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Dietary Patterns and Metabolic Syndrome in Adults

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Authors' contributions

All authors have significantly contributed, read and approved the final version of the paper and declare no conflict of interest.

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ABSTRACT

Aims: Considering that diet is a potential factor contributing to the development of Metabolic Syndrome (MetS) and it is increasingly prevalent among population worldwide, the aim of the present study was to correlate dietary patterns with MetS and its main risk factors in adults.
Study Design: Cross-sectional.
Place and Duration of Study: School of Public Health, University of São Paulo, between August 2007 and January 2010.
Methodology: This study was conducted with 267 adults (189 women and 78 men) submitted to evaluation procedures which included body composition (waist circumference (WC), height and weight) and blood pressure measurements, biochemical analysis from a single blood sample after a 12-h fasting (serum triglycerides (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c) and fasting glucose) and assessment of dietary intake using a 24-hour recall. Dietary patterns (DPs) were identified using principal components factor analysis with varimax orthogonal rotation.
Results: Three distinct DPs were identified from the principal component factor analysis: "Traditional", "Healthy" and "Western". Among individuals with MetS, there was a positive correlation between Healthy pattern and HDL-c (P = .03), as well as between Western pattern and WC, TG and LDL-c (P = .001, P = .04 and P = .047). In people without MetS, the negative correlation was observed between Traditional pattern and LDL-c (P = .049), and positive correlation between Healthy pattern and age, TC and, LDL-c (P = .01, P = .03 and P = .03).
Conclusion: Our assessment offers information concerning food combinations that may increase the risk and prevalence of MetS. However, more studies are required to confirm these findings and

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to assist in the prevention and development of specific nutritional recommendations for this syndrome.

Keywords: Nutritional assessment; metabolic diseases; food habits.

ABBREVIATIONS

BMI : body mass index
BP : blood pressure
DPs : dietary patterns
FG : fasting glucose
HDL-c : high-density lipoprotein cholesterol
IDF : International Diabetes Federation
LDL-c : low-density lipoprotein cholesterol
MetS : metabolic syndrome
TC : total cholesterol
TG : triglycerides
WC : waist circumference

1. INTRODUCTION

Metabolic syndrome (MetS) is a cluster of metabolic and physical changes which increases the risk of cardiovascular disease and are closely related to central obesity and insulin resistance [1,2].

Epidemiological studies suggest highly variable frequencies of MetS between populations. However, it is estimated that its prevalence is somewhere between 20 and 25% of the general people and reaches 42% among elderly individuals [3,4]. In Brazil there are no studies with representative data of the frequency of MetS, but it is known that it has been rising and increasing overall mortality about 1.5 times and cardiovascular about 2.5 times [5].

This scenario emerged from the processes of industrialization, urbanization, economic development and globalization of markets, that led to economic, political, social and cultural changes in the way individuals and communities organize their lifestyles [6]. These changes led to a dietary transition worldwide, which resulted in substantial changes in nutrition, with the enlargement in the supply of industrialized foods (rich in fats, sugars and sodium), increased consumption of energy-dense diets (high in saturated fat and low in unrefined carbohydrates) and reduced consumption of healthier foods, such as cereals, fruits and vegetables in addition to the general decrease in physical activity [7].

Nevertheless, the relationship between nutrients and cardiovascular diseases, such as MetS is not yet well understood, and the questions around this issue may be due to the traditional methods often carried out to examine the relationship between diet and the risk of chronic diseases which analyzes the effects of a single nutrient or food on these disorders [8].

Recently, dietary pattern analysis has emerged as an alternative approach to the assessment of food consumption [9] enabling to explore the effects of overall diet and, unlike the analysis of individual nutrients or foods, allows to determine the effects of diet on disease development due to the complexity of the food and the interaction between diet components [10].

In this study we aimed to investigate the relations between dietary patterns (DPs) derived from a 24-hour recall and the presence of MetS and its main risk factors, including body mass index (BMI), blood pressure (BP), waist circumference (WC), serum lipids and fasting glucose (FG) in adults living in São Paolo, Brazil.

2. MATERIALS AND METHODS

2.1 Research Design and Study Population

This cross-sectional study was conducted with adults of both sexes who attend the primary health care center at the School of Public Health, University of São Paulo, and from the Adult Health Survey of the City of São Paulo (ISA-SP), described elsewhere (11) . This research is part of the project entitled "Relationship between nutritional status of vitamin D and metabolic syndrome in adults living in the metropolitan region of São Paulo" (12) which was carried out from August 2007 to January 2010.

Initially, 462 individuals were invited to participate. Individuals under 18 years of age, pregnant and lactating women, African-descendants and those with chronic diseases that potentially alter the metabolism of vitamin D as such osteoporosis, cancer, renal failure and immune diseases, as well individuals who were using vitamin D and/or calcium supplementation or multivitamins were not included. The present study consisted of a subsample (n = 267) of the primary study, including only individuals with dietary assessment data.

2.2 Measurements

The participants were submitted to several evaluation procedures at the cited center for primary health care which included measurements of body composition and blood pressure, biochemical analysis from the blood samples collected and assessment of dietary intake. All data were gathered by previously trained field researchers.

The measurements of height and weight were performed using a calibrated TanitaTM electronic scale (Tanita Corporation of America Inc, Illinois, USA) and a SecaTM stadiometer (Seca, Hamburg, Germany). BMI was calculated as weight in kilograms divided by the square of height in meters. WC was measured by horizontally positioning a measuring tape at the midpoint level between the lower intercostals border and the anterior superior iliac supine at the end of the normal expiration phase.

Blood samples were obtained by means of venipuncture from each participant after a 12-h fasting. Samples were immediately centrifuged, aliquoted and frozen at -80°C until analysis. Serum triglycerides (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c) and FG were determined by enzymatic colorimetric assay (Celm™, Barueri, SP, Brazil). For these parameters, the cutoff points were based on those established by the International Diabetes Federation (IDF) [13].

Dietary intake was assessed by trained nutritionists using a standardized protocol of a 24-hour recall method. To minimize reporting errors and ensure proper record of the quantities described by patients, a food photograph album was used at the interviews [14]. Data from food intake were entered and processed using Nutrition Data System for Research (NDSR) software. To identify the DPs, food items were categorized into groups based on food characteristics and nutritional composition. It is noteworthy that the foods or food groups consumed by less than 10% of the sample were excluded from the analysis. Thus, the twenty-two food groups that represent the DPs of the study are presented in Table 1.

2.3 Identifying Individuals with Metabolic Syndrome

The criteria for classifying adults with MetS were based on those established by the IDF [13]: abdominal obesity (WC >90 cm in males and >80 cm in females) and >2 of the following risk factors (i) high serum TG (>150 mg/dl); (ii) low serum HDL-c (<40 mg/dl in males or <50 mg/dl in females); (iii) high BP (>130 or >85 mmHg); and (iv) high FG (>100 mg/dl).

Table 1. Composition of food groups

Food Groups	Food Items
Fresh spice	Onion, garlic, culinary herbs
Oils	Olive and vegetable oils, margarine
Fruits	All fresh fruits and fruit salad
Vegetables	Leafy green vegetables, light- or dark- colored vegetables, cruciferous vegetables
Potatoes and tubers	Potatoes and root vegetables
Cereals and whole grains	Oat, bran, wheat germ, quinoa, flaxseed, corn flakes
Pasta	Noodles, spaghetti, gnocchi and other pasta preparations
Rice	White rice
Beans	Beans, peas, green beans, chick peas, lentils
White meat	All chicken preparations
Red meat	All beef preparations
Processed meat	Bacon, ham, salami, sausages, hamburgers
Dairy	Whole milk, full-cream milk, full fat cheese, full fat yoghurt,
Low fat dairy	Reduced-fat milk, skim milk, ricotta, low-fat cheese, cottage cheese, low-fat yoghurt
White bread	White breads, crackers, toasts, salted biscuits
Whole grain bread	Mixed grain or high-fiber breads, crackers and toasts
Sweets	Cakes, pies, muffins, cookies, biscuits, chocolates, marmalades, jams, jellies, chocolate covered bars, ice cream
Salty & savoury snacks	Sandwiches, pizzas, pastries, potato and corn chips
Juices	Fruit juice, fresh fruit juice
Soft drinks	Sodas, diet sodas, light sodas
Coffee and teas	Coffee, decaffeinated coffee, black tea, green tea and other herbal tea
Sugar	Sugar and honey

2.4 Statistical Analysis

Principal components factor analysis with varimax orthogonal rotation was performed to obtain the DPs from the twenty-two food groups, after verifying the adequacy of the sample by the Kaiser-Meyer-Olkin test (considering acceptable values above 0.50). PCA was chosen since it is a multivariate technique that evaluates the intercorrelations between the initial food variables and reduces food groups into a smaller number of factors (patterns) that can explain variations in dietary intake [15].

The number of patterns retained was based on a combination of food group components with an eigenvalue >1.5, the percentage of variance criteria (sufficient factors to meet at least 60% of variance explained), and examination of the break-point in the scree plot, resulting in three factors retained for further analyses. Each dietary pattern was interpreted and named based on the food groups with loadings above 0.25 or below -0.25, which were considered as significantly contributing to a pattern.

Each variable on this study was analyzed using the Kolmogorov-Smirnov test to determine whether the distribution was normal. Spearman correlation coefficients were calculated to examine the correlation between DPs and the main risk factors for MetS.

Scores were derived from the patterns obtained, and the average score was calculated for each pattern according to the presence or absence of metabolic syndrome. Student t test was used to compare means between groups with and without MetS.

The analyses were conducted using the Statistical Package for the Social Science (SPSS) software for Windows, version 18 (SPSS Inc., Chicago, IL, USA) and the Stata - Data Analysis and Statistical Software, version 11 (StataCorp., Texas, USA). Results were taken to be statistically significant when *P* values were < 0.05.

3. RESULTS AND DISCUSSION

As presented in Table 2, a total of 267 adults (189 women and 78 men) provided biochemical and dietary pattern data. Of these, 153 (106 women and 47 men) were in the “With MetS” group and 114 (83 women and 31 men) were in the “Without MetS” group. As expected, stratifying the individuals according to the presence of MetS, the mean age as well as BMI, WC, serum TG, TC, LDL-c and FG, systolic and diastolic BP pressure were significantly higher among individuals with MetS.

Three distinct dietary patterns were identified from the principal component factor analysis. The first factor was named “Traditional Dietary Pattern” because it represented the traditional Brazilian food consumption of rice and beans and also high intakes of fresh spice, vegetables, white meat, juices, coffee & teas and sugar; and low intake of pasta. The second factor was characterized by high intakes of fresh spice, fruits, vegetables, low-fat dairy and whole grain bread and low intake of potatoes & tubers, red meat, coffee & teas and sugar and thus it was named “Healthy Dietary Pattern”.

Table 2. Clinical characteristics of the studied sample

Variables	Total sample	With MetS	Without MetS	*P* value
	n=267	n=153	n=114	
Gender				
Female	189 (70.79%)	106 (69.28%)	83 (72.81%)	
Male	78 (29.21%)	47 (30.72%)	31 (27.19%)	0.531
Age (years)	51.48 (14.25)	55.29 (12.26)	46.36 (15.15)	0.000
BMI (kg/m^2)	29.74 (6.01)	31.10 (5.86)	27.91 (5.74)	0.000
WC (cm)	98.06 (13.61)	102.01 (12.25)	92.61 (13.56)	0.000
TG (mg/dl)	130.95 (68.58)	158.02 (74.62)	94,61 (35.47)	0.000
TC (mg/dl)	193.85 (43.70)	200.88 (45.15)	184.43 (39.97)	0.002
LDL-c (mg/dl)	122.05 (38.86)	126.74 (40.13)	115.87 (36.38)	0.024
HDL-c (mg/dl)	44.89 (12.33)	41.70 (10.62)	49.17 (13.18)	0.000
FG (mg/dl)	98.95 (18.60)	104.58 (18,99)	91.39 (15.13)	0.000
SBP (mmHg)	130.34 (19.40)	137.57 (19.13)	120.69 (15.15)	0.000
DBP (mmHg)	79.88 (10.40)	83.25 (10.00)	75.39 (9.18)	0.000

Abbreviations: MetS – metabolic syndrome; BMI – body mass index; WC – waist circumference; TG – triglycerides; TC - total cholesterol; LDL-c – LDL-cholesterol; HDL-c – HDL-cholesterol; FG – fasting glucose; SBP – systolic blood pressure; DBP – diastolic blood pressure.

Data are expressed as means (SD), except gender n (%). T Test.

The third factor represented high intakes of olive & vegetable oils, processed meat, dairy, white bread, juices, sodas and low intake of low-fat dairy and whole grain bread and the pattern was named "Western Dietary Pattern". These patterns explained 25.59% of the dietary intake variance. Factor loadings of food groups across these DPs and the variance explained by each dietary pattern are presented in Table 3.

Table 4 shows Spearman correlation coefficients of each DP and categories of risk factors for MetS according to its presence or absence within the study participants. Among individuals with MetS, there was a positive correlation between Healthy DP and serum HDL-c (*P* = .03), as well as between Western DP and WC (*P* = .001), TG (*P* = .04) and serum TG (*P* = .047). The same did not applied to subjects without MetS, in which a positive correlation was seen between Healthy DP and age (P = .01), serum TC (P = .03) and serum LDL-c (P = .03). In addition, a negative correlation was found between Traditional DP and serum LDL-c (P = .049).

The major objective of this research was to examine the relation between patterns of food consumption and the occurrence of MetS and its main risk factors in our study population.

Table 3. Dietary patterns and factor loadings

Food groups	Factor loadings of each dietary pattern		
	Traditional	Healthy	Western
Fresh spice	***0.4264***	***0.3958***	0.1214
Olive and vegetable oils	-0.0234	0.1678	***0.5773***
Fruits	0.0420	***0.4387***	0.0087
Vegetables	***0.3399***	***0.3008***	-0.0735
Potatoes and tubers	-0.0623	***-0.3894***	-0.0745
Cereals and whole grains	-0.1952	0.2332	-0.0176
Pasta	***-0.2679***	0.2137	0.0047
Rice	***0.7677***	-0.1281	-0.0178
Beans	***0.6065***	-0.1948	0.0040
White meat	***0.5758***	0.2015	-0.0489
Red meat	0.2191	***-0.3894***	-0.0607
Processed meat	0.0347	-0.0073	***0.3129***
Dairy	0.2499	-0.1707	***0.4643***
Low fat dairy	-0.1083	***0.4254***	***-0.2728***
White bread	-0.0156	-0.0422	***0.6897***
Whole grain bread	-0.0621	***0.3105***	***-0.2966***
Sweets and snacks	0.1238	0.0245	-0.0019
Salty & savoury snacks	-0.2038	-0.1831	0.0918
Juices	***0.3637***	0.1009	***0.2607***
Sodas	-0.1308	-0.0157	***0.5608***
Coffee & teas	***0.2688***	***-0.3390***	-0.0948
Sugar	***0.2901***	***-0.5350***	0.0209
% Total variance explained	***9.96***	***17.78***	***25.59***

Table 4. Correlation between each dietary pattern and MetS components

	With MetS			Without MetS		
	Traditional	Healthy	Western	Traditional	Healthy	Western
Age	-0.099	0.088	-0,044	-0.019	**0.213**[f]	-0.033
BMI	-0.038	0.067	0.147	-0.134	0.113	0.111
WC	0.003	-0.086	**0.288**[b]	0.011	0.135	0.168
FG	0.042	0.031	0.047	-0.013	0.004	-0.006
TG	0.063	0.166	**0.183**[c]	0.115	0.116	0.001
TC	-0.026	0.072	0.149	-0.153	**0.192**[a]	-0.079
LDL-c	-0.029	0.052	**0.172**[d]	**-0.171**[e]	**0.185**[a]	-0.099
HDL-c	-0.122	**0.184**[a]	-0.161	-0.038	0.077	-0.076
SBP	0.040	0.019	0.133	0.134	0.083	-0.082
DBP	0.073	-0.061	-0.005	0.006	0.012	-0.086

Abbreviations: MetS – metabolic syndrome; BMI – body mass index; WC – waist circumference; FG – fasting glucose; TG – triglycerides; TC - total cholesterol; LDL-c – LDL-cholesterol; HDL-c – HDL-cholesterol; SBP – systolic blood pressure; DBP – diastolic blood pressure.

Spearman correlation: [a]P = .03; [b]P = .001; [c]P = .04; [d]P = .047; [e]P = .049; [f]P = .01.

Our results showed no direct association between DPs and the presence or absence of MetS. Other studies [16,17] have found similar results, in which DPs were not associated with overall prevalence of the syndrome. Differently from these findings, a Western DP was associated with MetS in Iran women, Americans, Mexicans and Chinese adults [18-21].

However looking separately to the risk factors for MetS, it was possible to note that some were associated with the DPs. For instance, the correlation between Western pattern and WC and serum TG was positive among those with MetS. Similar results were found in two different researches with Samoans adults in which a modern pattern of eating (characterized by high intake of processed foods and low intake of local traditional fresh foods) was associated with higher serum TG levels [22], BMI and WC [23]. Also, a study with German adults pointed that a high adherence to a "processed foods" pattern (composed of refined grains, processed meat, red meat, high-sugar beverages, eggs, potatoes, beer, sweets and cakes, snacks and butter) increased the occurrence of abdominal obesity, hypertension and hypertriacylglycerolaemia [24].

The positive correlation found between Healthy DP and serum HDL-c was similar to the findings of a cross-sectional study with 19 750 Dutch men and women, in which a dietary pattern characterized by greater intakes of vegetables, salad, rice, chicken, fish, and wine was significantly associated with lower blood pressure and higher HDL-c concentrations [25].

We also found some unexpected results, such as the positive correlation between Healthy DP and serum TC and serum LDL-c among those without MetS. These findings are in discordance to other studies that confirm that vegetables, fruits and whole grains have been associated with lower incidence of risk factors for MetS [26-30]. However, this divergence detected in our results could be explained by the positive correlation also found between this pattern and age. Other studies also pointed out the direct association between these last two variables [31,32].

The Traditional DP was negatively correlated to serum LDL-c among individuals without MetS. This finding could be consistent with the results of another study [33] which indicated that the consumption of a traditional Brazilian DP was inversely associated with LDL-c and TC values among men and women [34].

4. CONCLUSION

The present study demonstrated that DPs had some influence on the components of MetS, indicating that Western pattern was involved in metabolic deregulation. However, prospective and intervention studies could confirm that nutritional advice in form of food combinations could prevent and treat the MetS.

4.1 Limitations

The present study had some limitations. First, was its cross-sectional design, wich does not permit to examine the causal link between dietary patterns and MetS risk, because the temporal relation of these events could not be clearly established. Second, the findings from this study could be specific to southeastern Brazilian adults, and did not represent national findings. Finally ,the sample size and the use of only one 24h dietary recall could underestimated the individual variability of food intakes which implicates that the dietary patterns identified by principal were plausible but they did not reveal all possible patterns.

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ETHICAL APPROVAL

The Ethics Committees of University of São Paulo approved the study protocol and the consent form was obtained from all participants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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