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Dietary inflammatory index and prevalence of overweight and obesity in Brazilian graduates from the Cohort of Universities of Minas Gerais (CUME project)

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ABSTRACT

Objectives: The aim of this study was to evaluate the independent association of the dietary inflammatory index (DII®) score with overweight and obesity in Brazilian participants of the Cohort of Universities of Minas Gerais (CUME project).

Methods: This was a cross-sectional study consisting of 3,151 graduates and postgraduates (2197 women) with a mean (SD) age of 36.3 y (±9.4 y). Sociodemographic characteristics, lifestyle, and anthropometric data were assessed via online self-reported questionnaire. Additionally, a validated food frequency questionnaire with 144 food items was used to generate energy-adjusted DII (E-DII™) scores, which evaluated the inflammatory potential of the diet.

Results: The prevalence of overweight and obesity were 28.2% and 11%, respectively. Participants in the highest E-DII quartile (most proinflammatory diet) were more likely to be smokers/former smokers; sedentary; and consumers of red and ultra-processed meats, fats and oils (excluding olive oil), bottled fruit juices and soft drinks, sugars, sweets, and higher overall caloric intake, compared with the first quartile of E-DII. Both men and women in the fourth E-DII quartile had the highest prevalence of overweight and obesity (prevalence ratio [PR], 1.35; 95% confidence interval [CI], 1.14–1.59 and PR, 1.97; 95% CI, 1.20–3.22, respectively, in men; PR, 1.38; 95% CI, 1.17 to 1.65 and PR, 1.95; 95% CI, 1.31–2.90, respectively, in women).

Conclusion: The most proinflammatory dietary pattern was associated with a higher prevalence of overweight and obesity and other unhealthy lifestyles including being sedentary, smoking, and consuming a obesogenic diet.

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Introduction

Obesity, defined as excessive accumulation of body fat, is a chronic multifactorial disease considered a public health problem in Brazil [1] and worldwide [2]. In Brazil, the percentage of overweight individuals increased from 42.6% in 2006 to 53.8% in 2016, and obesity rose from 11.8% to 18.9% in the same time [1]. By 2030, the number of overweight or obese people worldwide could reach 3.3 billion [3].

In this sense, low-grade inflammation is a recognized link between obesity and other chronic diseases (e.g., diabetes, metabolic syndrome, and cardiovascular diseases) [4–6]. At the same time, healthy dietary patterns and specific dietary components (e.g., folate, unsaturated fatty acids, and polyphenols) have been associated with inflammation [7–9] as well as with comorbidity-related obesity [10–13].

Additionally, global dietary indexes allow a more comprehensive evaluation of dietary patterns. Among them, the dietary inflammatory index (DII®) has emerged as a new tool to assess the inflammatory potential of the diet and its relationship with cardiometabolic risk, such as excess body weight, in different populations [14]. In fact, most proinflammatory diets (higher DII values) have been associated with higher occurrences of metabolic disorders, cardiovascular diseases, and overall and cause-specific mortality [15–18]. The relationship between DII and chronic disease outcomes has not been reported in the Brazilian population in general, but was documented in specific groups, such as adolescents [19], young adults [20], or individuals undergoing bariatric surgery [21].

In this cross-sectional study, we aimed to evaluate the independent association of DII scores with overweight and obesity at baseline in participants of the Cohort of Universities of Minas Gerais (CUME project) [22]. Our hypothesis is that higher DII score (more proinflammatory diet) would be associated with a higher prevalence of overweight or obesity, after accounting for several confounders.

Materials, participants, and methods

CUME project

The CUME project is a concurrent open cohort whose objective is to evaluate the effects of the Brazilian dietary pattern and the nutritional transition on noncommunicable diseases (NCD) in adults ≥18 y of age, who are graduates and postgraduates at the Universidade Federal de Viçosa (UFV) or the Universidade Federal de Minas Gerais (UFMG), institutions located in the state of Minas Gerais, Brazil [22].

The cohort methodology has been previously described [22]. Briefly, potential volunteers were invited by e-mail and directed to the CUME's virtual page. A self-reported, online questionnaire consisted of two parts and were sent separately within 1 wk of each other. The first stage consisted of questions related to sociodemographic, anthropometric, lifestyle, and health-related data. In the second stage, participants completed the food frequency questionnaire (FFQ) and additional questions related to dietary practices and consumption of specialty products [22].

The CUME project was designed in accordance with the experience of the team as researchers of the study Seguimiento University of Navarra (SUN project), which was developed in Spain, and whose objective is to analyze the influence of the Mediterranean diet on health outcomes [23].

Study population

This was a cross-sectional analysis of baseline data from the CUME project [22]. Of the 4986 volunteers who answered the baseline CUME questionnaire from March to August 2016, 3151 were included in the present study. Inclusion criteria were residency in Brazil over the previous year and completion of the baseline questionnaire, including the FFQ.

The study was approved by the Human Research Ethics Committees of UFMG and UFV. All participants read the informed consent form and indicated online agreement (with an online command) before responding to the questionnaire [22].

Food consumption and DII computation

In order to evaluate food consumption and calculate the energy-adjusted DII (E-DII™) score, a 144-item FFQ was applied, which was previously validated for the Brazilian population [24]. Each participant reported the frequency of consumption of a food (daily, weekly, monthly, or annually), the number of times it was consumed (0 to ≥9 times) and the portion size appropriate to each food. Moreover, they answered questions related to daily dietary practices, such as number of meals per day; intake of visible fat of meats; and addition of salt and sugar in ready-made meals. To enhance self-completion of the FFQ, the team developed a photographic album with 96 images of foods and serving utensils to facilitate the visualization of portions of food to enhance a reliable response regarding consumption.

Nutrient intakes were calculated using daily intake of each food item and its nutrient composition, according to the Brazilian Food Composition Table [25]. Where data were lacking in the Brazilian tool, the US Department of Agriculture table [26] was used. The Brazilian Carotenoid Composition Table in Foods [27] and the Phenol-Explorer database [28] were used for estimation of β-carotene and flavonoids, respectively.

DII scores were calculated using a scoring algorithm based on a review of 1943 articles linking 45 food parameters and six inflammatory biomarkers (interleukin [IL]-1β, IL-4, IL-6, IL-10, tumor necrosis factor [TNF]-α, and C-reactive protein [CRP]). Then, food parameters were assigned to a positive score (+1) if the effect was proinflammatory or a negative score (−1) if the effect was anti-inflammatory. A score of zero was assigned if the parameter did not generate significant changes in the inflammatory biomarkers, as previously detailed [14]. DII density scores, which adjust for energy intake, also were calculated; before standardizing to ation with the energy-adjusted global reference database, the parameters were each converted to 1000 kcal of energy intake, and energy intake as food parameters was excluded from the actual E-DII calculation. These scores were based on a similar algorithm that used an energy-adjusted global database [29,30]. Positive DII and E-DII scores represent food patterns with the most proinflammatory potential, whereas negative DII and E-DII values represent food patterns with the most anti-inflammatory potential. The DII has been construct validated with several inflammatory markers in various studies [14,31].

The E-DII scores in the present study were based on 35 food parameters available from the FFQ: energy intake (used for adjustment); carbohydrate; protein; total fat; cholesterol; saturated fat; trans fat; monounsaturated and polyunsaturated fat; ω-3 and ω-6; fiber; alcohol; niacin; thiamine; riboflavin; vitamins B_{12} and B_6; folic acid; vitamins A, C, D, and E; iron; selenium; magnesium; zinc; caffeine; β-carotene; flavonol-3-ol; flavones, flavonols, and flavonoids; anthocyanidins; and isoflavones.

Determination of overweight and obesity

The participants reported their current weight and height by completing the online questionnaire. Body mass index (BMI; kg/m^2) was calculated as body weight (in kg) divided by height (in m) squared. The weight status of the adults was classified according to the criteria defined by the World Health Organization [32] as being normal weight (BMI 18.5 to <25 kg/m^2), overweight (BMI 25 to <30 kg/m^2), or obese (BMI ≥30 kg/m^2). For participants ≥60 y of age, weight status was classified according to the Pan American Health Organization [33]: normal weight (BMI 23 to <28 kg/m^2), overweight (BMI 28 kg/m^2), or obese (BMI ≥30 kg/m^2). A validation study of a subsample of 172 CUME participants at baseline compared self-reported height and weight with measured height and weight and obtained adequate correlation coefficients (intraclass correlation coefficients [ICC], 0.989; 95% confidence interval [CI], 0.985–0.992 and ICC, 0.995; 95% CI, 0.993–0.996 for height and weight, respectively, and kappa coefficient of 0.882 between obesity diagnosis based on self-reported and measured data, indicates almost perfect agreement) [22,34].

Assessment of other variables

Information on the practice of physical activity (yes or no), smoking (never, former or current smoker), age (y), sex (male or female), and subject area of concentration (health sciences, humanities, physical sciences and agrarian sciences) also was collected.

Statistical analysis

Based on a previous study that investigated the relationship between DII and overweight/obesity cases [28], with a similar population to the CUME project, a minimal sample of 1426 participants was calculated for this study using a 95% CI (type 1 error rate of 0.05, two-tailed); 80% statistical power; ratio exposed/unexposed of 1; prevalence of overweight/obesity of 20% in individuals in the first quartile of the inflammatory diet index (most anti-inflammatory); and obesity prevalence ratio of 1.32.

The database was written in SPSS® version 20 (SPSS, Chicago, IL, USA). All analyses were performed with Stata® version 13 (StataCorp, College Station, TX, USA) and statistical significance was set at $\alpha = 5\%$ ($P < 0.05$). To control for the effect of

caloric intake on nutrients and food groups evaluated, models were adjusted by the residual nutrient method [35]. To evaluate the associations between E-DII score and nutrient intake, food groups, BMI, and prevalence of overweight and obesity, participants were categorized by E-DII quartile.

The comparisons of sociodemographic characteristics and BMI among E-DII quartiles were made with Pearson's χ^2 test for categorical variables and analysis of variance for continuous variables. When a significant difference was detected, the Bonferroni *post hoc* test was applied to correct multiple comparisons.

Multiple linear regression analyses were performed with adjustment for sex, age, BMI, smoking, and physical activity to compare the consumption of macro- and micro-nutrients, food groups, and feeding practices among the E-DII quartiles.

Finally, Poisson regression multivariate models, adjusted for age, smoking, physical activity, and graduation area, for male and female groups, and additionally adjusted for sex for total sample, were fitted to evaluate the association of a proinflammatory diet with overweight and obesity. Prevalence ratio (PR) and 95% CIs were estimated using the first E-DII (anti-inflammatory) quartile as the reference category.

Results

Of the 3151 participants in the CUME project, 30.3% were men and 69.7% women, with a mean age (SD) of 36.3 y (± 9.4 y), as only 3% of the population were >60 y of age. The E-DII score had a mean (SD) of −0.12 (1.63) and ranged from −5.48 to +4.55. The prevalence of overweight was 28.2% and obesity was 11%. Among overweight participants, 42.6% were men and 57.4% were women ($P < 0.001$).

The total energy intake of participants was ~3000 kcal/d across all E-DII quartiles ($P < 0.001$).

Table 1 shows the main sociodemographic characteristics of the participants according to E-DII quartile. The individuals included in the last quartile (most proinflammatory) were more likely to be former or current smokers, sedentary, and to consume more alcohol compared with those included in the first quartile (most anti-inflammatory). Regarding the graduation area, participants included in the first quartile were more likely to have concentrated in the health sciences.

Women were represented in higher proportions than men in all quartiles. Unlike men, however, their frequency decreased as E-DII scores became most proinflammatory (Table 1). Furthermore, BMI values were significantly higher in the highest E-DII quartile, compared with the first quartile, for both men and women (Fig. 1).

In relation to food consumption according to E-DII scores, the intake of dairy, white and lean meats, fish or shellfish and eggs, whole grains, legumes, olive oil and oilseeds, fruits, vegetables, and natural fruit juices was significantly higher in the first quartile (most anti-inflammatory) and the consumption of red, fat. and ultra-processed meats, fats, and oils with the exception of olive oil, industrial juices, soft drinks, sugars and sweets was higher in the last quartile (most pro-inflammatory; Table 2).

Participants in the last quartile (most pro-inflammatory) were more likely to be overweight (Table 3) or obese (Table 4), regardless of confounding factors, including sex, age, smoking status, physical activity, and graduation area. When the sample was stratified by sex, the results were similar for both outcomes (Tables 3 and 4).

Discussion

In the present study, participants of the CUME project in the most proinflammatory E-DII quartile had higher BMI values and a higher prevalences of overweight and obesity than those in the lower (most anti-inflammatory) E-DII quartiles.

Results from the present study are in agreement with those obtained in studies conducted with other populations. In the Spanish SUN cohort, with 7027 individuals having a mean age of 37.4 y, the most proinflammatory DII was also associated with a higher risk for weight gain and a greater risk for overweight and obesity, independently of total caloric intake, physical activity, history of obesity, and baseline weight [31]. In the PREDIMED (PREvención con DIeta MEDiterránea) trial (also in Spain), with 7236 individuals with cardiometabolic risk, the authors also observed that participants with a most proinflammatory diet (higher DII scores) presented higher values of BMI independent of total caloric intake, age, diabetes, hypertension, smoking

Table 1
Sociodemographic characteristics according to E-DII of the participants of the CUME project (N = 3151), 2016

	E-DII				
	Q1 (−5.48 to −1.37) (most anti-inflammatory)	Q2 (−1.37 to −0.26)	Q3 (−0.26 to 1.08)	Q4 (1.08 to 4.55) (most proinflammatory)	
Characteristics	n = 787	n = 788	n = 788	n = 788	*P*-value
Sex, n (%)					
Male	205 (26.1)	215 (27.3)	247 (31.4)	287 (36.4)	<0.001
Female	582 (73.9)	573 (72.7)	541 (68.6)	501 (63.6)	
Age, y, mean (SD)	36.5 ± 9.9	36.8 ± 10	35.7 ± 8.8	36.1 ± 8.9	0.04
Marital status, n (%)					
Married or stable union	413 (52.7)	410 (52.6)	403 (51.8)	392 (50.5)	0.84
Single, separated/divorced, widower	370 (47.2)	371 (47.4)	377 (48.2)	390 (49.5)	
Smoking. n (%)					
Never smoked	660 (83.8)	626 (79.4)	610 (77.4)	603 (76.5)	0.001
Former and current smokers	127 (16.2)	162 (20.6)	178 (22.6)	185 (23.5)	
Alcoholic beverage consumption, n (%)					
No	253 (32.2)	229 (29.1)	172 (21.8)	202 (25.7)	<0.001
Yes	534 (67.8)	559 (70.9)	616 (78.2)	586 (74.3)	
Physical activity practice, n (%)					
Yes	642 (81.6)	625 (79.3)	570 (72.4)	538 (68.3)	<0.001
No	145 (18.4)	163 (20.7)	218 (27.6)	250 (31.7)	
Graduation area, n (%)					
Health sciences	305 (38.7)	297 (37.7)	267 (33.9)	255 (32.3)	0.02
Humanities	271 (34.4)	250 (31.7)	262 (33.2)	288 (36.5)	
Physical sciences	141 (17.9)	156 (19.8)	163 (20.7)	139 (17.6)	
Agrarian sciences	70 (8.9)	85 (10.8)	96 (12.2)	106 (13.4)	

CUME, Cohort of Universities of Minas Gerais; E-DII, energy-adjusted dietary inflammatory index.
P-value of analysis of variance or χ^2 test, for continuous or categorical variables, respectively.

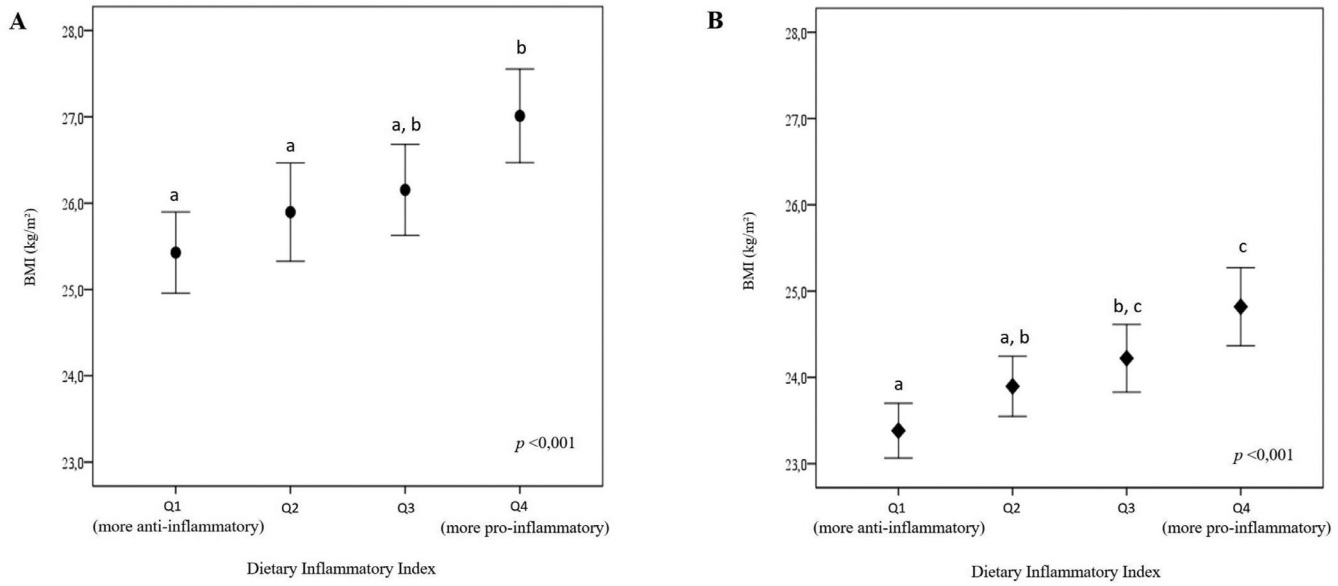

Fig. 1. Body mass index values according to E-DII for male (A) and female (B) participants in the CUME project (n = 3151), 2016.
P value < 0001 from ANOVA tests. Different letters (a, b and c) indicate mean statistical differences according to Bonferroni post hoc to correct multiple comparisons. Q, quartile.

status, physical activity, educational level, and marital status [36]. A positive correlation between BMI and DII values was reported by Ruiz-Canela et al. [37] in a review that included data from the following:

- PREDIMED;
- The SUN project;
- The Geelong Osteoporosis Study with 1363 Australian men ≥18 y of age;

Table 2
Daily food consumption according to E-DII of the participants of the CUME project (n = 3151), 2016

	Daily consumption E-DII				
	Q1 (−5.48 to −1.37) (most anti-inflammatory)	Q2 (−1.37 to −0.26)	Q3 (−0.26 to 1.08)	Q4 (1.08 to 4.55) (most proinflammatory)	
	n = 787	n = 788	n = 788	n = 788	P_{trend}*
Energy intake, kcal	2899 ± 1483	3072 ± 1735	3155 ± 1471	3330 ± 1573	<**0.001**
Carbohydrate, %EI	50.7 ± 7.8	50.1 ± 9.5	49.5 ± 9.3	49.9 ± 12.8	0.13
Protein, %EI	19 ± 4.5	18.8 ± 5.9	18.7 ± 4.6	18.3 ± 5.7	**0.002**
Lipid, %EI	30.2 ± 6.3	31 ± 7.3	31.7 ± 7.5	31.9 ± 10.3	< **0.001**
MUFA, %EI	14.3 ± 4.3	13.8 ± 4.8	13.5 ± 4.8	12.6 ± 5.7	< **0.001**
PUFA, %EI	5.8 ± 2	5.4 ± 2.1	5.4 ± 2.4	4.6 ± 2.4	< **0.001**
SFA, %EI	7.9 ± 2.2	8.6 ± 3	9 ± 3.2	9.4 ± 4.6	< **0.001**
Food groups (g/d)					
Dairy products	274.5 ± 207.5	266.2 ± 207.7	258.1 ± 199.8	253.4 ± 232.2	**0.01**
Red, fat, and ultra-processed meats	115.8 ± 82	125.5 ± 99.0	142.4 ± 110.7	156.4 ± 153.4	<**0.001**
White and lean meats, fish/shellfish, and eggs	133.7 ± 117.6	121.6 ± 159.3	107.9 ± 116.5	91.5 ± 128	<**0.001**
Refined cereals (breads and noodles)	131.0 ± 89.6	142.9 ± 94.3	147.8 ± 99.5	149.2 ± 117.6	0.05
Whole grains (breads, oats, and rice)	63.3 ± 58.8	53.7 ± 55.1	46.4 ± 53.5	34.9 ± 51.5	<**0.001**
Legumes	115.5 ± 122.3	72.7 ± 96.5	66.8 ± 73.2	42.1 ± 46.1	<**0.001**
Fats and oils, excluding olive oil	14.1 ± 12.3	16.3 ± 14.9	18 ± 15.5	18.6 ± 17.8	<**0.001**
Olive oil	4.6 ± 3.6	4.2 ± 3.3	4.2 ± 4.3	3.9 ± 4.4	**0.003**
Fruits	766.6 ± 467.5	569.2 ± 333.4	397.7 ± 298.3	224.4 ± 241.1	<**0.001**
Vegetables, excluding potatoes	261.4 ± 169.7	199.5 ± 110	154.7 ± 93.4	109.1 ± 84.9	<**0.001**
Natural fruit juice	153.9 ± 143.4	130.2 ± 124.6	106.7 ± 118.2	85.8 ± 126.8	<**0.001**
Industrial juices and soft drinks	100.5 ± 142.1	110.7 ± 152.8	133.4 ± 165.9	138.8 ± 192.9	**0.002**
Alcoholic beverage	93.0 ± 136.7	95.6 ± 173.5	108.2 ± 193.2	92.7 ± 145.9	0.15
Oilseeds	18.2 ± 23.2	15.7 ± 29.9	13.5 ± 29.6	9.6 ± 22.5	<**0.001**
Sugars and sweets	33.2 ± 33.7	34.9 ± 37.7	39.4 ± 39	40.5 ± 51.1	**0.001**
Preparation of the refined cereal base and fried foods	61.9 ± 59	69.8 ± 72.2	75.6 ± 79.8	69.4 ± 102	0.49

BMI, body mass index; CUME, Cohort of Universities of Minas Gerais; E-DII, energy-adjusted dietary inflammatory index; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; EI, energy intake.
Data are expressed as mean ± SD.
*_P-values_ < 0.05 are in bold style by the multiple linear regression model, adjusted for sex (male or female), age (y), BMI (kg/m^2), smoking (never smoked or former or current smokers).

Table 3
Prevalence ratio for overweight[*,†] according to E-DII of the participants in CUME project (N = 3151), 2016

	Simple Poisson regression		Adjusted Poisson regression[‡,§]	
Total	PR (95% CI)	*P*-value	PR (95% CI)	*P*-value
E-DII (quartile)				
1 (most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.15 (1.01–1.33)	**0.036**	1.13 (0.98–1.29)	0.08
3	1.26 (1.11–1.44)	**0.001**	1.22 (1.07–1.39)	**0.002**
4 (most proinflammatory)	1.50 (1.32–1.70)	<**0.001**	1.39 (1.23–1.57)	<**0.001**
Male				
E-DII (quartile)				
1 (most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.08 (0.90–1.32)	0.381	1.08 (0.89–1.31)	0.40
3	1.10 (0.91–1.32)	0.310	1.10 (0.91–1.32)	0.31
4 (most pro-inflammatory)	1.35 (1.14–1.59)	<**0.001**	1.35 (1.14–1.59)	<**0.001**
Female				
E-DII (quartile)				
1 most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.19 (0.99–1.43)	0.064	1.14 (0.95–1.36)	0.14
3	1.32 (1.10–1.58)	**0.002**	1.30 (1.10–1.55)	**0.003**
4 (most proinflammatory)	1.46 (1.22–1.74)	<**0.001**	1.38 (1.17–1.65)	<**0.001**

BMI, body mass index; CUME, Cohort of Universities of Minas Gerais; E-DII, energy-adjusted dietary inflammatory index; PR, prevalence ratio.
P-values in bold style are presented in significant regression models.
*Overweight for BMI ≥25 kg/m^2 [33] and BMI ≥28 kg/m^2 [32].
†Total sample shows 1233 overweight individuals: 525 men and 708 women.
‡Adjusted for age (y), smoking (never smoked or former or current smokers), physical activity (yes or no), and graduation area (health, human, exact, and agrarian sciences) for male and female groups.
§Additional adjustment for sex (male or female), for total sample.

- The SU.VI.MAX (Supplementation Study on Vitamins and Minerals Antioxidants) study with 7743 French women between 35 and 60 y of age and French men 45 to 60 y of age; and
- The NHANES (National Health and Nutrition Examination Survey) with 1734 Americans with previously diagnosed cardiovascular disease [38].

Together, these outcomes support the hypothesis that a more proinflammatory diet is related to the prevalence of overweight and obesity.

In this context, the origin of inflammation during obesity is not yet fully understood [39]. Inflammation is known to be associated with adiposity, but this relationship could be bidirectional, creating a vicious cycle of positive feedback [40]. Additionally, excess of specific nutrients and some foods that have been associated with inflammation [41–44] may exacerbate the effects of adiposity. Furthermore, the most proinflammatory DII (highest quartile) in this study was associated with the most unhealthy eating habits (e.g., higher consumption of red, fat, and ultra-processed meats, and fats, soft drinks, sugar, and sweets), and the lowest DII quartile was associated with the healthiest diet (e.g., higher consumption of dairy products, white and lean meats, fish/shellfish and eggs, whole grains, legumes, olive oil, fruits, and vegetables). In fact, dietary patterns provide one of the best approaches to understanding

Table 4
Prevalence ratio for obesity[*,†] according to E-DII of the participants of CUME project (N = 3151), 2016

	Simple Poisson regression		Adjusted Poisson regression[‡,§]	
Total	PR (95% CI)	*P*-value	PR (95% CI)	*P*-value
E-DII (quartile)				
1 (most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.63 (1.17–2.27)	**0.004**	1.56 (1.12–2.17)	**0.008**
3	1.78 (1.28–2.47)	<**0.001**	1.68 (1.21–2.31)	**0.002**
4 (most proinflammatory)	2.24 (1.64–3.06)	<**0.001**	1.99 (1.46–2.71)	<**0.001**
Male				
E-DII (quartile)				
1 (most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.65 (0.97–2.81)	0.064	1.63 (0.96–2.77)	0.07
3	1.70 (1.01–2.85)	**0.043**	1.70 (1.01–2.84)	**0.04**
4 (most proinflammatory)	1.99 (1.22–3.26)	<**0.001**	1.97 (1.20–3.22)	<**0.001**
Female				
E-DII (quartile)				
1 (most anti-inflammatory)	1 (ref.)		1 (ref.)	
2	1.60 (1.05–2.44)	**0.028**	1.51 (0.99–2.29)	0.05
3	1.75 (1.16–2.66)	**0.008**	1.65 (1.09–2.50)	**0.02**
4 (most proinflammatory)	2.24 (1.50–3.36)	<**0.001**	1.95 (1.31–2.90)	**0.001**

BMI, body mass index; CUME, Cohort of Universities of Minas Gerais; E-DII, energy-adjusted dietary inflammatory index; PR, prevalence ratio.
P-values in bold style are presented in significant regression models.
*Obesity for BMI ≥30 kg/m^2 [32,33].
†Total sample presents 347 individuals with obesity, 144 men and 203 women.
‡Adjusted for age (y), smoking (never smoked or former or current smokers), physical activity (yes or no) and graduation area (health, human, exact, and agrarian sciences) for male and female groups.

the relationship between diet and disease because they allow for the evaluation of the inflammatory potential of diet, taking into account the potential synergies of different foods [45,46]. Given this, it is not surprising that diet quality tends to be better among those individuals with lower relative weight [47]. In turn, results from the present study also point to a possible solution for controlling chronic systemic inflammation. Although 8 of the parameters that comprise the DII are proinflammatory, 37 are anti-inflammatory. This latter group is characterized by being colorful, flavorful, nutrient dense, and calorie sparse [14]. So, consuming these constituents will not only reduce inflammation, but it is likely that it will lead to weight loss.

In the cross-sectional HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescents) study, conducted with 3528 adolescents, Shivappa et al. [48] found that consumption of food items that tended to increase DII include bread and rolls; chocolate; margarine, butter, animal fats, and vegetable lipids; carbonated soft drinks; meat; and cakes, pies, biscuits, and sugar/honey/jam; and had lower consumption of vegetables (excluding potatoes), fruits, fruits and vegetable juices, and fish. Additionally, higher serum concentrations of IL-1, IL-2, and TNF-α were observed in adolescents with higher DII scores. Studies using DII scores for analysis also have reported positive associations of unhealthy diets (proinflammatory DII) with increased IL-6, IL-1, TNF-α, and CRP concentrations and lower concentrations of IL-10; whereas in healthy diets (anti-inflammatory DII) the concentrations of these markers were uniformly lower [31,35,49,50]. Thus, we can conclude that a diet considered healthy tends to be associated with lower DII (more anti-inflammatory) scores which, in turn, will reduce the occurrence of subclinical inflammatory processes.

The present study also found other attributes of healthier lifestyles among those who consumed a most anti-inflammatory diet: They were more likely to be nonsmokers, non-consumers of alcohol, and were more physically active, as has been reported by previous studies [31,51,52]. This combination of factors can result in a better quality of life and reduce the risk for developing future problems such as chronic inflammation, obesity, and other chronic NCDs [53–55].

On other hand, our sample was predominantly composed of young adults (only 3% of the population is ≥60 y of age) and all participants graduated from university. Other studies have found associations between healthier (most anti-inflammatory) diet and higher educational attainment (>4 years of college) among older people [56,57].

The strengths of the present study are its large sample size, which guarantees a high statistical power; use of a validated instrument to measure the inflammatory potential of the diet; control of important confounding factors in the analysis; the high level of education of the participants, which would tend to increase reliability of the self-reported information and to ensure a degree of homogeneity, increasing the internal validity of our study and reducing confounding related to education. Moreover, we validated self-reported weight, height, and BMI in a subsample of our cohort [22,34]. Our study is only the second study of the DII in relation to food intakes and cardiometabolic outcome in the Brazilian population and the third study in South American. The other two studies were in Argentina, where higher DII scores were associated with increased incidence of colorectal [58] and prostate [59] cancers. The other studies included one in northeastern Brazil, where inflammatory bowel disease was positively correlated with BMI in people with progressive multiple sclerosis [60] and a cross-sectional study (nested within a cohort) in Ribeirão Preto, São Paulo, where the DII was evaluated in young adults and had no association with insulin resistance or metabolic syndrome in either sex [20].

Some potential limitations of the study need to be recognized: The use of BMI as an indicator of adiposity did not allow us to differentiate lean mass from fat mass, or even total adiposity versus central adiposity, despite being a tool widely used in epidemiologic studies, owing to its easy measurement and good correlation with body fat [61]. We did not measure inflammatory markers in plasma to assess their association with E-DII scores in the sample studied, due to the nature of online data collection. However, such associations had previously been reported [62–64]. In this context, Garcia-Arellano et al. [9] point out that the use of DII could help in the study of associations between food exposures and clinical events, with lower costs and avoidance of blood collection. Finally, the analysis of physical activity was classified only as whether or not it was practiced, as the study does not yet present the evaluation by the Brazilian version of the International Physical Activity Questionnaire [65] or the Global Physical Activity Questionnaire [66]. However, even using this crude measure we showed that the non-practice of physical activity contributes to the presence of obesity.

Conclusion

The most proinflammatory dietary pattern was associated with a higher prevalence of overweight and obesity in men and women participating in the baseline of the CUME study. E-DII scores also were associated with other unhealthy lifestyle characteristics, including sedentariness, smoking, and consumption of an obesogenic diet.

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