Dietary patterns associated with anthropometric indicators of abdominal fat in adults

Padrões alimentares associados a indicadores antropométricos de adiposidade abdominal em adultos

Patrones alimentarios asociados a los indicadores antropométricos de adiposidad abdominal en adultos

Ana Amélia Freitas Vilela [1,2]
Rosely Sichieri [3]
Rosângela Alves Pereira [2]
Diana Barbosa Cunha [3]
Paulo Rogério Melo Rodrigues [1]
Regina Maria Veras Gonçalves-Silva [1]
Márcia Gonçalves Ferreira [1]

[1] Departamento de Alimentos e Nutrição, Universidade Federal de Mato Grosso, Cuiabá, Brasil.
[2] Departamento de Nutrição Social e Aplicada, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.
[3] Departamento de Medicina Social, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brasil.

Correspondence
A. A. F. Vilela
Departamento de Alimentos e Nutrição, Universidade Federal de Mato Grosso.
Av. Fernando Corrêa da Costa 2367, Cuiabá, MT 78060-900, Brasil.
anaameliafv@gmail.com

Abstract

This study aimed to identify dietary patterns and assess their association with abdominal fat. A cross-sectional study was conducted in the Central West Region of Brazil with a probabilistic sample of 208 adults of both sexes. Data on food intake was obtained using a food frequency questionnaire and factor analysis (principal components) was conducted to identify dietary patterns. Waist circumference (WC) and waist-to-hip ratio (WHR) were used to assess abdominal fat. The association between dietary patterns and body fat distribution was examined using multiple linear regression analysis adjusted for confounders. Three dietary patterns were identified: Western, regional traditional, and prudent. A positive association was found between the Western pattern and WC (p = 0.04) and WHR (p = 0.001) and between the regional traditional pattern and WHR (p = 0.05) among women. A slight association was also found between the latter pattern and WC (p = 0.07) also among women. An association was found between the Western and regional traditional dietary patterns and a larger concentration of abdominal fat among women.

Food Consumption; Statistical Factor Analysis; Waist Circumference; Waist-Hip Ratio; Adults

Resumo

Este estudo teve o objetivo identificar padrões alimentares e analisar a associação com a adiposidade abdominal. Estudo transversal, realizado na Região Centro-Oeste do Brasil, com amostra probabilística de 208 adultos, de ambos os sexos. O consumo alimentar foi obtido por questionário de frequência alimentar e aplicada análise fatorial (componentes principais) para identificar padrões alimentares. A circunferência da cintura (CC) e a relação cintura quadril (RCQ) foram indicadores de adiposidade abdominal. A associação dos padrões alimentares com adiposidade abdominal foi analisada em modelos de regressão linear múltipla ajustados por fatores de confusão. Identificaram-se três padrões alimentares: ocidental, tradicional regional e prudente. O padrão ocidental associou-se positivamente com CC (p = 0,04) e RCQ (p = 0,001) e o padrão tradicional regional associou-se também com RCQ (p = 0,05), e marginal a associação com a CC (p = 0,07) somente em mulheres. Os padrões ocidental e tradicional regional associaram à maior adiposidade abdominal em mulheres.

Consumo de Alimentos; Análise Fatorial; Circunferência da Cintura; Relação Cintura-Quadril; Adultos

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Introduction

Central adiposity is the accumulation of intra-abdominal fat in the trunk region. It is an important risk factor for disorders such as type 2 diabetes and cardiovascular disease and is considered to play a more significant role in the development of these diseases than the total amount of body fat [1,2,3,4].

Accurate methods for assessing central adiposity, such as computed tomography scans and magnetic resonance imaging are costly and difficult to apply to epidemiological studies [5]. The World Health Organization (WHO) recommends anthropometric measurements as an adequate and accurate assessment method and waist circumference (WC) and waist-to-hip ratio (WHR) have been shown to be accurate indicators of abdominal fat [6].

A number of studies on the association between dietary factors, particularly those related to nutrients and energy, and fat distribution have been conducted [7,8]. However, the use of this approach limits investigation to the association between health outcomes and food intake [9]. Studies of dietary patterns have been shown to provide promising models for analyzing these associations because they have a greater focus on dietary recommendations and guidelines [10].

Dietary patterns can be defined as sets of foods commonly consumed by a specific population and may be described using food intake reports or methods for estimating food availability [11]. This approach provides a more realistic reflection of the food habits of the group of interest because it reveals the overall dietary pattern rather than isolated estimates of energy and nutrient intake or general food intake [12,13].

Factor analysis is a statistical method that is widely used to identify dietary patterns (or factors) that are not directly observable by aggregating original data on the consumption of several food items based on the existing dependency arrangement (represented by correlation and covariance between food items) [11,14].

Published studies on the eating habits of the population of the Central West Region of Brazil have yet to identify dietary patterns among adults. The objective of the present study was therefore to identify dietary patterns among adults and evaluate their association with estimates of abdominal fat derived from anthropometric measurements.

Materials and methods

A sub-sample of a population-based survey conducted to estimate the prevalence of arterial hypertension among adults in Cuiabá the capital city of the State of Mato Grosso located in the Central West Region of Brazil [15] was used. All 686 adults of both sexes between 20 and 50 years of age were considered eligible for the evaluation using a food frequency questionnaire (FFQ) of which a total of 208 participants were randomly selected to answer questions on food consumption. The quantity of participants selected from each of the four zones of the city of Cuiabá was determined using the proportions adopted by the main study so as to ensure full coverage of the social makeup of the city. The study comprises a secondary analysis of food consumption data obtained by a FFQ validation study developed for use with adults in Cuiabá [16].

The food items used to identify dietary patterns were obtained from a semiquantitative FFQ which included 81 food items and was based on a FFQ validated for use in the adult population of Cuiabá [16]. Eight frequency of consumption options were offered: more than three times a day; twice to three times a day; once a day; five to six times a week; twice to four times a week; once a week; once to three times a month; and never or hardly ever. Frequency of consumption reported in the FFQ was converted into a daily frequency equivalent where proportionate values were attributed to the above frequency options based on a value of 1.0 for once-a-day; for example, twice to four times a week was equated to 0.43 times/day. The chemical composition of each food item was defined based on the nutritional composition data contained in the NutWin software (Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, Brazil) which uses the food database of the United States Department of Agriculture with added food items from Brazilian Food Composition Table [17].

Guarana powder, garlic, onion and pepper were excluded from the analysis due to their low frequency of consumption or because they are used as spices and consumed with other prepared foods. The remaining 77 food items were divided into 21 food groups (Table 1) based on similarities in nutrient composition, particular dietary habits in the study population and frequency of consumption. Some of the commonly consumed food items reported by more than 80% were set apart (rice, beans, bread, sugar, coffee and butter/margarine).

Weight, height and waist and hip circumferences were measured using standard methods [18]. Height was measured using a Seca 206

Table 1

Food groups used in the factor analysis derived from the food frequency questionnaire. Cuiabá, State of Mato Grosso, Brazil, 2007.

Food group	Foods from the food frequency questionnaire
Rice	Rice
Beans	Beans
Cakes, cookies	Plain cakes, cakes with filling and topping/with fruit syrup, cookies-crackers, filled cookies, savory crackers
Breads	French roll/loaf of bread
Refined grains, roots and tubers	Baked/mashed potato, cassava, cassava flour and sweet potato/yam/yams
Pasta	Pasta; pancakes/gnocchi/lasagna/ravioli
Regional dishes	Baked rice/rice with meat/chicken with rice/pork with rice, *pequi* (souari nut), fried banana
Fats	Butter/margarine
Dairy products	Cheese, milk, cottage cheese, yogurt/cheese curds
Meat and eggs	Pork, beef, beef or chicken stroganoff/chicken *bobó* (dish made of highly-spiced chicken); barbecue, giblets (gizzard, heart, liver, stomach/tripe, kidneys) and eggs
White meat	Fish and chicken
Sausages and deli meats	Sausage, cold cuts (bologna, ham, fatty ham, salami and frankfurter), bacon, smoked pork loin, beef jerky, canned corned beef
Canned vegetables	Canned vegetables such as peas, corn, palm heart, olives
Fruits	Orange/tangerine, banana, papaya, apple, watermelon, pineapple and mango
Green vegetables and legumes	Lettuce, cabbage/kale/chard, arugula/endive/watercress, cauliflower/broccoli, tomato, cucumber, chayote, gherkin/eggplant, squash/zucchini, carrots, beets and okra/pod
Sodas	Cola soft drinks and other soft drinks/guarana-flavored soft drink
Juice and tea	Fruit juices/pulp and tea
Coffee	Coffee
Fast food	Pizza, hot dogs, hamburgers, French fries/chips/mayonnaise, snacks, popcorn, fried salted pastries/pies and cheese bread
Sweets	Ice cream or popsicles, candies, caramels, chewing gum, chocolate powder, chocolate bars/bonbon, fruit jam or jelly or hard fruit molasses/milk molasses
Sugar	Sugar

portable stadiometer (Seca, São Paulo, Brazil) with a 220cm millimeter scale. Weight was measured using an electronic scale (Tanita, Model UM 080; Tanita, São Paulo, Brazil) with a 150kg capacity and accurate to 0.1kg. Body mass index (kg/m²) was classified according to the WHO [6] categories to define weight status.

Waist and hip measurements were taken using an anthropometric tape (model Gulick, Mabb, Curitiba, Brazil) with a 150cm millimeter scale following the recommendations of Callaway et al. [19]. Height, waist and hip circumference were measured twice. A maximum difference of 0.5cm for height and 1.0cm for waist and hip circumferences was allowed between the first and the second measurements. WC was measured on the smallest abdominal curvature or at the midpoint between the iliac crest and the last rib when the former was difficult to identify.

Dietary patterns were identified using principal component factor analysis [11] based on the food items contained in the FFQ. A correlation matrix was constructed to determine the correlation between variables and the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were used to determine whether the assumptions used in the factor analysis were correct. Sampling is considered adequate when the KMO value is greater than 0.6 and when the p-value of Bartlett's test of sphericity is less than or equal to 0.05 [11,20].

Principal component analysis was performed, followed by orthogonal rotation (varimax method). The criterion used for determining the number of factors to extract was an eigenvalue of > 1.5 [14,21,22]. Food groups with factor loadings greater than 0.30 were retained in the identified patterns and the cut-off value for communality was set at 0.20. The internal consistency of the extracted factors was determined using Cronbach's alpha [11]. A score was determined for each dietary pattern using principal components factor analysis.

Multiple linear regression analysis was used to verify the association between the respondent's eating habits and the identified dietary patterns. The dependent variables were the dietary pattern scores and the independent variables were those which had a $p < 0.20$ in the linear regression analysis.

Multiple linear regression was carried out to analyze the association between abdominal fat indicators and dietary patterns using WC and WHR as dependent variables. The WC and WHR variables presented a symmetric distribution ($p > 0.05$; Kolmogorov-Smirnov test). The independent variables were the dietary pattern scores. The models were adjusted for age (years), smoking (smoker, former smoker and nonsmoker), alcohol consumption (consumption or nonconsumption during the last week), regular leisure physical activity classified as practicing (three or more leisure physical activities in the three months preceding the interview) or not practicing (no or up to two leisure physical activities in the three months preceding the interview) weekly physical activity, and socioeconomic status (SES) based on the categories adopted by the Brazilian Association of Market Research Companies (ABEP; http://www.abep.org/novo/Default.aspx, accessed on 26/Jul/2011). The models were also adjusted for total energy consumption and BMI.

This study was approved by the ethics committee of the Júlio Müller University Hospital of the Federal University of Mato Grosso (application number 234/CEP/HUJM/05). Participants gave written informed consent after receiving details regarding the study.

Results

A total of 108 females and 100 males with a mean age of 33.7 years (standard deviation = 9.7) were evaluated. The sample showed the following characteristics: 45.2% were from SES class B; 71.6% were nonsmokers; 66.8% consumed alcohol; 60.6% did not practice physical activity; 34.6% (n = 72) were identified as being overweight (BMI ≥ 25kg/m^2); and 19.2% (n = 40) were obese (BMI ≥ 30kg/m^2) (Table 2).

Mean WC and WHR among women was 80.1cm (95%CI: 78.0-82.2) and 0.79 (95%CI: 0.78-0.80), respectively, while among men, mean WC and WHR was 90.6cm (95%CI: 88.1-93.1) and 0.88 (95%CI: 0.87-0.90), respectively (data not shown).

The KMO coefficient (0.621) and p-value of Bartlett's test of sphericity ($p < 0.001$) showed sufficient and adequate correlation between data in the factor analysis [11]. Three dietary patterns were identified that together accounted for 35% of explained variance. The first pattern, called "Western pattern", explained 14.9% of variance and included the food groups breads, pasta, fats, dairy products, sausages and deli meats, canned vegetables, sodas, fast food, and sweets. The second pattern, called "regional traditional", explained 10.5% of variance and included mainly rice, beans, refined grains and tubers, regional dishes, meat and eggs, coffee, and sugar. The third pattern, called "prudent", was characterized by the consumption of fruits, green vegetables and legumes, white meats, juices and tea, and cakes and cookies/crackers and explained 9.6% of variance. This pattern was labeled "prudent" because all items, except cakes and cookies/crackers, are considered part of a healthy diet. Commonality (h_2 = 0.20) and the factor loadings (0.30) were greater than the acceptable values. Cronbach's alpha was 0.61 for the "Western" and "regional traditional" patterns and 0.41 for the "prudent" pattern (Table 3).

Table 4 shows that high energy consumption in young adults was associated with the "Western" pattern. Being a nonsmoker and having a low BMI was associated with the "regional traditional" pattern, and practicing physical activity, being a nonsmoker and having high BMI was associated with the "prudent" pattern. A positive association was found between the "Western" pattern and WC (β = 1.11, p = 0.04) and WHR (β = 0.02, p = 0.001) among women. The "regional traditional" pattern was associated with WHR (β = 0.01, p = 0.05) and a slight association was found between this pattern and WC (β = 0.87, p = 0.07) (Table 5).

Discussion

Three dietary patterns were identified among this sample of adults using principal component analysis: "Western"; "regional traditional"; and "prudent". The percentage of variance explained found in the three dietary patterns was consistent with that identified in other studies (for example Neumann et al. [23] 35.6%, and Cunha et al. [24] 34.9%) and lower than the values observed by other studies, such as Sieri et al. [13] (30%) and Kjøllesdal et al. [25] (20%). While a positive association was observed between the "Western" and "regional traditional" dietary patterns and abdominal fat, no significant association was found between the "prudent" pattern and anthropometric indicators of abdominal fat.

A positive association was found between the "Western" pattern, characterized by a high intake of fat and carbohydrates, and increased WC and

Table 2

Distribution of respondents according to sociodemographic characteristics, lifestyle and weight status. Cuiabá, State of Mato Grosso, Brazil 2007.

Variables	n	%
Gender		
Male	100	48.1
Female	108	51.9
Age (years)		
20-29	87	41.8
30-39	56	26.9
40-50	65	31.3
Socioeconomic status		
Class A	22	10.6
Class B	94	45.2
Class C	78	37.5
Class D	14	6.7
Smoking		
Smoker	30	14.4
Former smoker	29	13.9
Nonsmoker	149	71.6
Alcohol consumption (last week)		
Yes	139	66.8
No	69	33.2
Leisure physical activity (last three months)		
Yes	82	39.4
No	126	60.6
Weight status assessment		
Under weight	6	2.9
Normal weight	90	43.3
Overweight	72	34.6
Obese	40	19.2

WHR among women. Studies have shown a positive association between a high intake of fat (saturated, monounsaturated or polyunsaturated) and central adiposity [26]. A study conducted in Brazil by Neumann et al. [23] showed an association between the consumption of foods labeled as the "coffee shop/cafeteria" pattern – whole milk, bread, pasta, snacks, sweets, fats, ham, artificial juices, sodas, and, to a lower extent, *feijoada* (stew of beans with pork), natural juices and chicken – was associated with increased WHR. Eating habits are influenced by cultural, social and demographic factors [9]. Lifestyle changes, socioeconomic factors and easy access to processed foods have all contributed to changes in eating habits over time leading to a high intake of protein, fat and refined carbohydrates [23,25,27].

The "regional traditional" pattern comprised food items and food dishes typical to the study region (fried banana, rice dishes and *pequi*, or souari nut) and foods traditionally consumed by the Brazilian population (rice and beans). Similar patterns were identified by other studies undertaken in Brazil [9,24,28]. Dietary pattern studies have shown that these foods are part of the traditional dietary pattern which has a protective effect on BMI, WC and WHR [23,24,28]. However, the present study found a positive association between WHR and the traditional dietary pattern identified by this study, called the "regional traditional" pattern, among women. It should be noted that this pattern included other foods considered typical to the region studied which are not included in the traditional pattern described by other studies conducted in Brazil [24,28]. This factor may have contributed to this association since some of these food items are rich in fat and have a high energy density (for example, fried banana and some rice dishes). The "regional traditional" pattern identified by this study also included sugar, which may contribute to an increased accumulation of abdominal fat [29].

Contrary to the general literature, a protective effect of the "prudent" pattern [30] on abdominal adiposity was not observed by this study. Although the "prudent" pattern consisted of mainly healthy foods, such as white meat, fruits, vegetables, juices and tea, it also included cakes and cookies/crackers, which are not considered healthy because they contain high levels of trans fatty acids, particularly crackers [31] which also have a high sodium content. Another possible explanation is that those subjects with these eating habits adhered to this dietary pattern due to conditions that led them to adopt a healthier diet. It is interesting to note that those individuals that adhered to this pattern had high BMI, were nonsmokers and reported practicing physical activity, showing that adherence to this diet pattern is probably a result of health problems and/or weight loss efforts. Rossi et al. [32] also found that there was no significant association between WC and the Mediterranean diet pattern, which is characterized by foods that are considered to be healthy.

A limitation of this study is the cross-sectional nature of the design which may make it susceptible to reverse causality and explain the lack of association between the protective effect of the "prudent" pattern and abdominal fat. The sample size is considered sufficient for a principal component analysis to identify dietary patterns. The required sample size is between five and 10 subjects per variable included in the model [11]. In this study the food items in the

Table 3

Distribution of factor loadings and commonalities (h_2) of the three dietary patterns identified by the study. Cuiabá, State of Mato Grosso, Brazil 2007.

Food groups	Factor loadings			
	Three-factor solution			
	"Western"	"Regional traditional"	"Prudent"	h_2
Breads	0.55			0.53
Pasta	0.53			0.30
Fats	0.51			0.50
Dairy products	0.37			0.21
Sausages and deli meats	0.69			0.47
Canned vegetables	0.62			0.23
Sodas	0.53			0.40
Fast food	0.44			0.31
Candies	0.50			0.31
Rice		0.75		0.57
Beans		0.71		0.51
Refined grains and tubers		0.37		0.21
Regional typical dishes		0.46		0.41
Meat and eggs		0.41		0.31
Coffee		0.54		0.30
Sugar		0.53		0.33
Cakes and cookies-crackers			0.36	0.20
White meat			0.48	0.26
Fruits			0.58	0.35
Green vegetables and legumes			0.60	0.36
Juices and tea			0.49	0.28
Number of items	9	7	5	
Eigenvalues	3.13	2.21	2.01	
Percentage of explained variance	14.89	10.50	9.58	
Percentage of explained cumulative variance	14.89	25.39	34.97	
Cronbach's alpha	0.61	0.61	0.41	

FFQ were aggregated into 21 food groups, which is equivalent to a sample size requirement of between 105 and 210 individuals and this study therefore meets the sample size requirements. Factor analysis is also limited because the researcher must make several arbitrary decisions regarding the selection of variables, retained factors and names assigned to the retained factors. Despite these limitations, this method is widely used in national and international studies to identify dietary patterns [13,24,28,33,34].

This study did not identify any association between the dietary patterns and abdominal obesity among men suggesting that it is possible that diet has a greater effect on central fat distribution in women than in men. This study demonstrated a statistically significant positive association between the "Western" and "regional traditional" dietary patterns and anthropometric measurements of body fat distribution among women. This finding suggests that the traditional diet patterns identified by previous studies were characterized by a lower variety of food items and lower energy intake. However, it should be noted that a recent association has been found between the traditional diet pattern and excess intake of other food items due to an increase in income and food availability. Therefore, the consumption of healthier foods should be promoted together with the control of total energy intake.

Table 4

Bivariate linear regression, multiple linear regression coefficients and associated p-values for dietary patterns and specific characteristics. Cuiabá, State of Mato Grosso, Brazil 2007.

	"Western" pattern				"Regional traditional" pattern				"Prudent" pattern			
	Bivariate linear regression		Multiple linear regression *		Bivariate linear regression		Multiple linear regression *		Bivariate linear regression		Multiple linear regression *	
	β **	p-value	β **	p value	β **	p-value	β **	p-value	β **	p-value	β **	p-value
Age (years)	-0.26	< 0.01	-0.26	< 0.01	0.07	0.31	***	***	0.16	0.03	#	#
Leisure physical activity	-0.09	0.19	#	#	0.05	0.46	***	***	0.09	0.18	0.17	0.02
Smoking	0.04	0.54	***	***	-0.22	< 0.01	-0.20	0.004	-0.11	0.11	-0.015	0.03
Energy consumption	0.16	0.02	0.14	0.03	0.05	0.46	***	***	-0.06	0.37	***	***
BMI	-0.08	0.28	***	***	-0.10	0.14	-0.13	0.05	0.12	0.09	0.15	0.03

BMI: body mass index.

* Model adjusted for gender;

** Standardized beta;

*** The variable was not significant in the bivariate linear regression analysis, p-value under 0.2;

No association was found for this variable in the multiple linear regression analysis.

Table 5

Regression coefficients, associated * p-values, and R^2 for dietary patterns and waist circumference, and waist-to-hip ratio. Cuiabá, State of Mato Grosso, Brazil 2007.

	Males			Females		
	β **	p-value	R^2	β **	p-value	R^2
"Western" pattern						
WC (cm)	0.11	0.82	0.86	1.11	0.04	0.85
WHR	0.01	0.19	0.58	0.02	0.01	0.38
"Regional traditional" pattern						
WC (cm)	0.56	0.30	0.86	0.87	0.07	0.86
WHR	0.01	0.61	0.57	0.01	0.05	0.35
"Prudent" pattern						
WC (cm)	0.55	0.36	0.86	0.28	0.50	0.84
WHR	0.01	0.08	0.59	0.01	0.35	0.33

WC: waist circumference; WHR: waist-to-hip ratio.

* Model adjusted for age, smoking, alcohol consumption, physical activity, socioeconomic status, body mass index and total energy consumption;

** Standardized beta.

Resumen

Este estudio tuvo como objetivo determinar los patrones alimentarios y analizar su asociación con la adiposidad abdominal. Estudio transversal, realizado en la región centro-oeste de Brasil, con una muestra probabilística de 208 adultos de ambos sexos. El consumo alimentario se obtuvo en un cuestionario de frecuencia alimentaria y para determinar los patrones alimentarios se utilizó un análisis factorial (componentes principales). El perímetro de cintura (PC) y la relación cintura/cadera (RCC) indicaron adiposidad abdominal. La asociación de patrones alimentarios y adiposidad abdominal se analizó en modelos de regresión lineal múltiple, ajustados por factores de confusión. Se identificaron tres patrones alimentarios: occidental, tradicional regional y prudente. El occidental se asoció positivamente al PC (p = 0,04) y RCC (p = 0,001), el tradicional regional se asoció también a RCC (p = 0,05) y marginal la asociación al PC (p = 0,07), sólo en mujeres. Los patrones occidental y tradicional regional se asociaron a una mayor adiposidad abdominal en mujeres.

Consumo de Alimentos; Análisis Factorial; Circunferencia de la Cintura; Relación Cintura-Cadera; Adultos

Contributors

A. A. F. Vilela participated in all aspects of the study, including the drafting of the manuscript, data analysis and interpretation. R. Sichieri and R. A. Pereira contributed to design, interpretation of data and the drafting of the manuscript. D. B. Cunha, P. R. M. Rodrigues and R. M. V. Gonçalves-Silva contributed to data analysis and interpretation, critical revision of the manuscript for important intellectual content, and the final approval of the published version. M. G. Ferreira participated in study design and coordination, data interpretation and the drafting of the manuscript.

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