Nutrition 000 (2020) 111045

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Profile of polyphenol intake by women with different classes of obesity: Consumption of these compounds does not reflect healthy eating

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ARTICLE INFO

Article History:
Received 8 June 2020
Received in revised form 21 October 2020
Accepted 21 October 2020

Keywords:
Obesity
Polyphenol
Phenolic compounds
Food intake
Phenol-Explorer

ABSTRACT

Objectives: The aim of this study was to evaluate polyphenol intake in women with different classes of obesity and identify which are consumed more frequently and what the food sources are.
Methods: A cross-sectional study was conducted with 114 women with obesity. The study evaluated polyphenol intake via a 3-d food record using Phenol-Explorer. Anthropometric, biochemical, and dietetic variables were evaluated.
Results: The women's habitual food intake was low calorie and adequate in macronutrients. Mean polyphenol intake by the group was 573 ± 490, 614 ± 475, and 379 ± 25 mg/d for class I, class II, and class III obesity ($P = 0.002$), respectively. The most frequent food or beverage consumed by the group was coffee and caffeoylquinic acid, its phenolic compound. Fruits, vegetables, and nuts contributed the least to the intake of polyphenols.
Conclusions: Although the diets of the study participants did include some food sources of polyphenols, they were not of sufficient quality to significantly contribute to a healthy diet; instead, they sometimes were foods may that contributed to weight gain. Women with class III obesity consumed the most calories; however, they had low fruit, vegetable, and whole foods intake.

Introduction

Obesity is a growing public health problem that affects 12% of adults worldwide, being more prevalent in women [1]. It is classified into three groups: class I obesity: body mass index (BMI) 30 to 34.9 kg/m^2, class II obesity: BMI 35−39.9 kg/m^2), and class III obesity: BMI: ≥40 kg/m^2 [1]. The accumulation of body fat is associated with health damage, which may lead to the development of other noncommunicable diseases such as diabetes mellitus, cardiovascular diseases, musculoskeletal diseases, and some types of cancer [2,3].

The etiology of obesity is multifactorial, involving genetic and environmental factors, with the latter being responsible for the increased prevalence of the disease [2,3]. Among lifestyle factors, diet plays an important role in the etiology of obesity. The dietary pattern of overweight individuals is rich in refined carbohydrates, sugar, fat, and foods of animal origin. It also is low in consumption of fruits, vegetables, legumes, and whole grains [4].

Currently, dietary treatment of obesity is based on calorie restriction, which promotes negative energy balance and, consequently, weight loss [2,3]. However, some compounds present in foods, especially polyphenols, may exert effects beneficial for the prevention and treatment of the disease [5,6]. These active compounds can increase energy expenditure and contribute to weight loss [7]. Food sources containing polyphenols are fruits, vegetables, teas, wine, seeds, herbs, and whole grains [8]. Consumption of these foods and beverages is reduced in overweight individuals [4].

The aim of the present study was to evaluate the dietary intake of polyphenols in women with different classes of obesity, identify

This work was supported by the Fundação de Amparo à Pesquisa Carlos Chagas Filho do Estado do Rio de Janeiro and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance code 001.The funders have no involvement in the study design, collection, analysis, and interpretation of data, writing of the report, or decision to submit the article for publication. All of the authors participated in the conception and design of the study, interpretation of the data, drafting the article and gave final approval of the version to be submitted. LCO was responsible for the acquisition and analysis of data.

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https://doi.org/10.1016/j.nut.2020.111045
0899-9007/

the most consumed phenolic compounds and their food sources, besides anthropometric and biochemical characterization of the women with obesity.

Methods

Participants and design study

We selected women between 19 and 50 y of age with obesity (BMI ≥30 kg/m^2), who were not in menopause, not pregnant, not nursing, non-smokers, and/or non-alcohol users to participate in the cross-sectional study.

The present study was conducted with data collected from three research studies conducted by our group. The research was approved by the Research Ethics Committee of the Clementino Fraga Filho Hospital of the Federal University of Rio de Janeiro. All volunteers signed an informed consent form.

The volunteers attended the Clinical Analysis Laboratory of the Faculty of Pharmacy after 12 h of fasting for the collection of blood samples. Subsequently, the women were directed to the Nutritional Assessment Laboratory for the evaluation of anthropometric variables, and submission of a 3-d food records.

Anthropometric and laboratory variables

BMI, waist circumference (WC), glycemia, and lipid profile of the women were evaluated and characterized. BMI was calculated by dividing weight by height squared. WC was measured from the midpoint between the last rib and iliac crest using Sanny inelastic tape [9]. Glycemia, triacylglycerides, total cholesterol, and high-density lipoprotein cholesterol (HDL-C) were analyzed by enzymatic-colorimetric methods [10-13], and corresponding very low-density lipoprotein cholesterol and low-density lipoprotein cholesterol (LDL-C) were calculated [14].

Evaluation of dietary intake and polyphenol intake

Dietary intake and the quantification of phenolic compounds consumed by the women were evaluated by a 3-d food record considering 2 typical days and 1 atypical day (holiday and weekend) in the same week [15].Total calories, protein, carbohydrate, and fat intake were analyzed in DietPro Professional version 5.8.1. Using the Phenol-Explorer version 3.6 website (http://phenol-explorer.eu/compounds) [16], we conducted a search of the polyphenol contents of the foods reported in the food records. The average consumption of food sources of phenolic compounds in each group was considered, although some food sources were not consumed by some participants.

Statistical analysis

Kolmogorov-Smirnov normality test was conducted to define the statistical test to use in the analysis. For intergroup comparison, one-way analysis of variance and post hoc Bonferroni test were employed. The comparison of food sources and phenol compounds between groups was conducted by the Kruskal–Wallis test, and when significantly the Mann–Whitney U test was performed to compare the groups considering type 1 error.

Results

We included 114 women with mean ages of 32.5 ± 6.3, 33 ± 7, and 36 ± 7.5 y with class I, class II, and class III obesity, respectively. All the volunteers presented a risk for metabolic complications, high LDL-C and low HDL-C. Their habitual food intake was characterized as low in calories and adequate in protein, fat, and carbohydrates. Additionally, women with class III obesity showed higher glycemia and energy intake compared with the other groups (Table 1).

Supplementary Tables 1 and 2 showed that the food sources of polyphenols and the phenolic compounds consumed, respectively, were significantly different among the women. The study identified 70 food sources of polyphenols consumed by the women. Among these foods, seven differed between groups. A higher intake of banana, chocolate (beverage), and whole grain bread was observed in women with class I obestity than in those with class III. In relation to women with class II obesity, we found a higher intake of whole grain rice and a lower intake of bread and coffee compared with women in the class III group. Women with class III obesity consumed more white rice than the other groups. The food sources commonly consumed by all the women were coffee, chocolate (beverage), grape juice, orange, and black beans. The top 10 food sources consumed among the class I obesity group were coffee, followed by chocolate (beverage), grape juice, orange, black beans, whole grain bread, dark chocolate, pasta, milk chocolate, and guava; for women with class II obesity it was coffee, chocolate beverage, black beans, grape juice, beer, pasta, whole grain bread, and lettuce. The class III obesity group consumed coffee, orange, grape juice, chicory, beer, black beans, chocolate (beverage), strawberry, whole grain bread, and guava. Also, a lower consumption of fruits, vegetables, and whole foods was observed in the class III group, although this trend did not differ from the other groups.

Mean total polyphenol intake was estimated at 523.5 ± 464.89 mg/d, with 573 ± 490 for class I obesity, 614 ± 475 for class II obesity, and 379 ± 25 for class III obesity (Table 1). Women in the class III group had lower total polyphenol intake than those in other classes of obesity. We identified 259 compounds in the food records. Among these compounds, 33 differed between groups. In the class I obesity group, matairesinol and secoisolariciresinol were higher, and *cis*-ferulic acid was lower than in the class III group. Additionally, syringic acid was higher in the class I obesity group than in the class II group. p-Coumaric acid, caffeoyl aspartic acid, procyanidin dimer B12, procyanidin dimer B3 were higher in class II obesity than in class III obesity. In the class III obesity group,

Table 1
Baseline characteristics of the participants

Variables	Class I obesity (n = 46)	Class II obesity (n = 32)	Class III obesity (n = 36)	*P*-value
Age, y	32.54 ± 6.26 (30.68–34.40)	32.59 ± 6.71 (30.17–35.01)	35.53 ± 7.47 (33.00–38.05)	0.100
BMI, kg/m^2	32.61 ± 1.57^a (32.14–33.07)	37.54 ± 1.46^b (37.02–38.07)	46.21 ± 2.89^c (44.55–47.86)	**0.000**
WC, cm	95.65 ± 6.76^a (93.64–97.65)	104.61 ± 9.20^b (101.29–107.93)	118.17 ± 10.48^c (114.62–121.71)	**0.000**
Glycemia, mg/dL	91.76 ± 8.92^a (89.11–94.41)	90.06 ± 8.42^a (87.03–93.10)	104.80 ± 36.68^b (92.39–117.22)	**0.009**
TC, mg/dL	184.43 ± 29.45 (175.69–193.18)	173.81 ± 33.32 (161.80–185.82)	169.72 ± 41.42 (155.71–183.73)	0.142
LDL-C, mg/dL	110.63 ± 27.40 (102.49–118.77)	107.72 ± 32.05 (96.16–119.27)	109.05 ± 28.76 (99.32–118.78)	0.909
HDL-C, mg/dL	48.85 ± 12.54 (45.12–52.57)	44.59 ± 8.23 (41.63–47.56)	44.44 ± 9.39 (41.27–47.62)	0.102
TG, mg/dL	124.72 ± 58.92 (107.22–142.21)	116.78 ± 57.86 (95.92–137.64)	104.89 ± 52.43 (87.15–122.63)	0.294
Energy, kcal	1908.15 ± 732.28^a (1690.69–2125.61)	1942.00 ± 452.16^a (1778.98–2105.02)	2500.93 ± 917.22^b (2190.59–2811.28)	**0.001**
Protein, g/kg of body weight	0.95 ± 0.30 (0.86–1.04)	0.79 ± 0.21 (0.71–0.86)	0.89 ± 0.35 (0.77–1.01)	0.057
Carbohydrate, %	50.98 ± 6.00 (49.20–52.76)	51.76 ± 6.23 (49.52–54.01)	49.22 ± 7.79 (46.58–51.85)	0.270
Fat, %	31.07 ± 5.84 (29.33–32.80)	31.57 ± 5.89 (29.44–33.69)	32.91 ± 6.92 (30.57–35.25)	0.404
Total polyphenol intake	573.07 ± 489.99^a (490.59–655.55)	614.44 ± 475.14^a (518.16–710.71)	379.18 ± 386.25^b (305.50–452.86)	**0.002**

ANOVA, analysis of variance; BMI, body mass index; WC, waist circumference; BFM, body fat mass; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triacylglycerides.
One-way ANOVA was conducted to compare the groups, and Bonferroni post hoc. Different letters indicate difference between groups. *p*-value significant were highlighted in bold.

Table 2
Ranking of food intake by polyphenols content in grams of food and per capita

Rank	Food	Polyphenol (mg)/100 g or mL of food	Rank	Food	Polyphenol per capita
1	Black olives	563.84	1	Coffee	429.5
2	Cocoa	549.13	2	Guava	214.88
3	Dark chocolate	261.50	3	Red wine	162.58
4	Coffee	214.74	4	Grape juice	136
5	Chicory	192.59	5	Tangerine juice	88.46
6	Fresh plum	190.47	6	Orange	87.93
7	Strawberry	137.76	7	Cocoa	87.86
8	Guava	126.40	8	Lemon juice	83.46
9	Red wine	108.39	9	Strawberry	66.12
10	Black grape	91.24	10	Dark chocolate	65.37
11	Grape juice	68.00	11	Chocolate (beverage)	58.66
12	Olive oil	60.85	12	Beer	58.10
13	Orange	48.85	13	Chicory	38.52
14	Tangerine juice	44.23	14	Prune plum	29.20
15	Lemon juice	41.73	15	Pear	21.68
16	Tofu	39.24	16	Black olive	16.91
17	Garlic	30.84	17	White wine	15.99
18	Chocolate (beverage)	29.33	18	Black grape	14.60
19	Wheat flour	28.56	19	Whole grain bread	12.35
20	Whole grain bread	24.71	20	Tangerine	10.66
21	Carrot	20.45	21	Green grape	8.38
22	Milk chocolate	19.22	22	Black bean	6.08
23	Green grape	17.45	23	Melon	6.02
24	Pear	16.68	24	Wheat flour	5.71
25	Beer	16.60	25	Pasta	5.31
26	Raisin/grape	13.66	26	Olive oil	4.87
27	White wine	10.66	27	Milk chocolate	4.80
28	Almond	8.90	28	Apple	4.48
29	Oat	8.82	29	Tofu	3.92
30	Lettuce	8.43	30	Watermelon	3.85
31	Tangerine	7.90	31	Raisin/grape	3.28
32	Cherry tomato	7.08	32	Orange juice	2.8
33	Melon	6.69	33	Cooked sweet potato	2.75
34	Onion	5.40	34	Carrot	2.45
35	Cress	5.16	35	Mango	2.41
36	Cooked pasta	4.83	36	Persimmon	2.40
37	Black bean	4.34	37	Cherry tomato	2.12
38	Tomato	4.15	38	Tomato	1.87
39	Cucumber	3.96	39	Oat	1.32
40	Cooked spinach	3.91	40	Cooked potato	1.25
41	Apple	2.99	41	Avocado	1.18
42	Banana	2.55	42	Banana	1.02
43	Persimmon	2.18	43	Cooked spinach	0.98
44	Watermelon	1.93	44	Cooked cauliflower	0.88
45	Cooked potato	1.78	45	Lettuce	0.84
46	Pumpkin	1.74	46	Pineapple	0.72
47	Mango	1.72	47	Onion	0.65
48	Green bean	1.58	48	Pumpkin	0.62
49	Cooked sweet potato	1.53	49	White rice	0.62
50	Soy sauce	1.48	50	Cooked chickpeas	0.59
51	Orange juice	1.40	51	Kiwi	0.53
52	Cooked chickpeas	1.34	52	Cress	0.51
53	Cooked broccoli	0.99	53	Whole grain rice	0.4
54	Cooked carrot	0.98	54	Strawberry sweet	0.39
55	Strawberry sweet	0.98	55	Cucumber	0.36
56	Pineapple	0.96	56	Green bean	0.32
57	Cooked cauliflower	0.73	57	Garlic	0.31
58	Kiwi	0.70	58	Peanut	0.22
59	Cooked zucchini	0.65	59	Cooked zucchini	0.19
60	Peanut	0.65	60	Almond	0.18
61	White rice	0.62	61	Cooked carrot	0.15
62	Avocado	0.55	62	Cabbage	0.11
63	Beetroot	0.51	63	Beet root	0.10
64	Cabbage	0.41	64	Cooked broccoli	0.10
65	Whole grain rice	0.40	65	Bread	0.09
66	Cooked soy	0.23	66	Cooked soy	0.09
67	Bread	0.19	67	Soy sauce	0.08
68	Passion fruit	0.02	68	Arugula	0.03
69	Papaya	0.002	69	Passion fruit	0.009
70	Arugula	0.001	70	Papaya	0.003

gallocatechin, protocatechuic acid, caffeic acid, sinapic acid, 4-caffeoylquinic acid (CQA), 3-CQA, 3,4-dicaffeoylquinic acid (DCQA), 3,5-DCQA, 4,5-DCQA, 3-,4- and 5-feruloylquinic acid (FQA), 4-ethylguaiacol, 4-vinylguaiacol, guaiacol, 3-methylcatechol, 4-methylcatechol, catechol, phenol, and pyrogallol were higher than in class II obesity. We observed that lariciresinol and 5-CQA were higher in the class III obesity group than in the other groups but *trans*-ferulic acid and procyanidin dimer B2 were also lower.

The main compounds consumed were CQA, (3- and 4-) CQA, and (4-, 5-) FQA. The 10 major phenolic compounds consumed by women with class I obesity were procyanidin dimer B2, CQA, (4-, and 3-) CQA, (5-, 4-, and 3-) FQA, epicatechin, catechin, and caffeoyl aspartic acid; women with class II obesity consumed procyanidin dimer B2, CQA, (4-, and 3-) CQA, (5-, and 4-) FQA, catechin, epicatechin, caffeoyl aspartic acid, and vanillic acid; and the class III obesity group consumed CQA, (4-, and 3-) CQA, (5-, 4-, and 3-) FQA, hesperetin, 3- FQA, (2,4-, and 4,5-) DCQA, and naringenin.

Table 2 shows the polyphenol content of foods consumed in descending order. The ranking was also performed according to the amount of polyphenols per capita. Table 2 shows the dietary intake and the consumption of polyphenols per food, respectively. Coffee was the most consumed food source of polyphenols (Table 2). However, the polyphenol content of coffee is not very high compared with black olives, which contain a higher number of phenolic compounds among the consumed food sources (Table 2).

Of the 114 women with obesity, 90 consumed coffee, with only 4 not sweetening the beverage. Nineteen used sweetener, 62 used sugar, and 5 used both sweetener and sugar. Among sweeteners used by women, saccharin, sucralose, or stevia were cited. Mean sugar intake was 20 ± 17 g (95% confidence interval, 17–23) for those who sweetened coffee with sugar, equivalent to four full teaspoons in 215 ± 156 mL (confidence interval 190–241) of coffee.

Discussion

Unhealthy food sources accounted for polyphenol intake among the women. The food that most contributed to the intake of phenolic compounds was coffee. Accordingly, the compound most ingested was CQA. Additionally, the most common food sources containing phenols consumed by the women were not fruits and vegetables. The few fruits, vegetables, and whole grain bread among the top 10 food sources of polyphenols were not consumed by majority of the women.

Previous studies have reported mean total consumption of phenols to be between 330 and 1190 mg/d. Thus, a mean consumption of 523 ± 417 mg/d is consistent and similar to other values reported in the literature [17–20]. Despite this similarity, we emphasize that the cited studies were conducted in different countries with specific dietary patterns. Moreover, the studies varied regarding the use of different dietary assessment instruments and participants of both sexes with different ages and BMI.

The high SD of our result lies in the variability of polyphenol intake among the women characterized by volunteers who consumed high amounts of polyphenols and others who consumed few phenolic compounds. Also, some food records did not contain all the food sources.

In agreement with the present study, a study performed in Brazil found coffee to be the main contributor of polyphenols; however, the studied population had age ranges higher than the present study [19]. Coffee is one of the beverages most consumed in Brazil and it is a food culture of Brazilians, which justifies it being the food source mostly consumed [21,22]. However, excessive use of sugar to sweeten coffee is not beneficial to health. High sugar consumption is associated with weight gain, as well as risk for type 2 diabetes mellitus and cardiovascular diseases [23]. The World Health Organization recommends that 10% of the total energy intake be added sugar, which corresponds to 50 g of sugar in a 2000-kcal diet. Four teaspoons is almost half of the daily recommendation and corresponds to the mean intake of the volunteers [24].

Other food sources that made an important contribution to polyphenols intake were black beans and chocolate (beverage), foods consumed almost daily and by majority of the women in all three groups. Both foods are sources of carbohydrates; however, black beans are a source of fiber, whereas chocolate (beverage) is rich in simple carbohydrates and their excess intake can lead to weight gain [25].

As mentioned, there is a low contribution of fruits and vegetables to the diet of the study population. These fruits include orange, guava, and grape juice as the main sources. These data are in agreement with the low intake of fruits and vegetables by the Brazilian population as reported by Souza et al. [21], which could justify the few sources of phenolic compounds from these food groups. Additionally, it was observed these fruits were not consumed daily by all the women.

Other studies, especially those with European populations, show a strong presence of oil seeds and olive oil as important contributors to polyphenol intake [17,18], due to the Mediterranean diet [26]. However, the same was not observed in the present study, where the intake of these foods was very low, probably because they are not a component of the food culture of the Brazilian population, which could justify their low representation in polyphenol consumption [21].

Women with class III obesity showed higher intake of polyphenols, especially those found in coffee [16], a food mostly consumed by this group. 5-CQA is highlighted as the most consumed compound regardless of group. An experimental study with rats showed that this compound appears to have beneficial effects in the treatment of obesity, favoring weight loss and improvement in the metabolic profile [27]. However, we observed the low intake of some compounds such as kaempferol 3-*O*-galactoside, which contribute to weight loss, improvement of glycemic control, and hyperlipemia [28], in addition to isorhamnetin, which has antiobesity effects [29].

Although the women showed a low consumption of compounds with antiobesity effects, they consumed a significant quantity of compounds that exert the same effect. However, diet must be considered as a whole because as previously reported, coffee was the main food source of phenolic compounds, and its intake was associated with a considerable sugar consumption.

Conclusion

Total polyphenol intake of the women was lower than other studies probably due to the low intake of fruits, vegetables, and nuts. Additionally, the food sources of polyphenols consumed by the participants were unhealthy and were not consumed in considerable quantities, which may have contributed to low intake. Coffee, chocolate (beverage), grape juice, beer, beans, and bread were among the foods that most contributed to the intake of polyphenols. It is important to emphasize that in the context of obesity and healthy eating, one should not consider only the nutrients and/or bioactive compounds present in a food source but also the nutritional quality of the same. Although a food source can contain high levels of polyphenols, it might contain elements that increase body weight or are harmful to health.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2020.111045.

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