Figure 1 Spatial representation of the relationship between the derived dietary patterns and the food groups in 1014 subjects. The vertical axis represents the vegetable dietary pattern; the horizontal axis the staple dietary pattern. For clarity, only the food groups with absolute factor loadings greater than 0.20 are shown. The solid triangles are the food groups with high absolute loadings (>0.2) for the vegetable dietary pattern. The empty diamonds are the food groups with high absolute loadings (>0.2) for the staple dietary pattern. Six food groups had absolute factor loadings greater than 0.20 in both dietary patterns: chicken (regular and lean, skinless), sugar, fresh condiments, coffee, and fruit juices.

In contrast, higher staple dietary pattern scores were associated with higher percentage of smokers and higher energy expenditure, and lower total energy intake, income, plasma HDL cholesterol, and adipose tissue α-linolenic acid.

As shown in Table 5, there was no association between the vegetable pattern scores and the risk of MI. The results were marginally modified after adjusting for potential confounders. In contrast, the highest quintile of staple pattern score was associated with a 2.5-fold increase in the risk of MI. Adjustment for total energy intake, smoking, income, physical activity, and waist-to-hip ratio attenuated the OR. The point estimate in the final model after further adjustment for self-reported history of diabetes and hypertension was similar to the basic model.

Discussion

We identified two major dietary patterns in the Costa Rican population. The staple pattern, characterized by refined carbohydrates and the use of palm oil for cooking, was associated with a 2.5-fold increased risk of MI. Increased staple pattern scores were also associated with a more atherogenic profile characterized by low HDL cholesterol

Table 4 Baseline characteristics[a] of controls according to quintiles of dietary factor scores

	Quintiles of factor score for each dietary pattern					
	Vegetable pattern			*Staple pattern*		
	Q1	*Q3*	*Q5*	*Q1*	*Q3*	*Q5*
Subject characteristics						
Women (%)	8.1	25.3	46.7[b]	28.5	23.1	26.7
Waist-to-hip ratio	0.95	0.93	0.92[c]	0.93	0.94	0.93
Current smokers (%)	46.5	28.6	13.3[b]	27.0	20.9	36.7[d]
Physical activity (METs)	1.47	1.52	1.38	1.29	1.42	1.86[b]
Monthly household income, $	508	548	626	900	432	296[b]
Self-reported history of diabetes (%)	6.1	10.1	18.1[d]	10.2	16.5	8.9
Self-reported history of hypertension (%)	18.2	25.3	29.5	30.7	26.4	25.6
Plasma triacylglycerol (mmol/l)	2.32	2.28	2.34	2.33	2.30	2.26
Plasma LDL cholesterol (mmol/l)	2.98	3.11	3.00	3.01	3.02	3.03
Plasma HDL cholesterol (mmol/l)	1.03	1.08	1.14[c]	1.15	1.04	1.06[d]
α-Linolenic acid in adipose tissue (%)	0.51	0.54	0.60[b]	0.59	0.57	0.47[b]
Nutrient intakes (adjusted)[e]						
Total energy intake (kcal[f]/day)	2267	2276	2386	2412	2320	2212[d]
Protein (g/day)	75	80	82[c]	78	78	84[c]
Carbohydrate (g/day)	304	322	331[c]	301	335	328[b]
Saturated fat (g/day)	32	30	29[d]	30	28	33[b]
Monounsaturated fat (g/day)	32	32	33	38	29	31[b]
Polyunsaturated fat (g/day)	14	15	15[c]	17	15	12[b]
Trans fat (g/day)	4.5	4.1	3.8[c]	4.3	4.6	2.6[b]
Cholesterol (mg/day)	317	289	268[d]	271	269	326[b]
Dietary folate (μg/day)	304	372	456[b]	395	368	406
Fiber (g/day)	20	25	30[b]	23	25	30[b]

[a]Means.
[b,c,d]Linear trend across quintiles of dietary pattern [b]$P<0.0001$; [c]$P<0.01$; [d]$P<0.05$.
[e]Adjusted for total energy intake using the residual method (Willett and Stampfer, 1986).
[f]Multiply kcal by 4.186 to obtain kJ.

Table 5 Odds ratios (ORs) and 95% confidence intervals (CI) of MI according to quintiles of factor scores

	Quintiles of factor scores					P *(linear trend)*
	1	*2*	*3*	*4*	*5*	
Vegetable pattern						
Cases/controls	103/99	93/110	104/99	98/105	98/105	
Basic model[a]	1	0.83 (0.57, 1.20)	1.02 (0.69, 1.50)	0.89 (0.60, 1.33)	0.89 (0.60, 1.33)	0.71
Adjusted model 1[b]	1	0.92 (0.61, 1.39)	1.18 (0.77, 1.83)	1.26 (0.79, 2.01)	1.09 (0.69, 1.73)	0.55
Adjusted model 2[c]	1	0.89 (0.58, 1.37)	1.08 (0.69, 1.70)	1.17 (0.72, 1.92)	0.92 (0.57, 1.50)	0.92
Staple pattern						
Cases/controls	65/137	100/103	112/91	106/97	113/90	
Basic model[a]	1	2.43 (1.56, 3.79)	3.26 (2.07, 5.13)	2.98 (1.89, 4.71)	3.70 (2.30, 5.97)	<0.0001
Adjusted model 1[b]	1	2.31 (1.41, 3.77)	3.24 (1.91, 5.47)	3.00 (1.77, 5.08)	3.11 (1.78, 5.45)	0.0005
Adjusted model 2[c]	1	2.42 (1.44, 4.08)	3.55 (2.05, 6.15)	3.21 (1.85, 5.57)	3.53 (1.98, 6.31)	0.0002

[a]Basic model: adjusted for age (±5 years), sex, and area of residence (matching variables).
[b]Adjusted model 1: basic model + additional adjustment for total energy intake (in quintiles), smoking status (never, past, present), household income (in quintiles plus an additional category for missing values), physical activity (in quintiles), and waist-to-hip ratio (in quintiles).
[c]Adjusted model 2: model 1 + additional adjustment self-reported diabetes (no/yes) and self-reported hypertension (no/yes).

and low adipose tissue α-linolenic acid. The vegetable pattern, characterized by high intake of vegetables, fruits, and lean chicken was not associated with MI. These results were robust and were not modified after adjusting for suspected risk factors and confounders, such as household income, self-reported history of diabetes and hypertension, waist-to-hip ratio, total energy intake, physical activity, and smoking status.

Dietary patterns have been used as an alternative approach to the analysis of individual foods and nutrients in relation to chronic disease (McCann *et al*., 2001; Kim *et al*., 2004; Sieri *et al*., 2004). Two studies have identified dietary patterns associated with CVD risk (Osler *et al*., 2001; Kerver *et al*., 2003). In one of these studies (Kerver *et al*., 2003), a Western dietary pattern characterized by increasing intakes of processed meats, eggs, red meats, and high-fat dairy products was positively associated with biomarkers of CVD risk (serum C-peptide, serum insulin, and glycated hemoglobin) and inversely with red blood cell folate concentrations. In contrast, the American-healthy dietary pattern that includes green-leafy vegetables, salad dressings, tomatoes, peppers, green beans, corn, peas, cruciferous vegetables, and tea had no association with any of the biomarkers examined. Interestingly, a prudent dietary pattern in Danish men and women, characterized by increasing intake of whole meal bread, fruits, and vegetables, was inversely associated with cardiovascular mortality (Osler *et al*., 2001). In contrast, the same study showed that a Western pattern (meat products, potatoes, white bread, butter, and lard) was not significantly associated with mortality (Osler *et al*., 2001). The staple pattern in our study appears to be unique with respect to the foods associated with it, and it is not comparable with the Western patterns identified in the other populations mentioned above. Red meat intake has been reported by others as a food item with a high factor loading in one of the dietary patterns identified as 'Western' (Hu *et al*., 2000; Fung *et al*., 2001b; Sanchez-Villegas *et al*., 2003) and 'Meat' (Maskarinec *et al*., 2000). It has been proposed that the potential atherogenicity of Western patterns identified in other studies (Hu *et al*., 2000; Fung *et al*., 2001a; Kerver *et al*., 2003) is owing to its high content of meat and dairy products which are high in saturated fat including shorter chain fatty acids that have greater effects on plasma lipid levels (Khor, 2004). Red meat, which is not widely consumed in Costa Rica, is not a major component of the staple dietary pattern.

The explanation for the atherogenicity of the Costa Rican staple pattern could be related, in part, to the high glycemic index of staple foods (white rice, white bread, and sugar) (Foster-Powell *et al*., 2002; Amano *et al*., 2004), and the fatty acid composition of palm oil (high in saturated and low in linoleic and α-linolenic acid) (USDA, 2004). It should also be noted that the risk of MI does not increase past the third quintile of the staple dietary pattern, suggesting a threshold beyond which risk is not further increased.

Of note is the strong association observed between the staple pattern and low HDL cholesterol. Low HDL cholesterol is a well-established biomarker for increased risk of MI (Fruchart and Duriez, 2002), and it is also associated with increased glycemic index and glycemic load (Karim *et al*., 2003; Amano *et al*., 2004). Furthermore, lower levels of α-linolenic acid in adipose tissue were observed in the highest quintile of the staple dietary pattern compared to the lowest. Low α-linolenic acid in adipose tissue is a major independent predictor of MI in the Costa Rican population (Baylin *et al*., 2003). Interestingly, important constituents of beans (folate and dietary fiber), a major component of the staple dietary pattern, have been associated with protection against MI (Rimm *et al*., 1996; Liu *et al*., 2002; Tavani *et al*., 2004); as well as beans themselves in this particular population (Kabagambe *et al*., 2005). Intake of folate and dietary fiber is higher in the fifth quintile of the staple dietary pattern score compared to the lowest. Thus, it is possible that the potentially beneficial effects of beans in this pattern are overcome by the detrimental components of other foods.

The foods in the vegetable pattern identified in our study are consistent with the foods in the prudent (Slattery *et al.*, 1998; Fung *et al.*, 2001b), vegetable (Maskarinec *et al.*, 2000), and healthy (Terry *et al.*, 2001) patterns described by others, yet the vegetable pattern was not associated with protection against MI in Costa Rica. This inconsistency could be related to differences in the variation of foods within the pattern across different studies. For example, the prudent pattern identified in the US reflects the intake of fruit, vegetables, whole grains, and poultry, while the vegetable pattern identified in this study was characterized almost exclusively by vegetables. Still, consistent with findings in the US (Fung *et al.*, 2001b), the Costa Rican vegetable pattern was associated with increase levels of biomarkers associated with decreased CVD risk such as HDL cholesterol and α-linolenic acid in adipose tissue. However, in Costa Rica, the highest quintile of the vegetable dietary pattern had an increased number of diabetic and hypertensive subjects which were most likely motivated to follow a healthier diet after the diagnosis of the disease. Thus, the lack of association between the vegetable pattern and MI in this study could be attributed to residual confounding by diabetes and hypertension.

A potential limitation of the study is that dietary information was collected after the MI among the cases, and they are likely to have modified their dietary habits. To minimize these possible recall errors, dietary data collection was conducted in the subjects' home as close as possible to hospital discharge (26 ± 10 days after the MI). If cases did report with higher error because of the event, most likely they were random and would reduce the possibility of finding an association. This is because the association between specific foods and health is not part of the general knowledge in the study population as it is in Europe and the US, and the possibility of systematic error is minimized.

Thus, a dietary pattern consisting of foods with high glycemic index was identified in this population. This pattern, denominated 'staple' is likely to be the most common in many countries in transition. Given the economic constraints of many developing countries and the cultural acceptance of new foods, it is difficult to devise reasonable affordable substitutions for staple foods. It seems likely, however, that the dietary pattern in the studied population could be improved by slowly introducing the use of brown rice for white rice and whole wheat bread for white bread. Priority should be given to the use of water as opposed to sweetened beverages of any type, and the use of beans and unsaturated oils rich in α-linolenic acid, such as soybean oil, should be encouraged.

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