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ORIGINAL ARTICLE

Association between the Phytochemical Index and Risk Factors for Cardiovascular Disease in Adults

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Abstract

Background: There are few publications about the association between the phytochemical index (PI) and risk factors for cardiovascular disease.

Objective: To evaluate the association between the PI and risk factors for cardiovascular disease in adults.

Methods: This was a cross-sectional study with 141 adults, between 20 and 59 years of age. We analyzed lifestyle (physical activity), sociodemographic data (sex, age), anthropometric data (body mass index [BMI], waist circumference [WC]), biochemical data (lipid profile, blood glucose), food consumption, and phytochemical intake (expressed as PI = daily energy derived from phytochemical-rich foods ÷ total daily energy intake × 100). We performed bivariate analyses (Spearman's correlation) and multiple linear regression adjusted for potential confounders, considering $p < 0.05$ as significant.

Results: The median PI was 9.80 (interquartile range: 11.45). PI was inversely correlated with BMI (rs: −0.43) and WC (rs: −0.36) and positively correlated with high-density lipoprotein cholesterol (HDL-cholesterol) (rs: 0.25), all with $p < 0.05$. In multiple regression analysis, PI was inversely associated with BMI (B: −0.08; 95%CI: −0.15, −0.01) after adjusting for total energy, sex, age, and physical activity; and positively associated with HDL-cholesterol (Model 1 adjusted for total energy, sex, age, and physical activity [B: 0.21; 95% CI: 0.02, 0.41]; Model 2 adjusted for BMI, sex, age, and physical activity [B: 0.21; 95% CI: 0.008, 0.40]; Model 3 adjusted for WC, sex, age, and physical activity [B: 0.20; 95%CI: 0.01, 0.40]), all with $p < 0.05$.

Conclusion: The results have demonstrated that higher phytochemical intake, expressed by PI, was inversely associated with BMI and positively associated with HDL-cholesterol.

Keywords: Phytochemicals; Cardiovascular Diseases; Risk factors; Adults.

Introduction

Chronic non-communicable diseases, which include cardiovascular diseases (CVD), cancer, diabetes mellitus, and chronic respiratory diseases,[1] are responsible for approximately 38 million deaths per year, equivalent to approximately 70% of all deaths worldwide.[2] Among chronic non-communicable diseases, about 45%, more than 17 million deaths worldwide, are caused by CVD.[2] In Brazil, 72% of deaths occur due to chronic non-communicable diseases, 30% due to CVD.[2] Several factors increase the risk of CVD, including high levels of total cholesterol,[3-5] high low-density lipoprotein cholesterol (LDL-cholesterol),[3-5] high triglycerides,[5] low levels of high-density lipoprotein cholesterol (HDL-cholesterol),[5] hyperglycemia, unhealthy diet, sedentary lifestyle, systemic arterial hypertension, and obesity.[6]

There is evidence that higher consumption of fruits, vegetables, and whole grains is associated with a lower risk of CVD.[7-9] These foods contain, in addition to other substances, different phytochemicals.[10] Phytochemicals are bioactive compounds that occur naturally in fruits, vegetables, legumes, whole grains, and oilseeds,[10]

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which are classified as follows, based on their chemical structure and functional characteristics:[11] phenolic compounds (polyphenols), alkaloids, nitrogenous compounds, organosulfur compounds, phytosterols, and carotenoids.[10] Studies have suggested that consumption of phytochemical-rich foods decreases the risk of CVD[12,13] and mortality due to CVD.[14] The cardioprotective effect of phytochemicals has been attributed to their antioxidant activity, since the overproduction of oxidants is one of the main pathogenic factors of CVD,[15] and reactive oxygen species, mainly produced by vascular cells, are involved as possible underlying pathogenic mechanisms in the progression of CVD, including ischemic heart disease, atherosclerosis, cardiac arrhythmia, hypertension, and diabetes.[16] The antioxidant activity of phytochemicals may result in vasodilatory, antithrombotic, anti-inflammatory, antiapoptotic, hypolipemic, or antiatherogenic effects.[17]

Considering the cardioprotective effect of phytochemicals,[12,13,15,17] it has become important to assess phytochemical intake. However, the identification and quantification of phytochemical compounds in consumed foods or in human tissue samples is expensive, time-consuming, and impractical for large population-based studies.[18] McCarty[19] proposed an alternative method, the phytochemical index (PI), defined as the percentage of calories derived from phytochemical-rich foods, as a quantitative measure of phytochemical intake and suggested that it can be used as a very approximate index for the total phytochemical content of the diet.[19] Cross-sectional and longitudinal studies have shown an inverse association between PI and risk factors for CVD, including body mass index (BMI),[18] waist circumference (WC),[18,20] total cholesterol,[21] triglycerides,[20,21] and hypertension,[22] in addition to a positive association with HDL-cholesterol.[20] Nonetheless, studies are still scarce; to date, no study in the Brazilian population has been identified in the medical literature. Therefore, the objective of this study was to evaluate the association between the PI and risk factors for CVD in adults.

Methods

Study design

This cross-sectional study was conducted at the Clínica Escola de Nutrição "Irmã Anna de São José Camargo Barros" of the Centro Universitário Nossa Senhora do Patrocínio (CEUNSP, abbreviation in Portuguese), Cruzeiro do Sul Educacional, located in Itu, São Paulo, from August 2018 to February 2019.

The study protocol received approval from the Research Ethics Committee of the Max Planck Faculty (opinion number: 2.148.238), and it was conducted in accordance with Brazilian resolution 466/2012 and the 1975 Declaration of Helsinki, updated in 2013. All participants signed a free and informed consent form.

Study sample

The non-probabilistic, convenience sample included adults between 20 and 59 years of age who did not follow any specific diet and were in their first nutrition consultation at the Clínica Escola de Nutrição. As exclusion criteria, the following were considered: smoking; alcohol use; use of hypoglycemic or hypolipidemic drugs; medical diagnosis of hypothyroidism or use of medication to treat hypothyroidism; individuals reporting energy intake < 800 or ≥ 4200 kcal/day; and individuals with elevated HDL-cholesterol levels (> 90 mg/dL in men and > 75 mg/dL in women), given that Wilkins et al.,[23] did not observe additional reductions in the risk of coronary heart disease in individuals with HDL-cholesterol levels above these values.

Assessment of sociodemographic data, health, and lifestyle aspects

Socio-demographic data (sex and date of birth), health (medication use and personal history of diseases) and lifestyle (smoking, drinking, and physical activity) were investigated through interviews. For the assessment of lifestyle, the following indicators were considered: a) Smoking: current tobacco consumption (yes or no); b) Alcohol use: current consumption of alcoholic beverages (yes or no); and c) Physical activity: practice of physical activity (yes or no).

Anthropometric assessment

Weight, height, and WC were measured in duplicate, and the average was used in the analyses. For weight, a platform-type electronic scale (Welmy®, Santa Bárbara d'Oeste, São Paulo, Brazil) was used, with a capacity of 150 kg and sensitivity of 100 g. The participants wore light clothes and removed their shoes. They were instructed to position themselves in the center of the scale and remain erect, with arms extended beside the body, with their feet together.[24] For height, a stadiometer (Welmy®, Santa Bárbara d'Oeste, São Paulo, Brazil) was used, with a scale

in millimeters, fixed on a support, so that it formed a right angle between the floor and the wall. Participants were instructed to position themselves with their feet and heels together, knees extended, in an erect posture, with arms extended next to their body,[24] any they positioned their heads in the Frankfurt plane (the imaginary line from the external auditory canal to the inferior orbital margin).[24] The reading was performed at the centimeter closest to the horizontal rod of the vertical bar of the height scale placed against the participant's head. To calculate BMI, the means of the two measures of weight and height were used. For the classification of nutritional status, the following cutoff points of the World Health Organization were used:[25] underweight if BMI < 18.5; healthy weight if BMI between 18.5 and 24.9; overweight if BMI between 25.0 and 29.9; and obese if BMI ≥ 30.0. WC was measured at the midpoint between the lower edge of the last rib and the hip bone (iliac crest)[24] in non-obese individuals and at the level of the umbilicus, when it was not possible to identify the natural waist in obese individuals.[26]

Biochemical assessment

Sample collection and processing were carried out at the CEUNSP Biomedical Laboratory. Blood samples were collected after a 12-hour fast. Values of fasting blood glucose (glucose monoreagent-K082), total cholesterol (monoreagent-K083) and triglycerides (monoreagent-K117) were quantified by the enzymatic colorimetric method and HDL-cholesterol (enzymatic-K015) by the enzymatic trinder method. The kits used were from the Bioclin brand (Quibasa-Bioclin, Belo Horizonte, Minas Gerais, Brazil). LDL-cholesterol values were estimated using the formula by Friedewald et al.,[27] given that the samples had triglyceride results < 400 mg/dL.

Assessment of food consumption

Food consumption was assessed using a 24-hour recall performed during the first consultation. During the interview, participants reported all the foods and drinks they had consumed the day before, as well as the amounts consumed. Food portion sizes were collected in household measurements and later converted into grams using tables of household measurements of foods and preparations.[28,29] The analysis of nutritional composition (total energy consumption in kilocalories [total energy in kcal], percentage of proteins in total energy, percentage of fat in total energy, and percentage of carbohydrates in total energy) from the 24-hour recall was determined using the Brazilian Table of Food Composition,[30] the Tables of Nutritional Composition of Food Consumed in Brazil,[31] and the Food Composition Table: Support for Nutritional Decision.[32]

Assessment of phytochemical intake

To assess phytochemical intake, we used the PI proposed by McCarty,[19] calculated as follows: PS = daily energy derived from phytochemical-rich foods (kcal) ÷ total daily energy intake (kcal) × 100. The food groups included in the phytochemical-rich categories were fruits, vegetables (excluding potatoes but including other tubers), whole grains, legumes, seeds, nuts, natural fruit and vegetable juices, and soy products.[19]

Statistical analyses

For data analysis, the statistical program IBM SPSS Statistics for Windows, version 20.0 (IBM Corporation, Armonk, New York) was used, and p-values < 0.05 were considered statistically significant. To verify the distribution of continuous variables and residuals, the Shapiro-Wilk test was used. Continuous variables were presented as mean ± standard deviation or median (interquartile ranges) according to data normality, and categorical variables were expressed as percentages. Spearman's correlation coefficient was used to investigate the relationship between PI and CVD risk factors. Subsequently, multiple linear regression analyses were performed,[33] including only the variables that presented a statistically significant correlation with the PI in the bivariate analysis (Spearman's correlation coefficient), with the objective of investigating whether the relationship between the variables remained statistically significant after the inclusion of potentially confounding variables. The following independent variables were included in the regression models: PI, sex (where 0 = female; 1 = male), age (years), physical activity (where 0 = no; 1 = yes), and total energy (kcal) or BMI (kg/m^2) or WC (cm). The independent variables of total energy, BMI, and WC were not included in the same regression model because preliminary analyses showed a multicollinearity problem. The results of multiple linear regression were expressed as unstandardized regression coefficient (B) and 95% confidence interval (95% CI). The B values provide information about the relationship between the dependent variable and each independent variable.[34]

Results

During the study period, 276 individuals were treated at their first nutrition consultation at the Clínica Escola de Nutrição. Of this total, 15 were excluded for being adolescents, 67 for being elderly, and 53 for not meeting the eligibility criteria. The study population thus consisted of 141 individuals. Figure 1 displays the flowchart describing the study population.

Participant characteristics

Of the 141 individuals included in the study, the majority were female (90.1%) and did not practice physical activity (Table 1).

Table 2 displays the participants' food consumption. The main sources of phytochemical-rich foods consumed were fruits, natural fruit juices, vegetables, and legumes, and the least consumed were whole grains, seeds, soy products and nuts.

Association between the PI and risk factors for CVD

Table 4 displays the multiple linear regression analyses, including only the dependent variables that presented a statistically significant correlation with the PI in the bivariate analysis. PI was inversely associated with BMI after adjustment for total energy, sex, age, and physical activity. There was no significant association between PI and WC after adjustment for BMI, sex,

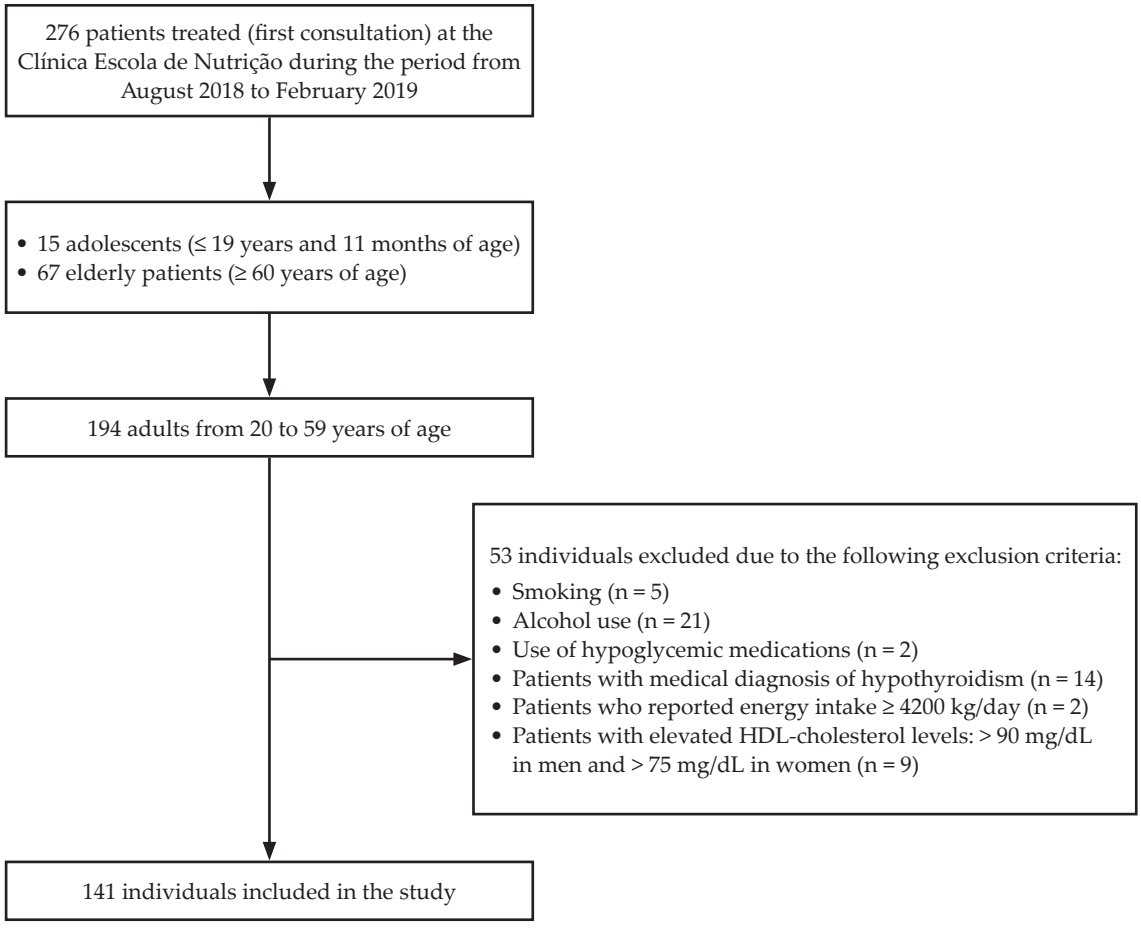

Figure 1 – Study sample selection flowchart.
Source: Authors. HDL: high-density lipoprotein.

Table 1 – Study participant characteristics

Variables	n = 141
Age (years)	36 (22)*
Sex	
Female	90.1†
Male	9.9†
Physical activity	
No	62.4†
Yes	37.6†
Weight (kg)	74.2 (17.9)*
Height (m)	1.60 (0.11)*
BMI (kg/m²)	29.0 (5.8)*
Low weight	0.7†
Healthy weight	19.9†
Overweight	36.2†
Obese	43.3†
WC (cm)	90.1 ± 13.4‡
Total cholesterol (mg/dL)	177 ± 36‡
LDL-cholesterol (mg/dL)	109 ± 34‡
HDL-cholesterol (mg/dL)	47 ± 10‡
Triglycerides (mg/dL)	95 (60)*
Fasting blood glucose (mg/dL)	90 (19)*

*Source: Authors. HDL-cholesterol: high-density lipoprotein cholesterol; LDL-cholesterol: low-density lipoprotein cholesterol; WC: waist circumference; BMI: body mass index. *Data presented as median (interquartile ranges). †Data presented as percentage. ‡Data presented as mean ± standard deviation.*

Table 2 – Study participants' food consumption

Variables	n = 141
PI	9.80 (11.45)*
Total energy (kcal)	2312 ± 487†
Carbohydrates (% of total energy)	56.5 ± 3.7†
Proteins (% of total energy)	14.7 ± 3.8†
Lipids (% of total energy)	28.8 ± 2.4†
Fruits (g)	106.3 ± 82.4†
Natural fruit juices (ml)	36.1 ± 87.9†
Vegetables (g)	28.4 ± 23.2†
Natural vegetable juices (ml)	0 ± 0†
Legumes (g)	16.5 ± 22.3†
Whole grains (g)	10.0 ± 13.3†
Seeds (g)	5.3 ± 7.3†
Nuts (g)	1.1 ± 2.4†
Soy products (g)	4.8 ± 8.2†

*Source: Authors. PI: phytochemical index. *Data presented as median (interquartile ranges). †Data presented as mean ± standard deviation.*

Table 3 – Correlation between the PI and risk factors for CVD

Variables	PI (n = 141)	
	rs*	p-value
BMI	-0.43	**< 0.001**
WC	-0.36	**< 0.001**
Total cholesterol	-0.07	0.43
LDL-cholesterol	-0.09	0.30
HDL-cholesterol	0.25	**0.003**
Triglycerides	-0.15	0.07
Fasting blood glucose	-0.16	0.06

*Source: Authors. HDL-cholesterol: high-density lipoprotein cholesterol; LDL-cholesterol: low-density lipoprotein cholesterol; PI: phytochemical index; CVD: Cardiovascular Disease; WC: waist circumference; BMI: body mass index. *Spearman's correlation coefficient.*

age, and physical activity. After adjusting for sex, age, physical activity, and total energy, PI was positively associated with HDL-cholesterol (Model 1). When the independent variable total energy was replaced by BMI (Model 2), PI remained positively associated with HDL-cholesterol. When the independent variable BMI was replaced by WC (Model 3), PI remained positively associated with HDL-cholesterol (Table 4).

Discussion

This is the first study to evaluate the association between PI and risk factors for CVD in Brazilian adults. The results of the analysis of the 141 individuals included

Table 4 – Association between PI and risk factors for CVD

Dependent variables	Model	Independent variables	B (SE)	95% CI	β	p-value
BMI (kg/m²)	1	Constant	7.49 (2.06)	3.42 – 11.57	NA	< 0.001
		PI	-0.08 (0.03)	-0.15 – -0.01	-0.14	0.02
		Total energy (kcal)	0.008 (0.001)	0.007 – 0.01	0.77	**< 0.001**
		Sex*	-7.00 (1.05)	-9.07 – -4.93	-0.40	**< 0.001**
		Age (years)	0.11 (0.02)	0.06 – 0.15	0.24	**< 0.001**
		Physical activity†	0.41 (0.59)	-0.75 – 1.57	0.04	0.49
WC (cm)	1	Constant	25.10 (4.36)	16.47 – 33.73	NA	< 0.001
		PI	-0.03 (0.07)	-0.17 – 0.12	-0.02	0.73
		BMI (kg/m²)	1.94 (0.13)	1.69 – 2.19	0.76	**< 0.001**
		Sex*	11.18 (2.05)	7.14 – 15.23	0.25	**< 0.001**
		Age (years)	0.22 (0.05)	0.12 – 0.33	0.20	**< 0.001**
		Physical activity†	-1.73 (1.27)	-4.24 – 0.77	-0.06	0.17
HDL-cholesterol (mg/dL)	1	Constant	54.57 (6.08)	42.55 – 66.58	NA	< 0.001
		PI	0.21 (0.10)	0.02 – 0.41	0.19	**0.03**
		Total energy (kcal)	-0.004 (0.002)	-0.008 – -0.0002	-0.20	0.04
		Sex*	-1.64 (3.09)	-7.74 – 4.47	-0.05	0.60
		Age (years)	-0.03 (0.07)	-0.17 – 0.11	-0.03	0.70
		Physical activity†	2.55 (1.73)	-0.87 – 5.98	0.12	0.14
	2	Constant	53.71 (5.99)	41.87 – 65.55	NA	< 0.001
		PI	0.21 (0.10)	0.008 – 0.40	0.18	**0.04**
		BMI (kg/m²)	-0.35 (0.18)	-0.692 – 0.002	-0.18	0.05
		Sex*	-4.94 (2.81)	-10.49 – 0.61	-0.14	0.08
		Age (years)	0.01 (0.07)	-0.13 – 0.16	0.02	0.84
		Physical activity†	2.63 (1.74)	-0.80 – 6.07	0.12	0.13
	3	Constant	57.55 (6.60)	44.50 – 70.61	NA	< 0.001
		PI	0.20 (0.10)	0.01 – 0.40	0.18	**0.04**
		WC (cm)	-0.17 (0.07)	-0.31 – -0.03	-0.22	**0.02**
		Sex*	-3.01 (2.84)	-8.62 – 2.60	-0.09	0.29
		Age (years)	0.05 (0.07)	-0.10 – 0.20	0.06	0.49
		Physical activity†	2.33 (1.72)	-1.08 – 5.73	0.11	0.18

*Source: Authors. B: unstandardized regression coefficients; CI: confidence interval; HDL-cholesterol: high-density lipoprotein cholesterol; NA: not applicable; SE: standard error; β: standardized regression coefficients; PI: ihytochemical index; CVD: Cardiovascular Disease; WC: waist circumference; BMI: body mass index. *Sex: 0 = female; 1 = male. †Physical activity: 0 = no; 1 = yes*

showed that PI was inversely associated with BMI and positively associated with HDL-cholesterol after adjusting for possible confounding factors.

The mean PI in the present study was 11.72. Previous studies[18,20,21,35] obtained higher mean values. In a cross-sectional study conducted in the United States with participants from 18 to 30 years of age, the mean PI was 13.2 in the obese group and 23.5 in the healthy weight group.[18] In contrast, studies conducted with individuals from Iran from 19 to 70 years of age, who were participants in the Tehran Lipid and Glucose Study (TLGS), obtained means ranging from 29.5 [20] to 29.8.[21,35] A cut-off point for the PI has not yet been defined, which would make it possible to classify a diet with a high or low content of phytochemicals, for a comparative evaluation of these two types of diet. According to McCarty,[19] the author who proposed the PI, "in theory, a vegan diet that excludes refined grains, potato products, strong liquors, and added sugars and oils could reach a PI of 100, whereas the PI of most American diets would probably not reach 20."[19] The discrepancies between the studies can be explained by differences in dietary patterns and eating habits, which are related to availability processes (production, commercialization, and access to food), income, and local cultures. A study that analyzed food consumption data from 34,003 Brazilians aged 10 years or older, included in the 2008-2009 Family Budget Survey, by the Brazilian Institute of Geography and Statistics, revealed low consumption of phytochemical compounds by the Brazilian population.[36] Another study that investigated the consumption of bioactive compounds according to the income level of the Brazilian population, in the same population, showed that individuals with higher income had a higher intake of phytochemical compounds compared to those with lower income.[37] The use of different data collection methods may also explain the differences between studies.

In the present study, the bivariate analysis showed an inverse correlation between PI and BMI. Only a previous cross-sectional study carried out in the United States evaluated this correlation,[18] and the authors observed results similar to those found in the present study.[18] Furthermore, in the present study, the association remained statistically significant in the multiple regression analysis adjusted for total energy, sex, age, and physical activity. In contrast, in the previous study, multivariate analysis adjusted for potential confounding factors was not performed. Some mechanisms may explain the anti-obesity effects of phytochemicals. There are reports that phytochemicals can suppress the growth of adipose tissue, inhibit preadipocyte differentiation, stimulate lipolysis, and induce apoptosis of existing adipocytes, thereby reducing adipose tissue mass.[38]

In this study, in the bivariate analysis, PI was inversely correlated with WC. This result is similar to that reported in the cross-sectional study conducted in the United States.[18] However, in the present study, the association lost statistical significance in the multiple regression analysis adjusted for BMI, sex, age, and physical activity. Contrary to our study, a cross-sectional study carried out with Iranian participants in the TLGS showed a significant inverse association between PI and WC.[20] However, in the longitudinal study, also with Iranian participants in the TLGS, which evaluated the association between PI (categorized in quartiles) and percentage change in WC after 3 years of follow-up, no significant association was observed between the highest quartile PI category and change in WC after 3 years.[35]

In relation to the lipid profile, the bivariate analysis showed a positive correlation between the PI and HDL-cholesterol. The association remained statistically significant in the multiple regression analysis adjusted for possible confounders. However, there was no statistically significant correlation between PI and total cholesterol, LDL-cholesterol, and triglycerides. Our results are partially in line with those observed in previous studies, although few studies have investigated the association between PI and lipid profile.[18,20,21] In a cross-sectional study carried out in the United States, the correlations of total cholesterol, LDL-cholesterol, HDL-cholesterol, and triglycerides with PI were not significant.[18] Another cross-sectional study that evaluated the association between PI and cardiometabolic risk factors, including triglycerides and HDL-cholesterol, in Iranian participants in the TLGS, showed that the PI was inversely associated with triglycerides and positively associated with HDL-cholesterol.[20] Finally, in a longitudinal study that evaluated the association between PI and changes in the lipid profile after a 3-year follow-up of patients participating in the TLGS, there was a significant inverse association between the highest quartile PI category and changes in triglyceride and total cholesterol levels in men, whereas, in women, the lipid profile did not show significant changes during the study period.[21]

Finally, in this study, there was no statistically significant correlation between PI and fasting blood glucose. This finding corroborates those of previous studies conducted in the United States and Iran.[18,20]

The results of the present study are partially in line with those observed in previous studies, although few studies have investigated the association between PI and risk factors for CVD.[18,20,21,35] The discrepancies between studies can be attributed to the type of phytochemical consumed. Calculation of the PI does not take into consideration the types of phytochemicals consumed,[22] which can have different effects on the risk factors for CVD.[15,39,40] In the present study, the main sources of phytochemical-rich foods consumed were fruits, juices natural fruits, vegetables, and legumes, and the least consumed were whole grains, seeds, soy products, and nuts. In contrast, in a cross-sectional study carried out with Iranian participants, the main sources of phytochemical-rich foods were fruits, vegetables, and whole grains, and the least consumed were legumes, nuts, soy products, seeds, and olive oils.[20] In spite of the differences between the phytochemical-rich food sources, a diet containing more fruits, vegetables, and legumes may have the same PI value as a diet containing more fruits, vegetables, and whole grains; however, they provide different types of phytochemicals.[22] Therefore, the quality of phytochemicals consumed varies from person to person with the same PI value, and their effects on risk factors for CVD are varied.[15,22,39,40] Some studies that have investigated the association between intake of polyphenols (the group of antioxidant phytochemicals that most contribute to the antioxidant properties of foods)[15] and their subclasses with risk factors for CVD demonstrated associations with different phytochemicals.[39,40] In a cross-sectional study from the United States, participants in the National Health and Nutrition Examination Survey 2007-2012, BMI was negatively associated with anthocyanidin intake, and HDL-cholesterol was positively associated with total flavonoid intake, while triglycerides were inversely associated with total flavonoid and anthocyanidin intake. There were no significant associations for intake of total flavonoids and their subclasses with WC, total cholesterol, LDL-cholesterol, or fasting blood glucose.[39] In contrast, in the Prevención con Dieta Mediterranea-Plus study, WC was inversely associated with flavonoids; fasting blood glucose was inversely associated with lignans, and HDL-cholesterol was positively associated with flavonoids, stilbenes, and total polyphenols, whereas triglycerides were inversely associated with stilbenes and lignans.[40]

The present study has some limitations. First, we use a cross-sectional design that does not allow determination of cause-effect associations. Second, the sample was non-probabilistic and convenience, with 90% of the sample composed of women, and women tend to have a healthier diet and higher consumption of bioactive elements, such as polyphenols, than men.[36] This limitation is due to the profile of individuals treated at the Clínica Escola de Nutrição. Third, for the evaluation of the practice of physical activity, the frequency and time spent in activities were not obtained; the study only considered whether or not the participants practiced physical activity. Fourth, food consumption was assessed by means of a 24-hour recall, which does not represent routine dietary intake. However, to minimize the likelihood of error, participants who had low or extreme levels of energy consumption were excluded. Finally, we used the PI, which has some limitations; for example, it does not include non-caloric drinks, such as green tea and coffee, which are rich in phytochemicals.[19,22,41] It does not consider the type of phytochemical consumed.[22] It does not take into consideration that the phytochemical-to-calorie ratio of plant foods varies substantially,[19,41] and it does not consider that some phytochemicals have more potentially beneficial effects than others.[19,41] Notwithstanding these limitations, we found associations between the PI and some risk factors for CVD.

Conclusion

Our results have demonstrated that a higher intake of phytochemicals, expressed by PI, was inversely associated with BMI and positively associated with HDL-cholesterol. However, longitudinal studies are needed to confirm these observations.

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Author Contributions

Conception and design of the research: Carvalhaes VZ, Catarino RM; acquisition of data and analysis and interpretation of the data: Carvalhaes VZ; writing of the manuscript and critical revision of the manuscript for intellectual content: Carvalhaes VZ, Meireles GCX, Catarino RM, Bueno R.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee on Animal Experiments of the Faculdade Max Planck under the protocol number 2.148.238.

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