

Dietary patterns are associated with excess weight and abdominal obesity in a cohort of young Brazilian adults

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Abstract

Purpose The objective of the present study was to investigate whether dietary patterns are associated with excess weight and abdominal obesity among young adults (23–25 years).

Methods A cross-sectional study was conducted on 2061 participants of a birth cohort from Ribeirão Preto, Brazil, started in 1978–1979. Twenty-seven subjects with caloric intake outside ± 3 standard deviation range were excluded, leaving 2034 individuals. Excess weight was defined as

body mass index ($\text{BMI} \geq 25 \text{ kg/m}^2$), abdominal obesity as waist circumference ($\text{WC} > 80 \text{ cm}$ for women; $> 90 \text{ cm}$ for men) and waist/hip ratio ($\text{WHR} > 0.85$ for women; > 0.90 for men). Poisson regression with robust variance adjustment was used to estimate the prevalence ratio (PR) adjusted for socio-demographic and lifestyle variables. Four dietary patterns were identified by principal component analysis: *healthy*, *traditional Brazilian*, *bar* and *energy dense*.

Results In the adjusted analysis, the *bar* pattern was associated with a higher prevalence of excess weight (PR 1.46; 95 % CI 1.23–1.73) and abdominal obesity based on WHR (PR 2.19; 95 % CI 1.59–3.01). The *energy-dense* pattern was associated with a lower prevalence of excess weight (PR 0.73; 95 % CI 0.61–0.88). Men with greater adherence to the *traditional Brazilian* pattern showed a lower prevalence of excess weight (PR 0.65; 95 % CI 0.51–0.82), but no association was found for women. There was no association between the *healthy* pattern and excess weight/abdominal obesity.

Conclusions In this sample, the *bar* pattern was associated with higher prevalences of excess weight and abdominal obesity, while the *energy-dense* (for both genders) and *traditional Brazilian* (only for men) patterns were associated with lower prevalences of excess weight.

Keywords Dietary patterns · Excess weight · Abdominal obesity · Young adults

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Introduction

Excess weight and obesity currently represent two of the biggest health problems in developed and developing countries, being considered important risk factors for various

non-communicable chronic diseases (NCCD) [1–3]. It is estimated that 1.46 billion adults are overweight all over the world, of whom 205 million men and 297 million women are obese [4]. In Brazil, 49.0 % of the adult population is overweight and 14.8 % of all individuals are obese [5].

The importance of diet in the genesis of obesity has been well established in the literature, although the pathways through which diet produces obesity remain controversial [6]. Studies on the dietary factors associated with excess weight and obesity conducted over the last decades have given priority to the determination of specific dietary components such as macronutrients and fiber [7, 8]. However, the variety of foods in a diet results in a complex combination of chemical compounds that may be antagonistic and that may compete with or alter the bioavailability of other chemical compounds or nutrients, a fact that is taken into account only when dietary patterns are considered [9]. The analysis of food consumption based on dietary patterns enhances the understanding of the processes of prevention and treatment of obesity and other NCCD, representing a fundamental tool for nutritional interventions [9, 10].

Over the last decade, the association of dietary patterns with obesity has been investigated in various studies [11–16]. Dietary patterns consisting of red meat, whole milk dairy products, processed foods and refined grains, usually denoted as “Western” [11, 13, 15], appear to be positively associated with general and abdominal obesity [13, 15]. In contrast, dietary patterns denoted “prudent or healthy,” involving the consumption of fruits, vegetables, whole grains and fish, are inversely associated with obesity [14, 17]. Most of these studies were conducted in developed countries on populations older than 30 years of age. Few studies have been specifically conducted [16] on young adults who are at risk of obesity or even for excess weight gain during this period that marks the transition between adolescence and the early stages of adult life [18, 19].

The objective of the present study was to investigate whether dietary patterns are associated with excess weight and abdominal obesity in young adults from the 1978/79 Ribeirão Preto birth cohort, São Paulo, Brazil. As a secondary objective, we aimed to describe daily portion sizes of each food group for those in the lowest and highest quartiles of adherence to each dietary pattern stratifying by sex.

Methods

Study design and setting

This was a cross-sectional study nested in the first Ribeirão Preto birth cohort, São Paulo, Brazil, started in 1978/79, which investigated live births that took place at hospitals

to mothers residing in the municipality. The study used data collected during the fourth phase of the research, conducted from 2002 to 2004. A total of 9396 children born at the eight maternities of Ribeirão Preto from June 1978 to May 1979 participated in the original study, corresponding to 98 % of live-born infants. Losses due to refusal or early hospital discharge amounted to 3.5 % (329). After the exclusion of children whose families do not reside in the municipality (2094) and of twins (146), 6827 of the initial sample were left. Of these, 343 died before completing 20 years of age, with 6484 eligible subjects remaining. Based on the records of the Unified Health System and of private health plans, and on contacts made during the second and third phase of the study, it was possible to locate 5665 individuals. Based on the socioeconomic characterization of the city, divided into four regions according to head of family income, one in three individuals was contacted. The losses due to refusal to participate (209 cases), death after 20 years of age (34 cases), imprisonment (31 cases) and failure to attend the interview (431 cases) resulted in a total of 705 individuals. Thus, a total of 2063 adults aged 23–25 years, corresponding to 31.8 % of the 6484 subjects, participated in the fourth phase of the Ribeirão Preto cohort study [20]. Two subjects were excluded because they did not fill out the Food Frequency Questionnaire (FFQ) and 27 because they reported energy intake outside the range $\pm 3SD$, leaving 2034 cases for analysis.

The study was conducted according to the directives established in the Declaration of Helsinki, and all procedures involving human beings were approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo, Brazil. All persons gave their informed consent prior to their inclusion in the study.

Study variables

The participants responded to a questionnaire containing socioeconomic, demographic and lifestyle data in which the following variables were considered: sex, self-reported skin color, marital status, monthly family income, education, level of physical activity, and current smoking habit. Skin color was investigated as a proxy for race, according to the Brazilian census criterion that considers the self-reported skin color. Educational status was obtained by the completed years of study. The monthly household income was calculated summing the income of all family members residing in the household in the last month and was subsequently converted into Brazilian minimum wages, which is the most used approach to assess monthly income in Brazil. The conversion of the Brazilian minimum wage was essentially equivalent to US\$ 89.8 in 2003. Currently, the Brazilian monthly household income is equivalent to US\$ 273.9

per month. The level of physical activity was assessed based on the International Physical Activity Questionnaire protocol [21]. Physical activity was then classified as low, moderate and high, based on the metabolic cost or unit of resting metabolic rate (MET) following IPAQ guidelines. Tobacco consumption during the last month preceding the interview was considered to be current smoking habit; however the amount of tobacco consumed was not investigated.

Dietary data were obtained from a FFQ adapted from an instrument validated for the Japanese–Brazilian community of São Paulo, which was later used in programs of prevention of NCCD diseases for adults after the exclusion of foods of Japanese origin [22]. The adapted FFQ contained 75 items, the respective option of frequency of consumption during the last year (number of times per day, week, or month) and the size of the mean reference portion, so that the individual would estimate whether the portion usually consumed was small (smaller than the reference), medium (equal to the reference) or large (larger than the reference), representing the 25th, 50th and 75th percentiles, respectively. A nutritionist administered the questionnaire and a photo album was used to help the subject estimate the portions consumed. The methodology of this study has been described in detail by Molina et al. [23].

The nutritional composition of the foods was obtained from the Dietsys software, version 4.0 (National Cancer Institute, Bethesda, MD, USA), which estimates the chemical composition of the foods by their daily portion sizes described in the FFQ. Some Brazilian foods and food preparations that were not available in the Dietsys program were added to this software when complete data about them were available from Brazilian tables of food composition [24]. Foods with incomplete or doubtful information regarding its chemical composition were replaced with foods of similar composition. We opted to use mainly the US food composition dataset, because when the data of this study were collected, although there was a Brazilian food composition dataset available, it was incomplete with missing information about nutritional composition of some foods. The caloric contributions of proteins, carbohydrates and fats were calculated by dividing the caloric value of each of these nutrients by the total caloric value of the diet and multiplying by 100 in order to express the values as percentages.

In order to identify the dietary patterns, the daily portion consumption of each food in grams or milliliters was the dietary variable used for analysis. The 75 items of the FFQ were divided into 48 groups according to similarity of nutritional composition and frequency of intake. The food items with high intake that were cited by at least 80 % of the subjects, such as rice, beans, banana, chicken, beef, eggs and non-diet sodas, were kept separate [25, 26].

Excess weight was measured by the body mass index (BMI), and abdominal obesity was measured according to waist circumference (WC) and the waist/hip ratio (WHR), which assess fat accumulated in the central or abdominal region. For this purpose, body weight, height [27] and waist and hip circumferences [28] were measured in the young adults according to the techniques standardized. Trained doctors and nurses made these measurements. Weight was measured with a Filizola® scale (São Paulo, SP, Brazil) with 100 g graduations and with a 140-kg capacity, and height was measured with a wood stadiometer with 0.5 cm markings. WC was obtained as the smallest circumference between the ribs and the iliac crest at the end of a normal expiration, with the subjects standing up with a relaxed abdomen. When there was no natural waist, the measurement was made at the level of the navel. The values were recorded with 0.1 cm precision. Height and waist and hip circumferences were measured in duplicate. When these two measurements differed by more than the amount recommended in the protocol, a third measurement was performed. The average of the two more similar measures was considered. BMI was calculated as weight in kg divided by height in meters squared (kg/m^2), and WHR was calculated as the measure of WC in cm divided by hip circumference in cm.

Statistical analysis

To determine the dietary patterns, we used the method of principal components analysis (PCA) followed by orthogonal varimax rotation. The fit of the data was confirmed by the coefficient of Kaiser–Meyer–Olkin (KMO) and the Bartlett's test of sphericity [29, 30]. The number of factors retained was defined according to the following criteria: components with eigenvalues higher than 1.0, Cattel graph (scree plot) and conceptual meaning of the patterns identified. Each principal component was interpreted on the basis of foods with a factorial load ≥ 0.3 or ≤ -0.3 , considered to make an important contribution to the pattern [10]. Within a component, negative loads indicate inverse association of the food item and positive loads indicate a direct association [31]. The dietary patterns were labeled according to the nutritional composition of the foods that the factors included. More methodological details of the dietary patterns have been published elsewhere [32].

Four principal dietary patterns were identified: *healthy* (positive factorial loads for vegetables, fruits, peas and other legumes, fish, non-fried potatoes, manioc and polenta, chicken and breakfast cereals); *traditional Brazilian* (positive factorial loads for beans, rice, margarine and beef and a negative factor loading for low-fat dairy foods, whole grain bread and diet sodas); *bar* (positive factorial loads for alcoholic beverages, salty snacks, pork meat, sausages, eggs,

bacon, seafood and mayonnaise); and *energy dense* (positive factorial loads for desserts, white bread, cookies, chocolates, popcorn/chips, fried potatoes, manioc and polenta and whole milk dairy products). Usually, the studies that have identified a dietary pattern composed of a combination of *bar* and *energy-dense* foods are labeled as processed pattern [25, 33, 34]. In our study, the *bar* and *energy-dense* dietary patterns were representative of the processed pattern and labeled as *bar* pattern because it was composed of alcoholic beverages and foods commonly served in bars or pubs, and like the *energy-dense* pattern, this dietary pattern was characterized by highly caloric foods.

Together, the four patterns explained 20.9 % of the total variance, with the *healthy* and *traditional Brazilian* patterns explaining the greatest proportion of variance (6.6 and 5.1 %, respectively).

Each individual received a score for each factor calculated by the sum of the standardized value of the items (food groups), weighted with their absolute scoring coefficients (factor loadings). In the PCA, the dietary patterns are not mutually exclusive. On the contrary, the individuals adhere to all dietary patterns (in a higher or lower degree). Thus, to verify the adherence, the dietary patterns were categorized into quartiles, with the upper quartile of the distribution representing those with the highest adherence to the pattern.

The main variables were analyzed descriptively according to sex divided in quartiles. To determine the differences between the characteristics of the individuals within the lower quartile (Q1) and those of the individuals within the highest quartile (Q4) of consumption in each pattern, we used analysis of variance for continuous variables and the Chi-square test for categorical variables. The Q2 and Q3 quartiles were omitted from this analysis. The Shapiro–Wilk test was used to assess normal distribution of the quantitative variables.

Daily portion intakes of each food group were described for those in the lowest and highest quartiles of adherence to each dietary pattern stratified by sex. The ANOVA was applied to compare the means of the quartiles.

To determine the association of the dietary patterns with excess weight and abdominal obesity, we used Poisson regression with robust estimate of variance in bivariate analysis and in multivariable analysis in order to estimate the prevalence ratios (PR). The dependent variables (excess weight/obesity according to the three indicators investigated) were classified as dichotomous, i.e., with excess weight/obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$ [35], $\text{WHR} > 0.85$ for women and >0.90 for men [36], and $\text{WC} > 0.80 \text{ cm}$ for women and $>0.90 \text{ cm}$ for men [37]) and without excess weight/obesity. In multivariable analysis, the adjustment was performed for the socio-demographic variables (self-reported skin color, monthly family income

and marital status) and variables associated with lifestyle (current smoking habit, level of physical activity and total energy intake). All dietary patterns were inserted in the analysis, i.e., simultaneous adjustment was made between the dietary patterns. Interaction terms between sex and excess weight/abdominal obesity were tested and when significant models were presented stratified by sex. Since the independent variables were categorized into quartiles, the *P* value for trend was calculated. Point estimate and 95 % confidence intervals were calculated. The level of significance was set at 0.05. Since power to test for interaction was lower than the power to test for main effects, significance level was set at 0.10 for interaction terms to increase sensitivity, although at the cost of increasing the risk of type I error (false positive) [38]. The statistical analyses were carried out with the aid of the Stata software, version 10.0.

Results

Individuals with greater adherence (Q4) to the *healthy* pattern were less sedentary (30.2 % of men and 44.5 % of women) than those with the lowest adherence (Q1) (53.1 and 65.9 % of men and women, respectively). Among men, the percentage of smokers was lower in the highest quartile (Q4) (18.5 vs. 28.0 %). Individuals in the Q4 of the *healthy* dietary pattern had more energy from protein and less energy from fats compared to individuals in Q1. There was no significant difference between Q1 and Q4 regarding excess weight and/or abdominal obesity among men and women (Table 1).

For the *traditional Brazilian* pattern, men in the upper quartile of adherence showed a lower prevalence of excess weight (35.9 %) than those in the lowest quartile (53.7 %), while women who more adhered to this pattern showed higher frequency of excess weight/obesity when compared to Q1 on the basis of the three indicators assessed: BMI (31.1 vs. 24.1 %), WC (18.5 vs. 9.0 %) and WHR (12.1 vs. 5.3 %). The diet consumed by men and women with greater adherence to this pattern showed a greater caloric contribution from carbohydrates and a lower contribution from proteins and fats compared to the diet of Q1 subjects (Table 1).

Considering the *bar* pattern, men in the Q4 showed a higher frequency of sedentary (44.0 vs. 42.1 %) and excess weight/obesity than Q1 men on the basis of the three indicators assessed: BMI (52.1 vs. 39.4 %), WC (18.1 vs. 7.4 %) and WHR (26.7 vs. 15.8 %). Current smoking habit was more frequent among men and women who adhere more to this pattern. The diet consumed by Q4 individuals showed a lower caloric contribution of carbohydrates and a higher contribution of proteins and fats compared to that consumed by Q1 individuals (Table 1).

Table 1 Characteristics of 23- to 25-year-old adults of the Ribeirão Preto birth cohort (4th phase: 2002–2004) according to quartile categories of dietary patterns

	Healthy pattern				Traditional Brazilian pattern			
	Males		Females		Males		Females	
	Q1	Q4	P		Q1	Q4	P	
N	243	243	–		243	243	–	
% Excess weight (BMI) ^a	44.6	49.8	0.312		53.7	35.9	0.015	
BMI (kg/m ²)	25.2/4.6	25.5/4.8	0.058		25.6/4.1	24.5/4.7	0.039	
% Central obesity (WC) ^b	14.1	11.9	0.180		12.4	10.3	0.888	
WC (cm)	88.2/12.1	88.7/12.3	0.175		88.7/11.0	86.4/12.6	0.125	
% Central obesity (WHR) ^c	23.5	24.7	0.387		20.7	20.6	0.736	
WHR	0.86/0.07	0.86/0.06	0.311		0.85/0.06	0.85/0.06	0.394	
% Smokers	28.0	18.5	0.006		21.0	21.4	0.501	
% Sedentary	53.1	30.2	<0.001		42.0	41.3	0.713	
Food intake								
% Carbohydrate calories	47.7/8.1	48.3/6.8	0.488		44.8/6.8	50.0/6.8	<0.001	
% Protein calories	14.9/2.7	16.9/3.6	<0.001		17.5/3.7	15.1/2.7	<0.001	
% Fat calories	37.1/6.5	34.5/5.2	<0.001		37.3/5.9	34.5/5.2	<0.001	
Bar food pattern								
N	243	243	–		243	243	–	
% Excess weight (BMI) ^a	39.4	52.1	0.033		50.8	39.3	0.074	
BMI (kg/m ²)	24.3/4.1	26.1/4.7	<0.001		25.5/4.7	24.5/4.1	0.074	
% Central obesity (WC) ^b	7.4	18.1	0.001		11.9	11.2	0.979	
WC (cm)	85.3/10.2	90.5/12.3	<0.001		88.9/12.1	86.7/10.9	0.175	
% Central obesity (WHR) ^c	15.8	26.7	0.032		24.7	18.6	0.445	
WHR	0.85/0.05	0.87/0.06	0.004		0.86/0.06	0.85/0.06	0.758	
% Smokers	7.0	35.8	<0.001		25.9	19.7	0.034	
% Sedentary	42.1	44.0	0.034		45.9	41.6	0.180	
Food intake								
% Carbohydrate calories	50.9/6.3	44.4/6.9	<0.001		49.1/8.6	46.7/6.1	<0.001	
% Protein calories	15.2/3.2	16.5/3.3	<0.001		16.7/4.1	15.0/2.4	<0.001	
% Fat calories	33.6/4.8	38.7/5.7	<0.001		33.6/5.9	38.2/5.5	<0.001	

Values reported as means/standard deviation for the continuous variables and as percentages for the categorical variables

Q1, the lower quartile of the distribution represents the lowest adherence to the pattern; Q4, the upper quartile of the distribution represents the highest adherence to the pattern

ANOVA for continuous variables and Chi-square test for categorical variables

^a Excess weight: body mass index—BMI ≥ 25 kg/m²^b Central obesity, waist circumference WC > 80 cm for women and >90 cm for men^c Central obesity, waist hip ratio WHR > 0.85 for women and >0.90 cm for men

Individuals in the highest quartile of consumption of the *energy-dense* dietary pattern showed a lower percentage of smokers (men: 19.7 vs. 25.9 % and women: 10.6 vs. 19.5 %) than those in the lowest quartile. The caloric contribution of protein was lower, while the contribution of fats was higher among individuals adhering to this pattern compared to Q1 individuals. Among men, the diet consumed by Q4 individuals showed a lower caloric contribution of carbohydrates. Prevalences of excess weight did not differ comparing those in the lower with those in the upper quartile of adherence to the *energy-dense* pattern (Table 1).

We observed that daily portion sizes of foods that composed the *healthy* pattern were higher for women as compared to men in the highest quartile, except for fish, chicken, banana and fruit juice (Online Resource Table 1). The daily portion intakes of those in the highest quartile of the *traditional Brazilian* pattern were higher for men when compared to women for rice, beans and low-fat dairy foods (Online Resource Table 2). Beer and salty snacks were the two items with the highest daily portion sizes for the *bar* pattern, independently of the sex. These items were followed by cold cuts and pork meat (Online Resource Table 3). Whole dairy products, white bread and desserts were the food items with the highest daily portion sizes in the highest quartile of adherence for the *energy-dense* pattern (Online Resource Table 4).

A significant interaction between sex and excess weight/obesity (BMI: $P = 0.005$; WC: $P = 0.054$; WHR: $P = 0.018$) was detected only for the *traditional Brazilian* dietary pattern (data not shown in table). We tested an interaction term between the *bar* pattern and sex, and it turned out to be nonsignificant, so the *bar* pattern is similar between both sexes.

In the adjusted analysis, a greater adherence to the *bar* pattern was associated with a higher prevalence of excess weight (PR 1.46; CI 95 % 1.23–1.73) and abdominal obesity as measured by WHR (PR 2.19; CI 1.59–3.01). The *energy-dense* pattern was found to be associated with lower prevalences of excess weight (PR 0.73; 95 % CI 0.61–0.88). After adjustment in multivariable analysis, there was no association between the *healthy* pattern and excess weight/abdominal obesity (Table 2). The *traditional Brazilian* pattern seemed to protect against excess weight among men (PR 0.63; CI 95 % 0.50–0.79). However, among women, the association between more adherence to this pattern and higher excess weight/abdominal obesity detected in the unadjusted analysis was no longer present after adjustment (Table 3).

Discussion

The *traditional Brazilian* (among men) and *energy-dense* patterns were associated with a lower prevalence, whereas

the *bar* pattern was associated with a higher prevalence of excess weight and/or abdominal obesity.

The dietary pattern labeled *healthy* was not associated with excess weight/abdominal obesity. These findings differ from those reported in most studies, in which dietary patterns considered healthy were inversely associated with obesity [14, 17, 39, 40] in cross-sectional studies and with lower BMI and WC gains in longitudinal studies [41, 42]. In a study on adult women from southern Brazil, different dietary patterns consisting of healthy foods were identified, in which the pattern denoted “fruits” was inversely associated with obesity, as measured by BMI, while the “vegetables” pattern was directly associated with obesity [7].

The composition of the *healthy* dietary pattern identified in the present study is similar to that reported in other studies [12, 13, 31, 43], composed of vegetables, fruits, peas and other legumes, fish and chicken, and characterized by foods rich in vitamins, minerals, fibers, unsaturated fats, containing low amounts of simple sugars and trans and saturated fats [15]. However, we hypothesize that the presence of foods with high starch content in this pattern may increase the glycemic content of such foods. However, we were unable to specify the way preparations were cooked. High consumption of energy-dense foods such as breakfast cereals may explain why we did not find an association between this pattern and lower prevalences of excess weight/abdominal obesity. In addition, some studies suggest that a wide variety of food items in the diet may play a role in the increase in BMI [44, 45].

Individuals of both sexes with higher scores for the *healthy* pattern (Q4) were found to be less sedentary and to consume a diet with a greater contribution of proteins and a lower contribution of fats compared to Q1 individuals, supporting the notion that a healthy diet is associated with other healthy habits [11, 14, 15, 25, 46, 47].

The second pattern identified was called *traditional Brazilian*, consisting of traditional foods of the Brazilian diet (rice and beans), and was found to protect against excess weight among men. Other Brazilian studies have also identified patterns similar to this [14, 25, 31, 44, 47, 48] and have observed a similar protective effect of the traditional pattern against excess weight measured by the BMI [16, 44, 45]. The protective effect of this pattern may be explained by: (1) a low glycemic index of the rice and beans combination; (2) the high fiber content of beans; (3) the reduced variety of the foods included in this pattern [44, 45]; and (4) a lower consumption of processed foods habitually consumed outside the home, since the consumption of rice and beans suggested a diet prepared at home [16, 45]. On the other hand, Neumann et al. [47] also observed a positive association of the “traditional” pattern with obesity, although measured according to the BMI. Among women, after adjustment, there

Table 2 Non-adjusted and adjusted prevalence ratios (PR) and 95 % confidence intervals (95 % CI) for the association of excess weight and abdominal obesity with the *healthy, bar and energy-dense food* dietary patterns identified among 23- to 25-year-old adults of the Ribeirão Preto cohort (4th phase: 2002–2004)

Dietary patterns	Excess weight (Body Mass Index—BMI) ^a		Abdominal obesity (waist circumference—WC) ^b		Abdominal obesity (waist hip ratio—WHR) ^c	
	%	Non-adjusted PR (95 % CI)	Adjusted PR ^d (95 % CI)	%	Non-adjusted PR (95 % CI)	Adjusted PR ^d (95 % CI)
<i>Healthy</i>						
Q1	38.1	$P = 0.719$ Reference	$P = 0.866$ Reference	14.4	$P = 0.558$ Reference	$P = 0.800$ Reference
Q2	35.2	0.92 (0.79–1.09)	0.95 (0.81–1.12)	12.6	0.87 (0.64–1.19)	0.89 (0.65–1.22)
Q3	35.0	0.92 (0.78–1.08)	0.97 (0.82–1.14)	11.8	0.81 (0.59–1.13)	0.86 (0.62–1.19)
Q4	36.0	0.95 (0.81–1.11)	1.01 (0.85–1.20)	11.8	0.82 (0.60–1.13)	0.89 (0.63–1.24)
<i>Bar</i>						
Q1	31.6	$P < 0.001$ Reference	$P < 0.001$ Reference	12.2	$P = 0.085$ Reference	$P = 0.149$ Reference
Q2	32.1	1.01 (0.85–1.21)	1.03 (0.87–1.23)	10.0	0.82 (0.58–1.16)	0.84 (0.59–1.19)
Q3	35.8	1.13 (0.95–1.34)	1.15 (0.97–1.37)	13.0	1.06 (0.77–1.47)	1.13 (0.82–1.58)
Q4	44.9	1.42 (1.21–1.67)	1.46 (1.23–1.73)	15.3	1.25 (0.92–1.71)	1.25 (0.89–1.76)
<i>Energy dense</i>						
Q1	42.4	$P = 0.004$ Reference	$P = 0.004$ Reference	13.2	$P = 0.673$ Reference	$P = 0.464$ Reference
Q2	34.1	0.80 (0.69–0.94)	0.83 (0.71–0.97)	12.2	0.93 (0.67–1.28)	0.95 (0.69–1.32)
Q3	35.8	0.84 (0.72–0.98)	0.86 (0.73–1.01)	11.4	0.87 (0.62–1.20)	0.82 (0.59–1.15)
Q4	32.1	0.76 (0.64–0.89)	0.73 (0.61–0.88)	13.8	1.04 (0.77–1.43)	0.79 (0.56–1.10)

The dietary patterns were categorized into quartiles—Q1 (the lower quartile of the distribution represents the lowest adherence to the pattern), Q2, Q3 and Q4 (the upper quartile of the distribution represents the highest adherence to the pattern)

* P value referring to the maximum likelihood ratio obtained by Poisson regression (P value for trend)

^a Excess weight: body mass index—BMI ≥ 25 kg/m²

^b Central obesity, waist circumference WC > 80 cm for women and >90 cm for men

^c Central obesity, waist hip ratio WHR > 0.85 for women and >0.90 cm for men

^d Adjusted for skin color, schooling, monthly family income, marital status, smoking habit, level of physical activity, and total caloric intake (kcal/day) and the other dietary patterns

Table 3 Non-adjusted and adjusted prevalence ratios (PR) and 95 % confidence intervals (95 % CI) for the association of excess weight and abdominal obesity with the traditional Brazilian pattern identi-

fied among 23- to 25-year-old adults of the Ribeirão Preto cohort (4th phase: 2002–2004)

Sex	Excess weight (Body Mass Index—BMI) ^a			Abdominal obesity (waist circumference—WC) ^b			Abdominal obesity (waist hip ratio—WHR) ^c		
	%	Non-adjusted PR (95 % CI)	Adjusted PR ^d (95 % CI)	%	Non-adjusted PR (95 % CI)	Adjusted PR ^d (95 % CI)	%	Non-adjusted PR (95 % CI)	Adjusted PR ^d (95 % CI)
<i>Male</i>		<i>P</i> = 0.001	<i>P</i> = 0.003		<i>P</i> = 0.888	<i>P</i> = 0.727		<i>P</i> = 0.736	<i>P</i> = 0.545
Q1	53.9	Reference	Reference	12.4	Reference	Reference	20.7	Reference	Reference
Q2	41.6	0.77 (0.64–0.93)	0.80 (0.65–0.97)	10.7	0.86 (0.53–1.42)	0.86 (0.51–1.45)	24.3	1.17 (0.84–1.64)	1.26 (0.89–1.78)
Q3	42.8	0.79 (0.66–0.96)	0.79 (0.65–0.97)	11.5	0.93 (0.57–1.51)	0.86 (0.51–1.45)	21.9	1.06 (0.75–1.49)	1.12 (0.77–1.63)
Q4	36.2	0.67 (0.55–0.82)	0.65 (0.51–0.82)	10.3	0.83 (0.50–1.37)	0.71 (0.40–1.27)	20.6	0.99 (0.70–1.41)	1.05 (0.70–1.59)
<i>Female</i>		<i>P</i> = 0.111	<i>P</i> = 0.587		<i>P</i> = 0.001	<i>P</i> = 0.464		<i>P</i> = 0.001	<i>P</i> = 0.267
Q1	24.1	Reference	Reference	9.0	Reference	Reference	5.3	Reference	Reference
Q2	28.3	1.18 (0.88–1.57)	0.95 (0.71–1.28)	10.2	1.13 (0.67–1.91)	0.93 (0.54–1.59)	6.4	1.22 (0.61–2.43)	0.89 (0.44–1.81)
Q3	33.1	1.37 (1.05–1.81)	0.93 (0.69–1.25)	18.1	2.00 (1.26–3.17)	1.30 (0.78–2.17)	13.5	2.57 (1.42–4.66)	1.51 (0.78–2.95)
Q4	31.3	1.30 (0.99–1.72)	0.81 (0.58–1.13)	18.5	2.04 (1.30–3.24)	1.55 (0.67–1.99)	12.1	2.29 (1.25–4.20)	1.16 (0.58–2.34)

The dietary patterns were categorized into quartiles—Q1 (the lower quartile of the distribution represents the lowest adherence to the pattern), Q2, Q3 and Q4 (the upper quartile of the distribution represents the highest adherence to the pattern)

* *P* value referring to the maximum likelihood ratio obtained by Poisson regression (*P* value for trend)

^a Excess weight: body mass index—BMI ≥ 25 kg/m²

^b Central obesity, waist circumference WC >80 cm for women and >90 cm for men

^c Central obesity, waist hip ratio WHR >0.85 for women and >0.90 cm for men

^d Adjusted for skin color, schooling, monthly family income, marital status, smoking habit, level of physical activity, and total caloric intake (kcal/day) and the other dietary patterns

was no association between the *traditional Brazilian* pattern and excess weight/abdominal obesity in the present study. Gimeno et al. [14], in a study of adults aged 30 years or more in Ribeirão Preto, also did not observe an association between the “popular Brazilian” pattern and BMI or WC. In general, the association of dietary patterns with BMI or with obesity has been less evident in women than in men [7].

The *bar* and the *energy dense* were the other two identified patterns. Patterns with similar compositions have been designated in other ways in other studies: *bar*—“atherogenic” [47], “alcohol” [34] and “processed foods” [25] and *energy dense*—“obesogenic” [14], “energy dense” [12], “snacks” [31], “dairy products and desserts” [25] and “cafeteria” [47]. However, in many other studies, a type of pattern was identified that was called in most cases “Western” [11, 15, 44, 45, 48, 49] or “unhealthy” [33], representing a combination of foods included in the *bar* and *energy-dense* patterns presented in our study. Combined or separate, these patterns included foods rich in sugars and saturated fats and were positively associated with indicators of excess weight/obesity [12, 13, 45, 47, 48]. An inverse association of the “Western” pattern with BMI was observed only in the study by Sánchez-Villegas et al. [11].

In the present study, in agreement with data reported in previous investigations [12, 13, 15, 16, 45], the *bar* pattern was directly associated with excess weight/abdominal obesity. On the other hand, the *energy-dense* pattern was associated with lower prevalence of excess weight, which may be explained by the cross-sectional design of our study. This is a limitation for the interpretation of the associations between dietary patterns and anthropometric characteristics, because of the potential reverse causality. There is also a possibility of misreporting. It is known that obese individuals tend to misreport their dietary habits more than the others [7]. In the association under study, reverse causality may have contributed to the discordant findings, since obese individuals may opt to consume healthier foods that do not belong to the pattern defined as *energy dense*. The hypothesis of reverse causality is supported by the lower frequency of unhealthy behaviors (current smoking habit in both sexes) among the individuals with more adherence to this pattern (Q4) compared to those in the category of lower consumption (Q1), a fact that also disagrees with data from other studies, which show that unhealthy dietary patterns are related to other unhealthy lifestyle behaviors [11, 25, 33]. This may indicate a reversal of some unhealthy behaviors associated with obesity among obese individuals that are trying to change their lifestyle to lose weight. Another possible explanation for

this finding is that those who consumed more energy-dense foods ate fewer overall calories. However, the models were adjusted for total energy intake. Thus, since the reverse association between the energy-dense pattern and excess weight/obesity is independent of the amount of calories consumed, this explanation seems unlikely.

Contrary to expectations, those who adhered more to the *healthy* pattern did not present lower prevalence of excess weight. This may be explained by the cross-sectional design of the study. Another possibility is that those in the upper quartile of adherence to the *healthy* pattern may be consuming more calories derived from healthy foods. However, the models were adjusted for total energy intake. Thus, the lack of association between the *healthy* dietary pattern and excess weight/obesity is independent of the amount of calories consumed.

The results that show the daily portion sizes of the food items that composed each of the four dietary patterns provide interesting data for comparisons. We observed that women tended to consume higher portion sizes of food items that compose the *healthy* pattern when compared to men. It is interesting to note that rice and beans were the two most important food items of the *traditional Brazilian* pattern in comparison with the other food groups that compose this pattern, as has been shown previously by their factor loading [32]. We also found that the food items that account to the alcohol content of the *bar* pattern were highly consumed by both men and women. Finally we observed an overall trend of a higher consumption of whole dairy products in comparison with low-fat ones, independently of the dietary pattern.

Some limitations should be considered when interpreting the findings of the present study. First, its cross-sectional design did not permit us to observe the effect of dietary patterns on the indicators of excess weight/obesity, but only to establish associations between independent and dependent variables, which may be due to reverse causality. Second, the subjectivity of the method of principal component factor analysis, which requires the investigators to make various decisions, includes how to group the food items and what to call the patterns [15, 30]. Third, the limitations inherent to dietary surveys such as errors in the estimate of food portions and memory bias [30]. Moreover, the US food composition dataset was used as a reference for almost all FFQ items. However, factors such as seasons, climate, soil nutrients, food preparation and processing can make the nutritional composition of Brazilian foods somewhat different from those included in the US food composition table. It should also be pointed out that selective losses occurred when the group of individuals followed up in the fourth stage of the cohort study was compared to the individuals who were not followed up. The follow-up rates were slightly higher for women and for subjects whose mothers had a higher schooling at the time of their birth.

However, although statistically significant, these differences were small [20].

Considering the strengths, it should be pointed out that the reproducibility and validity of the method used to define the dietary patterns in the present investigation, i.e., PCA with data from the FFQ, were confirmed in a previous study [50]. Nutritionists with the aid of a photo album applied the FFQ in order to facilitate estimation of portion sizes. The consumption period investigated was the last year, considering that longer recall periods may reduce the likelihood of reverse causality [7]. In addition, all the subjective decisions typical of the PCA method were based on scientific knowledge and on an extensive literature review.

In conclusion, the *traditional Brazilian* (only among men) and *energy-dense* (for both genders) patterns were associated with a lower prevalence, whereas the *bar* pattern was associated with a higher prevalence of excess weight and/or abdominal obesity. The recommendation is to reduce consumption of alcoholic beverages and foods composing the *bar* dietary pattern and to encourage consumption of traditional foods of the Brazilian diet (rice and beans) to reduce obesity among young adults.

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Author contributions Machado Arruda and Soraia Pinheiro participated in the stages of data analysis and was responsible for writing the manuscript; Silva, Antônio Augusto Moura da participated in the stage of data analysis and critical review of the manuscript; Kac, Gilberto, Vilela, Ana Amélia Freitas, and Goldani, Marcelo contributed to the discussion and critical revision of the manuscript; Bettiol, Heloisa and Barbieri, Marco Antônio were responsible for the original design of the project and participated in the discussion and critical revision of the manuscript.

Compliance with ethical standards

Conflict of interest All authors declare that there was no conflict of interest.

Ethical aspects The study was conducted according to the directives established in the Declaration of Helsinki, and all procedures involving human being were approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo, Brazil. All persons gave their informed consent prior to their inclusion in the study.

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