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No significant independent relationships with cardiometabolic biomarkers were detected in the Observation of Cardiovascular Risk Factors in Luxembourg study population★

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Abstract

Recently, there has been an influx of research interest regarding the anti-inflammatory role that diet has in chronic and metabolic diseases. A literature-based dietary inflammatory index (DII) that can be used to characterize the inflammation-modulating capacity of individuals' diets has even been developed and validated in an American population. We hypothesized that the DII could predict levels of high-sensitivity C-reactive protein (CRP), which is an important inflammatory marker, as well as metabolic measures that include the metabolic syndrome and its components in European adults. This hypothesis was tested according to data from 1352 participants from the Observation of Cardiovascular Risk Factors in Luxembourg study, a nationwide, cross-sectional survey based in Luxembourg. Statistical methods consisted of descriptive and multivariable logistic regression analyses. The DII ranged from a minimum of −4.02 (most anti-inflammatory) to a maximum of 4.00 points, with a mean value of −0.41. Participants with higher DII score were significantly younger and had lower body mass index, waist circumferences, and systolic blood pressure levels. Other cardiovascular biomarkers including diastolic blood pressure, CRP, lipids, and glycemic biomarkers did not vary significantly across DII tertiles. Participants with proinflammatory (>1) DII scores had increased adjusted odds (odds ratio, 1.46; 95% confidence interval, 1.00–2.13) of having a low high-density lipoprotein cholesterol, compared with those with anti-inflammatory scores (DII ≤ 1). There were no significant relationships between high-sensitivity CRP and the DII. This study, which tested the

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inflammatory capacity of the DII outside the United States, did not detect a significant independent relationship with cardiometabolic biomarkers, by using Food Frequency Questionnaire–collected data. These results are informative and representative of a relevant step in directing future research for nutrition and diet quality.

Keywords

Nutritional index; Metabolic syndrome; Cross-sectional study; Population-based; Nutritional assessment; Inflammation; Human

1. Introduction

Acute inflammation is the body's natural response to tissue injury and a necessary step in wound healing and tissue regeneration [1-4]. When acute inflammation is not controlled by normal processes of negative feedback, a chronic low-grade inflammatory state can occur [4]. Chronic inflammation is associated with metabolic syndrome (MetS) and its components [5] as well as type 2 diabetes [6], heart disease [6], and cancer [1], and diet plays an important role in the regulation of inflammation. A Western-type diet, which is typically high in red and processed meat, high-fat dairy products, and refined grains, is associated with higher levels of C-reactive protein (CRP) and interleukin 6 [7]. Alternatively, lower levels of inflammation are associated with the Mediterranean diet, which is characterized by a high intake of whole grains, fruit, green vegetables, and fish; moderate alcohol and olive oil consumption; and low intakes of red meat and butter [8,9]. Specific nutrients that are consistently associated with lower levels of inflammation include omega-3 polyunsaturated fatty acids (PUFAs) [10], fiber [11], vitamin E [12], vitamin C [13], β -carotene [14], and magnesium [15]. Diets high in fruits and vegetables are associated with lower levels of CRP and known to reduce the risk of MetS [16,17].

The dietary inflammatory index (DII) was developed to characterize the diets of individuals, according to their inflammatory potential [18,19]. The DII is based on an extensive review of literature and scoring of 1943 articles, published through 2010, which focused on the effects of diet on inflammation. Articles were scored according to whether each of 45 food parameters increased (+1), decreased (−1), or had no (0) effect on 6 inflammatory biomarkers (interleukins 1 β , 4, 6, and 10; tumor necrosis factor α ; and CRP) [18]. The parameters consisted of foods such as garlic, ginger, and onions; nutrients such as carbohydrates, fats, vitamins, and minerals; and other bioactive components such as flavonoids and resveratrol. This literature-based index, which focused on the inflammatory properties of the diets, aimed to facilitate research on diet-disease relationships and could even have potential implications for chronic disease prevention and patient counseling. The original index predicted interval changes in high-sensitivity CRP (hs-CRP) [19]. The updated version was recently validated using 2 different assessment methods of dietary intake (multiple days of 24-hour dietary recalls and a 7-day dietary recall) in each of 5 study periods from the Seasonal Variation in Blood Lipids Study (SEASONS). The results showed the capacity of the DII to predict hs-CRP greater than 3.0 mg/L (vs CRP $\leq$ 3.0 mg/L), using both assessment methods [20]. We also have observed that shift workers tended to have

proinflammatory diets (higher DII scores), compared with their day-working counterparts [21]. Furthermore, higher DII scores were linked to asthma [22].

The authors hypothesized that the DII could predict inflammation-related outcomes in any population, using diverse dietary assessment tools. The current study aimed to test the DII's capacity to predict levels of an inflammatory marker (hs-CRP) and related health outcomes outside the United States. Therefore, we had 2 primary objectives. First, we aimed to examine the association between the DII and the MetS and its components, by using data from the “Observation of Cardiovascular Risk Factors in Luxembourg” (ORISCAVLUX) study [23]. Second, we explored the inflammatory capacity of the DII, by using Food Frequency Questionnaire (FFQ)–derived data. This study constituted an opportunity to test the DII in a different setting, that is, in a sample representative of an adult European population who exercised different culinary and lifestyle habits as compared with the US population. Testing the performance of a novel dietary index is an important step to verify its future applicability in populations and could expand the scope of research in human nutrition and health.

2. Methods and materials

2.1. ORISCAV-LUX study population

Between November 2007 and January 2008, the ORISCAV-LUX study recruited a stratified random sample of 1432 subjects, between 18 and 69 years old. This nationwide, cross-sectional survey of healthy adults in Luxembourg aimed to establish baseline information on the prevalence of potentially modifiable and preventable cardiovascular risk factors, including obesity, hypertension, diabetes mellitus, lipid disorders, and smoking status. After the elimination of subjects with missing data on dietary intake, a total of 1352 individuals were available for the present analyses. A comprehensive description of the survey design, sample representativeness, and data collection is published elsewhere [23,24].

Demographic and socioeconomic variables, including age (in years), sex, education level (primary, secondary, or tertiary), marital status (live with partner or live alone), and economic status (below poverty threshold or above poverty threshold) were obtained. Further information about dieting practices, presence of chronic disease (diabetes, hypertension, or dyslipidemia), and use of medication were available for the analyses. Self-reporting of physical activity during the 7 days immediately before the interview was assessed using the International Physical Activity Questionnaire [25], which classifies subjects into active and inactive categories.

For all participants, anthropometric measurements of body weight (kilograms), height (centimeters), and waist circumference (WC) (centimeters) were collected according to standard operating procedures by using a digital column scale (Seca 701; Seca, Hamburg, Germany). Body weight was recorded with each subject barefoot and wearing light clothing and had an accuracy of ± 100 g, by using a digital column scale (Seca 701). With participant's heels together, shoulders in relaxed position, and arms freely hanging, standing body height (centimeters) was recorded to the nearest 0.2 cm by using a portable wall stadiometer (Seca). Body mass index (BMI) was calculated as weight divided by height

squared (kilograms per square meter). During mild expiration and using a flexible, nondistensible tape, WC (centimeters) was measured at the level midway between the 12th rib and the uppermost lateral border of the iliac crest. Blood samples were obtained after an 8-hour fast, centrifuged within a maximum 4 hours after extraction, and then immediately analyzed. Blood collection tubes containing glycolytic inhibitors were used for the serum glucose test. Standard laboratory assays were used to assess serum biomarkers, such as fasting plasma glucose (FPG), total cholesterol, triglycerides (TG), HDL cholesterol (HDL-C), hs-CRP, and insulin. Full details concerning the definition and calculation of variables are published elsewhere [26].

2.2. Dietary inflammatory index

Using a validated semiquantitative FFQ, dietary intake data were collected [27,28]. The FFQ provided data on the consumption frequency and portion size of 132 items over the previous three months. The methods used in the construction of the DII have been published elsewhere [18]. Briefly, to calculate DII for the participants of this study, the dietary data were first linked to the regionally representative world database that was created at the University of South Carolina and provided a robust estimate of a mean and SD for each parameter [18]. Then, these became the multipliers used to express an individual's exposure, relative to the “standard global mean” as a z-score. This was achieved by subtracting the “standard mean” from the amount reported and then dividing this value by the “standard deviation”. To minimize the effect of “right skewing,” this value was converted to a centered percentile score. The centered percentile score for each food parameter was then multiplied by the respective food parameter effect score. This was derived from the review and scoring of 1943 qualifying research articles, to obtain a food parameter-specific DII score for the individual. All of the food parameter-specific DII scores were then summed to create the overall DII score for every participant in the study [18]. Of a possible 45 parameters, a total of 24 nutrients and foods were available to calculate the DII for all eligible participants in the ORISCAV-LUX study. The overall index obtained by summing the 24 components ranged from a minimum of −4.02 (most anti-inflammatory) to a maximum of 4.00 points, with a mean value of −0.41.

2.3. Clinical definitions

Obesity was defined as BMI greater than or equal to 30 kg/m² [29]. An index of insulin resistance and sensitivity was calculated according to the homeostasis model assessment (HOMA-IR) formula [fasting plasma or serum glucose (milli-grams per deciliter) × fasting plasma or serum insulin (microunits per milliliter)]/405 [30]. Metabolic syndrome criteria were based on the US National Cholesterol Education Program Adult Treatment Panel guidelines, with recent modifications from the American Heart Association and the National Heart, Lung, and Blood Institute (R-ATPIII) [31]. MetS was characterized by the presence of at least 3 of the following conditions: (1) WC greater than or equal to 102 cm for men or greater than or equal to 88 cm for women, (2) raised concentration of TG greater than or equal to 150 mg/dL (1.695 mmol/L) or specific treatment for this lipid anomaly, (3) reduced concentration of HDL-C less than 40 mg/dL for men (<1.036 mmol/L) or less than 50 mg/dL (<1.295 mmol/L) for women or specific treatment for this lipid anomaly, (4) systolic blood pressure (SBP) greater than or equal to 130 mm Hg or diastolic blood

pressure (DBP) greater than or equal to 85 mm Hg or treatment of previously diagnosed hypertension, and (5) FPG level greater than or equal to 100 mg/dL (5.6 mmol/L) or use of medication for hyperglycemia [32].

2.4. Ethical aspect

All participants were duly informed and consented to take part in the ORISCAV-LUX survey. The study design and data collection procedures were approved by the Luxembourg National Research Ethics Committee and the National Commission for Private Data Protection.

2.5. Statistical analyses

The DII is a scalar variable that goes from maximally anti-inflammatory (most negative) to maximally proinflammatory (most positive). For the descriptive analyses, the DII was categorized into tertiles. The first tertile (score range, -4.02 to -1.33) represented an anti-inflammatory dietary profile, whereas the third tertile (score range, 0.34-4.00) represented a proinflammatory profile. Characteristics of participants by DII tertiles were compared using the χ^2 test for categorical variables (presented as percentages) and analysis of variance for continuous variables (presented as means $\pm$ SE).

To identify the potential independent association between proinflammatory dietary profiles and selected outcomes, univariate and multivariable logistic regression analyses were used to calculate the odds ratios (ORs) and 95% confidence intervals (CIs) for having MetS and its individual components. For these analyses, the DII was dichotomized (ie, ≥ 1 or < 1), and the less than or equal to 1 (anti-inflammatory) dietary profile was considered the referent. The regression analyses were adjusted for age, sex, education level (primary, secondary, or tertiary), economical status (living above or below the poverty threshold), smoking status (smokers or nonsmokers), and physical activity (active or inactive). In addition to being significantly related to either outcome or explanatory variables, the selection of covariates that might affect the likelihood of having MetS was based on an extensive review of the literature. Several sensitivity analyses were performed to confirm the robustness of the presented findings.

Results were considered significant at the 5% critical level ($P > .05$, 2 sided). All statistical analyses were performed by using PASW Statistics for Windows, Version 18.0. Chicago, USA: SPSS Inc.

3. Results

3.1. Demographic and lifestyle characteristics of the sample

There were no material differences in the distribution of demographic and socioeconomic characteristics across DII tertiles. However, lifestyle behaviors, such as smoking and physical inactivity, significantly increased with higher scores, that is, with the proinflammatory profile. The percentages of obesity and MetS as well as its components (particularly abdominal obesity and high blood pressure criteria) significantly decreased

across the DII tertiles. Subjects who reported being on weight loss diets during the survey period were found lower in the third tertile of the DII (Table 1).

Further descriptive analyses were completed to present the basic characteristics (demographic and lifestyle characteristics) of the participants according to dichotomized DII (Supplementary Table 1).

3.2. Dietary inflammatory index vs several cardiometabolic biomarkers

Participants with higher DII scores were significantly younger and had lower BMI, WCs, and SBP levels. The other cardiovascular biomarkers, including DBP, CRP, serum lipids, glucose, insulin, and measure of insulin resistance, did not vary substantially, according to DII tertiles (Table 2). Further descriptive analyses were conducted to present the cardiovascular risk factors of the participants, according to dichotomized DII (Supplementary Table 2).

3.3. Food and nutrients intake

The available food parameters used to calculate the DII in this study were energy, total carbohydrate, protein, total fat, alcohol, fiber, cholesterol, saturated fatty acid, monounsaturated fatty acid, PUFA, omega 3, omega 6, niacin, thiamin, riboflavin, vitamin B12, vitamin B6, iron, magnesium, vitamin A, vitamin C, vitamin D, vitamin E, folic acid, and β -carotene (Table 3).

3.4. Association of the DII with the MetS and its components

We opted to dichotomize the population into 2 distinct groups ($DII > 1$) and ($DII \leq 1$) because most participants had an anti-inflammatory dietary profile. The first group consisted of both the first tertile (range, -4.02 to -1.33) and second tertile (range, -1.32 to 0.33), with the second including the third tertile (range, 0.34 – 4.00). This cut-off point is rational to obtain a substantially 2 contrast groups of DII scores because within-group homogeneity may limit the ability to discriminate effects.

In the crude univariate analyses, no statistically significant relationship was found between the DII and MetS or its components, except for an inverse relationship with high blood pressure (OR, 0.75; 95% CI, 0.58–0.97). In multivariable analyses, participants with proinflammatory (> 1) DII scores had increased adjusted odds (OR, 1.46; 95% CI, 1.00–2.13) of having a low HDL-C, compared with those with anti-inflammatory scores ($DII \leq 1$) (Table 4). Either using the DII as a continuous variable or categorizing by tertiles, essentially, the same results were produced (data not shown).

4. Discussion

The present study applied the revised version of the DII [18] to test the inflammatory properties of the diets of a large sample of healthy adults residing in Luxembourg, in relation to cardiovascular-related health outcomes. The mean DII was -0.41 ± 1.62 , which is much less inflammatory compared with individuals from the SEASONS (0.84 ± 1.99) [20]. However, the range of DII in the SEASONS (-5.3 to 4.3) was comparable with that of the

ORISCAV-LUX population (−4.02 to 4.00). The DII scores of approximately two-thirds of the participants in the ORISCAV-LUX survey were anti-inflammatory, thus indicating that the Luxembourg study population may consume generally healthier food, as compared with the US study population.

In the present study, the dietary inflammatory potential of the ORISCAV-LUX sample, as assessed by the DII, did not vary considerably according to socioeconomic factors. However, smokers and the physically inactive consumed a diet characterized by a higher DII score, that is, proinflammatory profile. Surprisingly, most of the subjects with MetS, particularly those with abdominal obesity and elevated blood pressure, had a diet with an anti-inflammatory profile. Although higher DII scores have been linked with higher BMI and LDL values in the American SEASONS [20], inverse relationships with BMI, WC, and SBP were observed in the ORISCAV-LUX study population. Furthermore, the DII was unrelated to a set of cardiometabolic biomarkers (lipids, glucose, hs-CRP, insulin, and HOMA-IR) and appeared to be a poor predictor of MetS and its components. However, a tendency toward higher risk of the MetS with higher DII scores was also observed.

As previously mentioned, the diet of most participants was generally anti-inflammatory, suggesting that the studied population may be relatively health conscious. This is consistently shown with BMI values generally lower than their American counterparts. Within-group homogeneity may limit the ability to detect a discriminative effect of DII. Although the sample was divided into 2 distinct groups (DII ≤ 1 and DII > 1), no associations were observed. From a statistical point of view, the CIs were not excessively wide, thus indicating a relatively precise estimate of effect. The absence of a significant association between the DII and hs-CRP in the ORISCAV-LUX sample was probably due to the effect size (inflammatory diet) being too small to reach statistical significance, that is, although it may have existed, it was not discernible in the studied sample.

These null results were inconsistent with previous findings from the SEASONS [20] as well as the US National and Health Examination Survey and the Women's Health Initiative (manuscripts currently under review).

Literature confirms that inflammation is associated with cardiovascular disease, obesity, and insulin resistance [33]. Diet may play a central role in the regulation of chronic inflammation. Increased inflammatory stimuli by certain foods may, in turn, represent a triggering factor in the origin of the MetS. Such chronic stimulation may result in cytokine hypersecretion and even eventually lead to insulin resistance and diabetes in genetically or metabolically predisposed individuals [34]. Because the process of inflammation is very complicated, it is conceivable that other factors, besides those that were measured, could influence the process. As for any complex system, caution should be applied in interpreting results based on a single application of the DII. It is also important to note that the DII is based only on inflammatory mediators of protein nature and does not include well-established lipid mediators, such as eicosanoids and oxidized phospholipid [35,36].

In the current study, the DII calculated for the test sample of participants did not reveal a significant inflammatory potential of their diets. The study of Fung et al [37] compared 5

different diet quality scores (Healthy Eating Index, Alternate Healthy Eating Index, Diet Quality Index-Revised, Recommended Food Score, and the alternate Mediterranean Diet Index), in relation to several inflammatory biomarkers, including the CRP. Similar to our findings, their study showed that these dietary indexes (except Alternate Healthy Eating Index and alternate Mediterranean Diet Index) were not predictive of inflammatory biomarkers and endothelial dysfunction [37].

The structure of the calculated DII for the studied sample may also explain the lack of association of DII with inflammatory biomarker CRP. According to the number and types of items included, different combinations/nonspecific dietary patterns may result. For example, a DII score that is based ideally on all of the 45 foods or nutrients may be more sensitive than a DII score that is computed from fewer items.

The present study has several potential limitations. First, although our FFQ was based on 132 food items, information regarding spices (saffron, pepper, and turmeric), flavors, garlic, and ginger was absent. The unavailability of an exhaustive set of specific foods and nutrients most likely contributed to the poor performance of the DII in the present study. This lack could influence the resulting DII structure and, hence, hampered the detection of significant associations with the MetS and hs-CRP. Second, counterintuitive findings may be related to the inherent limits of the cross-sectional nature of the study, where the temporal relation of exposure and outcome cannot be determined. Participants may have altered their dietary habits in response to their cardiometabolic health problems. However, there were no changes in the results when data from those participants who were dieting (195 subjects) were removed from the analyses (data not shown). Alternatively, they may have been expressing reporting biases that were associated with their poorer health status [38] or due to the ever-present possibility of social approval or social desirability bias [39-41].

Despite the null findings, the ORISCAV-LUX survey provided an interesting opportunity to test the DII in a European population, by using FFQ-derived dietary measures. We should also acknowledge that the ORISCAV-LUX survey was primarily designed with specific monitoring objectives. The second wave of the ORISCAV-LUX (6-year follow-up) is currently under preparation. Detailed information regarding additional proinflammatory foods and nutrients will be integrated into the dietary data collection. To help confirm or refute the current findings, further prospective testing of health-related hypotheses in the ORISCAV-LUX population or in other European datasets should also be considered.

In conclusion, this study testing the inflammatory capacity of the DII outside the US population did not detect a significant independent relationship with cardiometabolic biomarkers, based on using FFQ-collected data. Therefore, this refuted our hypothesis regarding the applicability of the DII in our studied population. Nonconfirmatory or “null” results are an integral part of scientific progress [42]. The present findings are relevant for the scientific nutrition community and help to direct future research on diet quality and diet-disease relationships.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

BMI	body mass index
CI	confidence interval
CRP	C-reactive protein
DBP	diastolic blood pressure
DII	dietary inflammatory index
FFQ	Food Frequency Questionnaire
FPG	fasting plasma glucose
HDL-C	high-density lipoprotein cholesterol
HOMA-IR	insulin resistance and sensitivity calculated according to homeostasis model assessment
hs-CRP	high-sensitivity C-reactive protein
MetS	metabolic syndrome
OR	odds ratio
ORISCAV-LUX	Observation of Cardiovascular risk Factors in Luxembourg
PUFA	polyunsaturated fatty acid
SBP	systolic blood pressure
SEASONS	Seasonal Variation in Blood Lipids Study
TG	triglycerides
WC	waist circumference

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Table 1

Demographic and lifestyle characteristics of adults between 18 and 69 years old, according to the tertile of DII, ORISCAV-LUX 2007-2008

Demographic characteristics	DII			<i>P</i> ^c
	Tertile 1 (anti-inflammatory profile) (n = 450)	Tertile 2 (n = 450)	Tertile 3 (proinflammatory profile) (n = 450)	
	% with attribute	% with attribute	% with attribute	
Sex				.19
Men (n = 657)	51.1	49.4	45.2	
Women (n = 695)	49.9	50.6	54.8	
Education level				.94
Primary (n = 351)	24.8	27.3	26.6	
Secondary (n = 632)	48.5	46.5	46.6	
Tertiary (n = 355)	26.6	26.2	26.8	
Income				.96
Below poverty threshold (n = 252)	21.0	21.8	21.6	
Above poverty threshold (n = 922)	79.0	78.2	78.4	
Marital status, %				.78
Live with partner (n = 958)	71.6	69.6	71.4	
Live alone (n = 394)	28.4	30.4	28.6	
<i>Lifestyle characteristics</i>				
Smoking status				.025
Smoker (n = 288)	17.1	24.2	22.6	
Nonsmoker (n = 1064)	82.9	75.8	77.4	
Physical activity ^a				.002
Active (n = 1067)	86.6	83.9	77.7	
Inactive (n = 223)	13.4	16.1	22.3	
Obesity ^b				.030
Yes (n = 304)	26.2	22.4	18.8	
No (n = 1047)	73.8	77.6	81.8	
Underdieting				.001
Yes (n = 195)	19.5	13.1	10.9	
No (n = 1153)	80.5	86.9	89.1	
MetS				.039
Yes (n = 346)	30.4	24.9	23.2	
Components				
Abdominal obesity (n = 430)	36.0	31.3	28.4	.049
Raised TG (n = 351)	27.9	27.1	24.8	.56
Low HDL-C (n = 249)	22.4	17.4	16.8	.070
High BP (n = 741)	59.3	58.1	47.6	.001
Hyperglycemia (n = 307)	26.3	19.7	23.9	.068

Difference in the number of cases is related to missing values for several variables. Values are expressed as percentages.

Abbreviation: *BP*, blood pressure.

^aPhysical activity was assessed via International Physical Activity Questionnaire.

^b*Obesity* was defined as BMI greater than or equal to 30 (kilograms per square meter).

^c $P > .05$ considered significant.

Table 2

Cardiovascular risk factors in adults aged 18 to 69 years, according to the tertile of DII, ORISCAV-LUX 2007-2008

	DII			P for trend^a
	Tertile 1 (anti-inflammatory profile) (n = 450)	Tertile 2 (n = 450)	Tertile 3 (proinflammatory profile) (n = 450)	
Range of DII tertiles	−4.02 to −1.33	−1.32 to 0.33	0.34–4.00	
	Mean ± SE	Mean ± SE	Mean ± SE	
DII	−2.20 ± 0.03	−0.60 ± 0.02	1.49 ± 0.04	<.0001
Age, y	46.0 ± 0.63	44.4 ± 0.61	42.6 ± 0.60	<.0001
BMI, kg/m ²	27.0 ± 0.25	26.4 ± 0.22	26.3 ± 0.24	.043
WC, cm	90.9 ± 0.69	89.4 ± 0.62	88.4 ± 0.64	.007
SBP, mm Hg	131.0 ± 0.79	130.3 ± 0.86	127.9 ± 0.87	.010
DBP, mm Hg	82.8 ± 0.51	82.8 ± 0.51	81.4 ± 0.55	.061
CRP, mg/dL	2.7 ± 0.28	2.6 ± 0.18	2.5 ± 0.19	.39
Total cholesterol, mg/dL	198.8 ± 1.81	203.7 ± 1.96	201.9 ± 1.98	.25
LDL cholesterol, mg/dL	123.0 ± 1.58	125.8 ± 1.65	123.3 ± 1.73	.90
HDL-C, mg/dL	60.9 ± 0.81	61.5 ± 0.80	62.2 ± 0.80	.27
TG, mg/dL	111.1 ± 3.08	119.6 ± 4.68	116.2 ± 5.3	.41
Glucose, mg/dL	96.0 ± 0.84	94.3 ± 0.94	94.6 ± 0.84	.26
Insulin, mUI/L	8.3 ± 0.33	7.5 ± 0.31	7.6 ± 0.30	.12
HOMA-IR	1.92 ± 0.10	2.03 ± 0.16	1.68 ± 0.09	.59

Values are expressed as means ± SE. Abbreviation: *LDL*, low-density lipoprotein.

^a $P > .05$ considered significant.

Table 3

Description of foods and nutrients included in the DII structure, ORISCAV-LUX study, 2007-2008

Food/nutrients items	n	Mean	SD	Minimum	Maximum
Energy, kcal	1346	2419.41	934.71	859	6252
Total protein intake, g	1343	94.79	37.22	31	237
Total lipid intake, g	1341	103.88	46.38	33	294
Saturated fatty acid, g	1343	36.42	17.86	10	119
Monounsaturated fatty acid, g	1338	43.76	20.00	13	128
PUFA, g	1337	16.97	8.51	5	55
Omega 6, mg	1335	14.05	7.33	4	46
Omega 3, mg	1338	1.25	0.73	0	5
Cholesterol, g	1340	347.05	166.19	83	1051
Carbohydrates, g	1341	256.23	107.85	79	795
Total fiber, g	1339	25.03	10.44	8	72
Alcohol, mg	1339	8.65	11.41	0	64
Vitamin A (retinol), μ g	1335	498.07	376.49	75	2392
β -Carotene, mg	1329	5227.37	3840.84	881	25987
Vitamin B1 (thiamin), mg	1345	1.66	0.65	1	4
Vitamin B2 (riboflavin), mg	1344	2.03	0.83	1	6
Vitamin B3 (niacin), mg	1339	22.66	8.53	7	52
Vitamin B6 (pyridoxine), mg	1340	2.36	0.94	1	6
Vitamin B9 (folic acid), μ g	1340	377.10	158.69	111	961
Vitamin B12, μ g	1334	6.16	3.46	1	25
Vitamin C (ascorbic acid), mg	1331	159.02	98.03	31	628
Vitamin D (calciferol), IU	1335	3.37	2.71	0	16
Vitamin E (tocopherols), IU	1336	15.73	7.71	4	50
Iron, mg	1340	14.87	5.55	5	37
Magnesium, mg	1343	434.22	139.91	178	1006

Data presented are expressed as mean, *SD*, and minimum and maximum values of daily intake of each food/nutrient items included in the DII structure.

Table 4

Multivariate associations of the MetS or its components with the DII in adults participating in the ORISCAV-LUX study, 2007-2008

	Crude OR	95% CI	<i>P</i> ^a	Adjusted OR ^b	95% CI	<i>P</i> ^a
MetS ^c	0.99	0.74-1.34	.96	1.18	0.81-1.71	.39
Components						
Abdominal obesity	0.96	0.73-1.27	.78	1.12	0.81-1.56	.49
Raised TG	1.02	0.76-1.36	.92	1.17	0.82-1.67	.40
Low HDL-C	1.05	0.76-1.47	.75	1.46	1.00-2.13	.050
High BP	0.75	0.58-0.97	.03	0.85	0.61-1.18	.33
Hyperglycemia	1.18	0.87-1.60	.28	1.30	0.90-1.89	.17

^a $P > .05$ considered significant.

^b Odds ratio adjusted for age (continuous variable), sex, education, income smoking status, and physical activity. Anti-inflammatory profile of DII (DII -1) was considered as the reference category.

^c Metabolic syndrome determined if at least 3 of 5 following Third Adult Treatment Panel (ATP-III) criteria exist: (1) WC greater than or equal to 102 cm for men and greater than or equal to 88 cm for women, (2) raised concentration of TG greater than or equal to 150 mg/dL or specific treatment for this lipid anomaly, (3) reduced concentration of HDL-C less than 40 mg/dL for men and less than 50 mg/dL for women or specific treatment for this lipid anomaly, (4) SBP was greater than or equal to 130 mm Hg or DBP greater than or equal to 85 mm Hg or treatment of previously diagnosed hypertension, and (5) FPG level greater than or equal to 100 mg/dL or use of medication for hyperglycemia.