Research, Society and Development, v. 11, n. 10, e284111032721, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i10.32721

Macronutrient intake is not associated with cardiovascular risk assessed by Coronary Calcium Score, but dietary fiber showed a significantly inverse relationship

A ingestão de macronutrientes não está associada ao risco cardiovascular avaliado pelo Escore de Cálcio Coronariano, mas a fibra alimentar mostrou uma relação significativamente inversa

La ingesta de macronutrientes no está asociada al riesgo cardiovascular evaluado por el Puntaje de Calcio Coronario, pero la fibra dietética mostró una ralación significativamente inversa

Received: 07/09/2022 | Reviewed: 07/22/2022 | Accept: 07/24/2022 | Published: 07/312022

Natalia de Morais Cunha
ORCID: https://orcid.org/0000-0002-2877-9138
Universidade Federal do Paraná, Brazil
E-mail: cunhanutri@gmail.com
Francisca Eugenia Zaina Nagano
ORCID: https://orcid.org/0000-0003-0318-9331
Universidade Federal do Paraná, Brazil
E-mail: francisca_zaina@yahoo.com.br
Cassia Cristina Paes de Almeida
ORCID: https://orcid.org/0000-0003-4966-0053
Universidade Federal do Paraná, Brazil
E-mail: cassiacristina2@yahoo.com.br
Tiago Augusto Magalhães
ORCID: https://orcid.org/0000-0002-7232-4552
Universidade Federal do Paraná, Brazil
E-mail: tiaugusto@gmail.com
Franciane Silvana Formentini
ORCID: https://orcid.org/0000-0003-1286-4466
Universidade Federal do Paraná, Brazil
E-mail: francianeformentini@hotmail.com
Thais Regina Mezzomo
ORCID: https://orcid.org/0000-0002-0884-8052
Universidade Federal do Paraná, Brazil
E-mail: thaismezzomo@yahoo.com.br
Rodrigo Julio Cerci
ORCID: https://orcid.org/0000-0002-3913-7181
Quanta Diagnóstico e Tratamento, Brazil
E-mail: rjcerci@gmail.com
Emilton Lima Junior
ORCID: https://orcid.org/0000-0002-6887-9387
Universidade Federal do Paraná, Brazil
E-mail: doc.emilton@gmail.com

Abstract
Evidence of impact of dietary factors on development of coronary artery calcification remains uncertain. The objective of the study was to evaluate the association between the intake carbohydrates, proteins, total fats, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), trans fatty acids (TFA) cholesterol and fiber with cardiovascular risk. Cross-sectional analysis from 181 dyslipidemic patients. The Coronary Calcium Score (CCS) was used to measure cardiovascular risk. 24-hour recalls were applied and the Multiple Source Method was used to adjust dietary variability. The mean values of the cardiovascular risk categories were compared by analysis of variance, using ANOVA and Kruskal-Wallis. Tukey's post-test was used for multiple analyzes. Simple and multiple binary logistic regression, was used as a measure of association between nutrient intake and cardiovascular risk. Age, male gender, comorbidities and drug treatment were significantly prevalent in those with CCS>100. The average total energy intake was 1315.6 kcal. Total energy and macronutrient intake were higher among men ($p < 0.05$). No significant results were found regarding the association between cardiovascular risk and macronutrient intake. Fiber intake was inversely associated with cardiovascular risk, regardless of confusion factors (OR:0.918; 95% CI:0.845-0.999; p=0.047). The resultes that there was no association between

nutrientes analyzed to cardiovascular risk assessed by CCS. However, the increase of dietary fiber intake in 1 g/day has been shown to reduce the of future cardiovascular events in 8.2% among individuals in the highest risk category. Therefore, we strongly recommend that fiber intake be encouraged.
Keywords: Cardiovascular diseases; Dietary intake; Dietary fiber.; Tomography; Coronary artery disease.

Resumo
A evidência do impacto de fatores dietéticos no desenvolvimento de calcificação da artéria coronária permanece incerta. O objetivo do estudo foi avaliar a associação entre a ingestão de carboidratos, proteínas, gorduras totais, ácidos graxos saturados (AGS), ácidos graxos monoinsaturados (AGM), ácidos graxos poli-insaturados (AGP), ácidos graxos trans (AGT) colesterol e fibras com risco cardiovascular. Análise transversal de 181 pacientes dislipidêmicos. O Escore de Cálcio Coronariano (ECC) foi usado para medir o risco cardiovascular. Recordatórios de 24 horas foram aplicados e o Método de Fontes Múltiplas foi usado para ajustar a variabilidade da dieta. Os valores médios das categorias de risco cardiovascular foram comparados por análise de variância, utilizando ANOVA e Kruskal-Wallis. O pós-teste de Tukey foi utilizado para análises múltiplas. A regressão logística binária simples e múltipla foi utilizada como medida de associação entre ingestão de nutrientes e risco cardiovascular. Idade, sexo masculino, comorbidades e tratamento medicamentoso foram significativamente prevalentes naqueles com ECC>100. A ingestão energética total média foi de 1315,6 kcal. A ingestão total de energia e macronutrientes foi maior entre os homens (p < 0,05). Não foram encontrados resultados significativos quanto à associação entre risco cardiovascular e ingestão de macronutrientes. A ingestão de fibras foi inversamente associada ao risco cardiovascular, independentemente dos fatores de confusão (OR: 0,918; IC 95%: 0,845-0,999; p=0,047). Os resultados indicam que não houve associação entre os nutrientes analisados com o risco cardiovascular avaliado pelo ECC. No entanto, o aumento da ingestão de fibra alimentar em 1 g/dia demonstrou reduzir a incidência de eventos cardiovasculares futuros em 8,2% entre os indivíduos da categoria de maior risco. Portanto, recomendamos fortemente que a ingestão de fibras seja incentivada.
Palavras-chave: Doenças cardiovasculares; Ingestão dietética; Fibras na dieta; Tomografia; Doença da artéria coronariana.

Resumen
La evidencia del impacto de los factores dietéticos en el desarrollo de la calcificación de la arteria coronaria sigue sin estar clara. El objetivo del estudio fue evaluar la asociación entre la ingesta de carbohidratos, proteínas, grasas totales, ácidos grasos saturados (AGS), ácidos grasos monoinsaturados (AGM), ácidos grasos poliinsaturados (AGP), ácidos grasos trans (AGT), colesterol y fibras con riesgo cardiovascular. Análisis transversal de 181 pacientes dislipidémicos. Para medir el riesgo cardiovascular se utilizó el puntaje de calcio coronario (PCC). Se aplicaron recordatorios de 24 horas y se utilizó el método de fuentes múltiples para ajustar la variabilidad dietética. Los valores medios de las categorías de riesgo cardiovascular se compararon mediante análisis de varianza, utilizando ANOVA y Kruskal-Wallis. La prueba posterior de Tukey se utilizó para múltiples análisis. Se utilizó regresión logística binaria simple y múltiple como medida de asociación entre la ingesta de nutrientes y el riesgo cardiovascular. La edad, el género masculino, las comorbilidades y el tratamiento farmacológico fueron significativamente prevalentes en aquellos con PCC>100. La ingesta calórica total media fue de 1315,6 kcal. La ingesta total de energía y macronutrientes fue mayor entre los hombres (p < 0,05). No se encontraron resultados significativos en cuanto a la asociación entre el riesgo cardiovascular y la ingesta de macronutrientes. La ingesta de fibra se asoció inversamente con el riesgo cardiovascular, independientemente de los factores de confusión (OR: 0,918; IC 95%: 0,845-0,999; p=0,047). Los resultados indican que no hubo asociación entre los nutrientes analizados y el riesgo cardiovascular evaluado por el PCC. Sin embargo, se ha demostrado que aumentar la ingesta de fibra dietética en 1 g/día reduce la incidencia de futuros eventos cardiovasculares en un 8,2 % entre las personas en la categoría de mayor riesgo. Por lo tanto, recomendamos encarecidamente que se fomente la ingesta de fibra.
Palabras clave: Enfermedades cardiovasculares; Ingestión de alimentos; Fibras de la dieta; Tomographie; Enfermedad de la arteria coronaria.

1. Introduction

Coronary artery calcification (CAC) is calcium buildup in the arteries, a specific feature advanced atherosclerosis (Précoma et al., 2019). Pathologically begins with microcalcifications in lesions with intimal thickening (0.5 to 15.0 μm) and evolves into larger fragments that occasionally result in the formation of calcified sheets or plaques >3 mm, which in turn may break and form calcified nodules (Mori et al., 2018; Otsuka et al., 2014). The evolution of CAC is associated with calcium plaque growth, vascular injury and inflammation (Mcclelland et al., 2009). In the presence of diabetes mellitus (DM), hypertension and chronic kidney disease (CKD) the progression is enhanced directly implies the development of coronary artery disease (CAD) (Otsuka et al., 2014; Précoma et al., 2019).

The presence and extent of CAC may be identified by imaging exams, such as the Coronary Calcium Score (CCS), which is used to assess the severity of atherosclerosis besides has emerged as an available, consistent and reproducible method of assessing cardiovascular risk and predicting coronary events in an asymptomatic or symptomatic patient, thus essentially guiding primary prevention strategies (Précoma et al., 2019).

Although it is known that individuals with multiple risk factors, such as metabolic syndrome, dyslipidemia, DM, smoking, hypertension and chronic kidney disease, are more likely to develop CAC (Mori et al., 2018; Otsuka et al., 2014), it is still unclear whether dietary factors such as total fat intake, saturated fatty acids (SFA) and cholesterol, constitute significant risk factors for CAC (Sung et al., 2015).

The guidelines of the European Society of Cardiology (ESC) (Visseren et al., 2021), American Heart Association (AHA) and American College of Cardiology (ACC) (Arnett et al., 2019) suggest that healthy eating patterns are associated with better cardiovascular health. While previous research has shown associations between increased intake of SFA and trans fatty acids (TFA) and fiber decrease with the risk of cardiovascular disease (CVD) (Guasch-Ferré et al., 2015; Ricci et al., 2018), prospective studies revealed conflicting results, mainly on the role of dietary fats (Dehghan et al., 2017; Mente et al., 2017).

Evidence associating specific nutrients to cardiovascular risk remain uncertain and need to be better elucidated. Up to the present date, no epidemiological study has evaluated the direct impact of food intake, with cardiovascular risk, assessed by the presence of CAC, in dyslipidemic and asymptomatic patients. Therefore, the aim of the study is to evaluate the intake of carbohydrate, protein, total fat, SFA, monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), TFA, dietary cholesterol and fiber and the influence on the development of subclinical coronary atherosclerosis in individuals without a previous cardiovascular event.

2. Methodology

Study design

This is a cross sectional study carried out in Paraná/Brazil, between 2018-2020. The sample comprised 196 participants treated at the Nutrition Outpatient of Hospital de Clínicas – Universidade Federal do Paraná (HC/UFPR) (Clinical Hospital - Federal University of Paraná) and Quanta Diagnóstico e Tratamento service. Among them, 16 gave up the study for personal reasons, remaining 180 adult participants, of both sexes and with evidence of dyslipidemia. The collection took place after signing the Free and Informed Consent (IC). The study protocol was approved by the Human Research Ethics Committee of the institution in question, under number 2.399.025.

The exclusion criteria were: conditions that would prevent obtaining reliable clinical and anthropometric data (amputation, edema, ascites), goiter, pregnancy or lactation, participants with no evidence of dyslipidemia, refusal to report to the second 24-hour recall and failure to undergo CCS. Patients with a diagnosis of CAD or cardiovascular event (present in medical records) were also excluded because they are high cardiovascular risk and without indication for CAC investigation.

Coronary Calcium Score (CCS)

CCS was evaluated using computed tomography with multiple rows of detectors (Multi-Detector Computed Tomography), without contrast agent, using sections of similar thickness (usually 3.0 mm) acquired during diastole. The area and density of all calcium foci (Hounsfield Units - UH) were evaluated. For that, it was essential that the heart rate was kept regular (Heart Rate at 65 bpm). CCS was quantified using Agatston's average score (Bernardo et al., 2018).

The values obtained by CCS were interpreted Stratified form - there were two classifications to arrange patients into groups: category 0 for CCS = 0; category 1 for CCS = 1 - 100; category 2 for CCS > 100 (Blaha et al., 2010). Cardiovascular risk increases according to the score, so individuals with CCS > 100 correspond to a group with a higher risk of future coronary events (Neves et al., 2017).

CCS was performed before the first nutritional care or up to three months afterwards, to avoid the possibility of the consumption of macronutrients could be influenced by the CAC measurement. Participants did not have access to the result and did not receive dietary guidelines based on the CCS.

Dietary assessment

Nutritionists collected the 24-hour food recall (R24h), recorded on alternate days, once on a weekday and once on a weekend day, in different months of the year. The first R24h was collected in person during the nutritional consultation; the second, via telephone within a minimum interval of 30 days after the first R24h. Hoffman et al and Barr et al., when using several R24h to estimate the distribution of consumption in a short period, concluded that it is necessary to collect only two measurements, as long as it covers every weekdays and season of the year. Thus, the distribution of consumption is adjusted, reflecting the usual consumption of nutrients (Barr et al., 2002; Hoffmann et al., 2002).

Participants were instructed as to the measures to be recorded in the food intake form, based on the demonstration of the most common utensils (spoons, ladles, cups, glass and plates) available in the households. Food intake data were analyzed using the software NUTRILIFE - REC24HS®, version 9.12 2019 (February 2015). Dietary variability was corrected using the Multiple Source Method (MSM) software, which is available online. It firstly estimates an individual's usual intake and thereafter creates the moments of population distribution, such as mean, standard deviation, asymmetry and kurtosis (Harttig et al., 2011).

Nutrient intake data includes: carbohydrates, proteins, fats and their subtypes (SFA, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), TFA and cholesterol), and fiber. To adjust the intake of nutrients, were the considered the recommended values by Cardiovascular Prevention Guideline of the Brazilian Society of Cardiology, as follows: fiber minimum 25 g/day, carbohydrates 45-60% and protein 15% from total energy intake (Précoma et al., 2019). For fats the values are shown in Table 1. For cholesterol, due to the more recent guidelines did not establish a maximum limit for its consumption, it was decided to use, as a cutoff point, <300mg/day as established by the Brazilian Guideline on Fat Consumption and Cardiovascular Health (Santos et al., 2013), since dietary cholesterol is still important and should be considered in the development of healthy eating patterns since it contributes in a dose-dependent base to the increase of CVD incidence (Izar et al., 2021).

Table 1 - Dietary recommendations for fat intake.

Total fat (%) [b]	25 - 35% with LDL-c [a] above the target or with comorbidities or LDL-c between 150-199 mg/dL 30 - 35% for those with triglycerides > 200 mg / dL
Saturated fat (%)	< 7 % with LDL-c above the target or with comorbidities or LDL-c between 150-199 mg/dL < 5 % for those with triglycerides > 200 mg / dL
Monounsaturated fat (%)	15% with LDL-c above the goal or with comorbidities 10 a 20% with LDL-c between 150-199 mg/dL or triglycerides > 200mg/dL
Polyunsaturated fat (%)	5 - 10 % with LDL-c above the goal or with comorbidities 10 - 20 % with LDL-c between 150-199 mg/dL or triglycerides > 200mg/dL
Cholesterol	< 300 mg/day [c]
Trans fat (%)	< 1 % [d]

Adapted from the Cardiovascular Prevention Guideline of the Brazilian Society of Cardiology (Précoma et al.,2019). a: low-density lipoprotein cholesterol. b: total energy value. c: I Brazilian Guideline on Fat Consuption and Cardiovascular Heath (Santos et al., 2013). d: WHO report on global trans fat elimination (WHO, 2019). Source: Authors.

Trans fat intake (TFA)

TFA values were obtained from the elaboration of a standardized protocol, calculated based on the Brazilian Food Composition Table (TBCA) (Lima et al., 2011). In the absence of any food in the TBCA, the set of Brazilian food composition tables was used (Instituto Brasileiro de Geografia e Estatística (IBGE), 2011a).

TFA of animal and industrial origin was considered, in addition to preparations that could contain both (cakes, pizzas and pies). The type of oil and fat used in the preparation was also taken into account. The servings were based on the table of reference measures for food consumed in Brazil (Instituto Brasileiro de Geografia e Estatística (IBGE), 2011b). Finally, based on the frequencies and serving sizes, the daily intake average, for each individual, was calculated.

Due to the high variability in the proportion of TFA among foods of the same category, we opted for the item that contained the average of several samples, flavors or brands, analyzed in the TBCA, for example, salted and unsalted margarine, simple sweet biscuit, wafer biscuit, among others. Foods and preparations not identified in the table were replaced by another food with an approximate chemical composition: Brazilian farofa by farofa with eggs and bacon; lemon cake by orange cake and cream by sour cream.

Anthropometric assessment and general characteristics

Body mass index (BMI) was calculated as weight (kg) height (m²). The waist circumference (WC) was measured at the midpoint between the lowest rib and iliac crest in the middle axillary line with an inelastic measuring tape. Besides the aforementioned data, the following were also collected: recent weight change; gastrointestinal functioning; the presence of early familial CAD (women < 65 years and men < 55 years); physical activity and smoking. The covariables of interest to characterize the sample were total daily energy intake, biochemical tests (lipid profile), glomerular filtration rate (GFR), presence of comorbidities, use of medications, sex and age.

Statistical analyses

The statistical power was calculated using the post hoc method on the software G*Power 3.1.9, beta error of 1.00, considering the sample's effect size of 0.34 and 5% significance level.

Initially, descriptive analyses were performed with categorical variables expressed in frequencies and percentages, whereas numerical variables were expressed in measures of central tendency (means or medians) and dispersion (standard deviation or interquartile range). The normality and homogeneity of the data were verified using the Kolmogorov-Smirnov and Levene tests, respectively. Associations between categorical variables were verified using Pearson's chi-square test. To compare the average between two categories, Student's t-test for independent samples or the Mann-Whitney test was used depending on normality and homogeneity, and to compare averages across the CCS categories (≤ 100 and > 100), analysis of variance (ANOVA) was used for parametric data and Kruskal-Wallis for non-parametric data. Tukey's post-test was used for multiple analyses.

To assess the association between nutrient intake (independent variables) and the degree of cardiovascular risk (CCS ≤ 100 and CCS > 100) (dependent variable), simple and multiple binary logistic regression was used to estimate the odds ratio (OR) with 95% confidence intervals (95% CI). Four models were built for the multiple analyses: Model 1: no adjustment; Model 2: adjusted for age and sex; Model 3: model 2 + familial coronary artery disease, DM, systemic arterial hypertension, total cholesterol, cholesterol associated with high-density lipoprotein, cholesterol associated with low-density lipoprotein, triglycerides, GFR, use of fibrate, statin, hypoglycemic drugs/insulin and antihypertensive drugs; Model 4: model 3 + smoking, physical inactivity, body mass index and waist circumference. The analyses were performed on the software Statistical Package for the Social Sciences (SPSS) 22.0, adopting a 5% significance level ($p < 0.05$).

3. Results

180 participants were evaluated, with a mean age of 59.80 ± 11.32 years, ranging from 19 to 82 years, mostly female, 65.6% (n = 118). The studied population was mostly composed of hypertensive individuals (n = 138; 76.7%) and individuals who used statins and antihypertensive drugs (Table 2). Among the participants, 31.7% were in the group with the highest risk of future coronary events (CCS > 100).

The social, clinical, lifestyle and anthropometric characteristics of the participants are shown in Table 2, according to the CCS (CCS ≤ 100 low risk or > 100 high risk). The mean age and male prevalence were higher among those with CCS > 100. The metabolic profile was also significantly adverse in this group, including the presence of DM, hypertension, low GFR and use of statins, hypoglycemic drugs/insulin and antihypertensive drugs. In contrast, the levels of total cholesterol and low-density lipoprotein cholesterol (LDL-c) were higher in the group with CCS ≤ 100 ($p < 0.05$).

Table 2 – Social, clinical, lifestyle and anthropometric, characteristics, stratified by cardiovascular risk according to the CCS.

Variables	Total n=180	(CCS ≤100) [a] (n=123)	(CCS >100) (n=57)	*P* value
Age, years, mean±SD [b]	59,80±11,32	57,23±11,40	65,35±8,98	**<0,001**
Sex, female, n (%)	118 (65,60%)	83 (67,50%)	35 (61,40%)	0,425
Family CAD [c], yes, n (%)	70 (38,90%)	47 (38,20%)	23 (40,40%)	0,784
Diabetes, yes, n (%)	63 (35,00%)	35 (28,50%)	28 (49,10%)	**0,007**
Hypetension, yes, n (%)	138 (76,70%)	87 (70,70%)	51 (89,50%)	**0,006**
Total Cholesterol, mg/dL, mean±SD	180,18±53,99	187,01±54,84	165,44±49,41	**0,012**
HDL-c [d], mg/dL, mean±SD	45,10±13,72	45,83±13,71	43,51±13,73	0,292
LDL-c [e], mg/dL, mean±SD	105,10±46,26	111,12±47,96	92,09±39,71	**0,010**
Triglycerides, mg/dL, mean±SD	177,38±170,41	185,88±188,08	159,04±123,48	0,327
GFR [f], ml/min, mean±SD	76,30±20,45	78,86±19,08	70,75±22,32	**0,013**
Use of fibrate, yes, n (%)	29 (16,10%)	21 (17,10%)	8 (14,00%)	0,606
Use of statin, yes, n (%)	148 (82,20%)	95 (77,20%)	53 (93,00%)	**0,010**
Use of hypoglycemic/insulin, yes, n (%)	72 (40,00%)	39 (31,70%)	33 (57,90%)	**0,001**
Use of antihypertensive, yes, n (%)	139 (77,20%)	87 (70,70%)	52 (91,20%)	**0,002**
Smoker / ex-smoker, yes, n (%)	72 (40,00%)	45 (36,60%)	27 (47,40%)	0,170
Sedentary lifistyles, yes, n (%)	86 (47,80%)	53 (43,10%)	33 (57,90%)	0,064
BMI [g], kg/m², mean±SD	30,51±5,30	30,47±4,99	30,60±5,97	0,879
WC [h], cm, mean±SD	102,01±12,22	101,35±11,99	103,43±12,70	0,289

a: coronary calcium score low risk. b: standard deviation. c: coronary artery disease. d: high-density lipoprotein cholesterol. e: low-density lipoprotein cholesterol. f: glomerular filtration rate. g: body mass index. h: waist circumference. Statistical significance P < 0,05. Values described as mean ± standard deviation or n (%). Student t test to compare continuous variables and Pearson chi-square test to compare categorical variables. Source: Authors.

Regarding dietary parameters, the average total energy intake was 1315.6 kcal. Total energy and macronutrient intake were higher among men ($p < 0.05$). The ingestion of carbohydrates (% energy), total fat (% energy), PUFA (%), TFA (%) and cholesterol (mg/day) had acceptable level of intakes in both sexes. Nevertheless, ingestion of protein (% energy) and SFA (%) intake was slightly higher than the reference for both sexes. And, ingestion of MUFA (%) and fibers (g) was lower than the recommended level in both sexes (Table 3).

The results also showed significant statistical difference ($p<0,05$) between the sexes for nutrients: protein (g/day), carbohydrates (g/day), total fat (g/day), SFA (g/day), MUFA (g/day), PUFA (g/day), TFA (% energy), cholesterol (mg/day), and fiber (g/day), being the highest values in the male group, except for TFA (% energy) (Table 3).

Table 3 - Energy, macronutrient, fats and their subtypes and fiber consumption stratified by sex.

Nutrient	**Total (180)**	**Male (n = 62)**	**Female (n = 118)**	***P* value**
Energy (kcal)	1315.60 (1145.52-1697.80)	1560.40 (1301.64-1944.98)	1238.94 (1066.92-1478.54)	**<0.001** [a]
Protein				
g/day	65.10 (53.93-77.96)	74.70 (64.75-88.05)	60.24 (50.96-71.59)	**<0.001** [a]
% energy	19.07±3.14	18.96±3.11	19.13±3.17	0.730 [b]
Carbohydrate				
g/day	174.19±54.68	199.25±58.25	161.02±47.94	**<0.001** [b]
% energy	49.30±7.49	47.88±6.79	50.06±7.76	0.640 [b]
Total fat				
g/day	47.64 (38.17-60.84)	55.62 (44.52-76.66)	46.20 (35.09-54.67)	**<0.001** [a]
% energy	32.25±5.23	32.53±4.68	32.10±5.50	0.598 [b]
Saturated fat				
g/day	14.96 (11.38-19.30)	17.37 (13.65-22.44)	13.93 (10.37-18.16)	**<0.001** [a]
% energy	10.03±2.52	10.02±2.02	10.04±2.75	0.969 [b]
Monounsaturated fat				
g/day	14.40±5.71	17.22±6.24	12.92±4.80	**<0.001** [b]
% energy	9.05±2.18	9.29±2.04	8.93±2.25	0.293 [b]
Polyunsaturated fat				
g/day	8.44 (6.59-11.24)	9.66 (7.38-12.62)	8.01 (6.13-10.35)	**0.001** [a]
% energy	5.78±1.68	5.64±1.54	5.85±1.75	0.434 [b]
Trans fat				
g/day	1.01±0.36	1.07±0.32	0.98±0.38	0.103 [b]
% energy	0.67±0.28	0.60±0.20	0.71±0.31	**0.014** [b]
Cholesterol (mg/day)	238.80±96.60	274.68±103.11	219.9 ± 87.70	**<0.001** [b]
Fiber (g/day)	16.11±5.50	18.14±6.00	15.04±4.91	**<0.001** [b]

Statistical significance *P* <0,05. **a** Mann Whitney test. **b** Studant t test for independent samples. Values described as mean ± standard deviation or median (interquartile range). Source: Authors.

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Fiber intake was inversely associated with cardiovascular risk, regardless of age, sex, CAD, DM, hypertension, total cholesterol, high-density lipoprotein cholesterol (HDL-c), LDL-c, triglycerides, GFR, use of fibrate, statin, hypoglycemic drugs/insulin and antihypertensive drugs, smoking, physical inactivity, BMI and CP. The increase of fiber intake in 1 g/day decreases the chance of future cardiovascular events by 8.2% (OR: 0.918; 95% CI: 0.845-0.999; p = 0.047), obtained for CCS > 100 (Table 4). No significant results were found regarding the association between cardiovascular risk and the adequacy of macronutrient intake concerning the total energy intake (%) (Table 5).

Table 4 - Association between energy consumption, macronutrients, fats and their subtypes, fiber and the classification of cardiovascular risk according to the CCS (n=180).

Nutrient	OR	CI 95%	*P* value
Energy (kcal)			
Model 1	1.00	0.999-1.000	0.250
Model 2	1.00	0.999-1.001	0.429
Model 3	1.00	0.999-1.001	0.593
Model 4	1.00	0.999-1.001	0.631
Protein (g/day)			
Model 1	0.989	0.973-1.005	0.193
Model 2	0.993	0.973-1.013	0.483
Model 3	0.993	0.972-1.014	0.512
Model 4	0.993	0.972-1.015	0.552
Carbohydrate (g/day)			
Model 1	0.997	0.990-1.003	0.276
Model 2	0.997	0.990-1.004	0.359
Model 3	0.998	0.990-1.006	0.586
Model 4	0.998	0.990-1.006	0.612
Total fat (g/day)			
Model 1	0.995	0.977-1.012	0.539
Model 2	0.997	0.977-1.018	0.810
Model 3	0.999	0.977-1.023	0.958
Model 4	1.000	0.977-1.024	0.998
Saturated fat (g/day)			
Model 1	0.991	0.943-1.042	0.724
Model 2	1.000	0.944-1.060	1.000
Model 3	1.000	0.938-1.067	0.995
Model 4	1.002	0.938-1.070	0.956
Monounsaturated fat (g/day)			
Model 1	0.978	0.922-1.036	0.446
Model 2	0.989	0.923-1.058	0.741
Model 3	0.99	0.918-1.069	0.805
Model 4	0.992	0.919-1.072	0.848
Polyunsaturated fat (g/day)			
Model 1	0.992	0.908-1.085	0.867
Model 2	1.036	0.935-1.147	0.501
Model 3	1.068	0.949-1.201	0.278
Model 4	1.068	0.949-1.203	0.276
Trans fat (g/day)			
Model 1	2.320	0.872-6.177	0.092
Model 2	2.014	0.667-6.082	0.214
Model 3	2.508	0.718-8.758	0.149
Model 4	2.585	0.721-9.265	0.145
Cholesterol (mg/day)			

Model 1	0.998	0.995-1.002	0.336
Model 2	0.999	0.995-1.002	0.504
Model 3	0.999	0.995-1.003	0.744
Model 4	0.999	0.995-1.003	0.723
Fibers (g/day)			
Model 1	0.937	0.876-1.002	0.056
Model 2	0.924	0.857-0.997	**0.041**
Model 3	0.919	0.847-0.999	**0.046**
Model 4	0.918	0.845-0.999	**0.047**

Model 1: without adjustment. Model 2: adjusted for age and sex. Model 3: model 2 + family coronary artery disease, diabetes, hypertension, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, glomerular filtration rate, use of fibrate, use of statin, use of hypoglycemic / insulin and antihypertensive use. Model 4: model 3 + smoking, sedentary lifistyles, body mass index and waist circumference. CCS classification: ≤ 100 low risk and > 100 high risk. OR: odds ratio. CI 95%: confidence interval 95%. Simple and multiple binary logistic regression with statistical significance $P < 0.05$. Source: Authors.

Table 5 - Association between the adequacy of macronutrient intake and types of fat in relation to energy intake (%) with of cardiovascular risk according to the CCS (n=180).

Nutriente	**OR**	**IC 95%**	***P* value**
Protein (%)			
Model 1	0.970	0.875-1.076	0.568
Model 2	0.989	0.886-1.102	0.836
Model 3	0.968	0.858-1.093	0.600
Model 4	0.966	0.855-1.093	0.586
Carbohydrate (%)			
Model 1	1.005	0.962-1.049	0.838
Model 2	0.996	0.949-1.045	0.866
Model 3	0.997	0.945-1.052	0.918
Model 4	0.998	0.945-1.054	0.945
Fat total (%)			
Model 1	1.026	0.963-1.094	0.425
Model 2	1.028	0.959-1.102	0.431
Model 3	1.033	0.957-1.116	0.405
Model 4	1.033	0.956-1.118	0.411
Saturated fat (%)			
Model 1	1.050	0.925-1.193	0.448
Model 2	1.046	0.914-1.196	0.515
Model 3	1.039	0.897-1.203	0.608
Model 4	1.041	0.896-1.209	0.603
Monounsaturated fat (%)			
Model 1	1.019	0.880-1.181	0.798
Model 2	1.044	0.888-1.226	0.603
Model 3	1.042	0.872-1.246	0.649
Model 4	1.043	0.872-1.249	0.643

Polyunsaturated fat (%)			
Model 1	1.103	0.910-1.336	0.317
Model 2	1.193	0.966-1.472	0.101
Model 3	1.275	1.005-1.619	**0.046**
Model 4	1.268	0.998-1.611	0.052
Trans fat (%)			
Model 1	4.417	1.201-16.246	**0.025**
Model 2	3.155	0.777-12.802	0.108
Model 3	2.985	0.628-14.199	0.169
Model 4	3.01	0.651-13.914	0.158

Model 1: without adjustment. Model 2: adjusted for age and sex. Model 3: model 2 + family coronary artery disease, diabetes, hypertension, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, glomerular filtration rate, use of fibrate, use of statin, use of hypoglycemic / insulin and antihypertensive use. Model 4: model 3 + Model 4: model 3 + smoking, sedentary lifistyles, body mass index and waist circumference. CCS classification: ≤100 low risk and > 100 high risk. OR: odds ratio. CI 95%: confidence interval 95%. Simple and multiple binary logistic regression with statistical significance $P < 0.05$. Source: Authors.

4. Discussion

Our hypothesis that the intake of carbohydrate, protein, total fat, SFA, MUFA, PUFA, TFA and dietary cholesterol influences the cardiovascular risk was rejected. Even after controlling for confounding factors. However, we verified an inverse relationship between dietary fibers: each 1 g/day increase in fiber intake led to an 8.2% decrease in the chance of future cardiovascular events among individuals in the highest risk category (CCS > 100). The results also showed that individuals with a higher risk of future coronary events (CCS > 100) had a more critical metabolic profile, influenced by the presence of DM, hypertension, advanced age, male sex, reduced GFR and use of medications (statin, hypoglycemic/insulin and antihypertensive), indicating that clinical characteristics can directly impact cardiovascular health.

Traditional risk factors, such as sex, age and comorbidities, lead to a greater predisposition to the development and progression of CAC. Studies have related the late evolution of atherosclerosis in females, usually delayed by 10 to 15 years compared to men, with the protective effects of estrogens in the pre-menopausal years (Mori et al., 2018; Williams et al., 1990). Moreover, the increase in the incidence of CAC reaches 5% per year among the youngest (< 50 years) and 12% per year among the elderly (> 80 years) (Kronmal et al., 2007). The influence of comorbidities in CAC is related to greater chronic inflammation, triggering an increase in the area of macrophage plaque and infiltration of T cells (Mori et al., 2018).

As for dietary factors, this study found no relationship between proteins, carbohydrates, fats and their fractions to the cardiovascular risk assessed by the CCS. Similar results were found in the study by Sung et al., who also found no association between macronutrients and CAC prevalence (Sung et al., 2015). On the other hand, in a longitudinal study, the results showed that a low-carbohydrate diet, high in animal protein, high in total fat and lower in fiber, was significantly associated with a higher CCS (Gao et al., 2020). A Brazilian study conducted by Bruscato et al. (Bruscato et al., 2021), with 150 healthy men, has shown that 1% increase in total fat and SFA intake led to a 4% and 8% increase in the prevalence of moderate/severe CAC respectively. The Prospective Urban Rural Epidemiology (PURE) study has recently shown that a carbohydrate-rich diet was associated with a higher risk of mortality, but not with a risk of CVD, while the highest intake of fats (total, SFA, MUFA and PUFA) presented a lower risk of general mortality, stroke and cardiovascular outcomes (Dehghan et al., 2017; Mente et al., 2017). However, it is worth emphasizing the necessity of a dietary guideline based on the composition of macronutrients; therefore, recommendations on carbohydrate intake should consider its components, such as sugar, starch and types of fiber.

On the other hand, previous studies support that higher fiber intake is associated with a reduction in atherosclerosis and the risk of CVD (Soliman, G., 2019; Threapleton et al., 2013). Our study demonstrated a great protective fator of fibers for future cardiovascular events among individuals in the highest risk category. Similar to our findings, other studies have show that for every 7g of fiber intake, the risk of CAD decrease in 9% (RR 0.91) (Threapleton et al., 2013) or every 10g of fiber consumed, the risk of stroke decrease in 16% (RR 0.84) (Zhang et al., 2013). They results are due to its hypocholesterolemic effect, the reduce postprandial glucose responses after carbohydrate-rich meals and also lower triglyceride levels (Giacco et al., 2014). Soluble fiber is resistant to hydrolysis by the enzymes of the small intestine in humans, add volume to the diet and form a gel that binds to bile acids, which increases their excretion in the feces and limits their reabsorption. Thus, the synthesis of new bile acids occurs, decreasing the circulating cholesterol that would be incorporated into lipoproteins. Likewise, the fiber is fermented by bacteria into short-chain fatty acids in the large intestine, causing changes in the intestinal microbiota (Castellanos-jankiewicz et al., 2014; Chutkan et al., 2012; Soliman, G., 2019). The Global Disease Burden study showed that low fiber consumption was the main dietary risk factor for deaths and disability-adjusted life years (DALYs) in most regions studied, such as Brazil, United States, India (Afshin et al., 2019).

Studies that analyzed the effects of nutritional factors on a cardiovascular risk assessed by CCS are still scarce (Bruscato et al., 2021; Gao et al., 2020; Sung et al., 2015). In recent years, dietary recommendations have focused on restricting the intake of total fat and SFA, as well as partial replacement of SFAs by MUFAs and PUFAs and exclusion of TFAs (American Diabetes Association, 2017; Faludi et al., 2017; Stone et al., 2014). In the current context, guidelines recommend SFA reduction and the inclusion of adequate amounts of unsaturated fatty acids, still emphasizing that their replacement by refined carbohydrates can increase cardiovascular risk. In contrast, when an isocaloric substitution occurs for unsaturated or complex carbohydrates, the cardiovascular outcome tends to be favorable, as long as an adequate dietary pattern is maintained (Izar et al., 2021; Sacks et al., 2017).

Few studies have explored similar objectives and also due to the different methods applied, it was difficult to compare our results with previous studies. Additionally, as it is a study based on the premise that self-report reflects habitual dietary consumption, which can be influenced by educational level, individual perception, obesity, old age and female gender (characteristics prevalent in the studied population), some degree of underreporting may be present in the analyzed data.

Nevertheless, strengths may also be acknowledged. First, it is study that investigates the association between diet composition and cardiovascular risk, assessed by CCS, a valuable standard tool in risk stratification. Second, the estimates of usual energy and macronutrient intake were based on statistical methods (MSM) performed to adequately adjust intra-individual variability. And thirdly, our results may support initiatives aimed at improving the quality of eating habits, and at reducing cardiometabolic disorders.

5. Conclusion

The findings of this study suggest that there was no association between the of macronutrient consumption with cardiovascular risk assessed by CCS. However, dietary fiber has shown an inverse relationship, supporting previous findings that fiber reduces adverse cardiovascular outcomes. Therefore, it is recommended that nutritional counseling be based on the appropriate distribution of macro and micronutrients and that the intake of dietary fiber be encouraged among individuals with a higher risk of cardiovascular events.

That said, we understand the need for more focus by the scientific community on the subject, and we suggest that studies at an individual and population level be carried out to lead to a better understanding of the influence of nutritional factors on cardiovascular risk, taking into account the usefulness of CCS.

Acknowledgments

The authors would like to thank all the participants for their collaboration, the Clinical Hospital of Federal University of Paraná and Quanta Diagnostic and Therapy for the assistance. The Academic Publishing Advisory Center (Centro de Assessoria de Publicação Acadêmica, CAPA – www.capa.ufpr.br) of the Federal University of Paraná for assistance with English language translation and editing, and all the collaborating to make this study possible. We received permission from everyone who was mentioned.

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