Associations between dietary patterns and metabolic syndrome in adolescents

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Abstract
Objective. Evaluate association of dietary patterns with metabolic syndrome (MetS) and metabolic markers. **Materials and methods.** 654 adolescents from Guadalajara, Jalisco, participated in a cross-sectional study. Diet was evaluated using a food frequency questionnaire; 24 food groups were integrated, and dietary patterns were derived using cluster analysis. MetS was defined according to International Diabetes Federation (IDF), Cook and colleagues, Ford and colleagues, and de Ferranti and colleagues criteria. **Results.** Dietary patterns identified were: "DP1", "DP2", and "DP3". Among males, "DP3" was associated with MetS (Cook and collaborators) (OR, 12.14; 95%CI, 1.66-89.05), hypertriglyceridemia (OR, 3.89; 95%CI, 1.01-15.07), and insulin resistance (OR, 6.66; 95%CI, 1.12-39.70). "DP2" was associated with abdominal obesity (OR, 5.11; 95%CI, 1.57-16.66). **Conclusions.** "DP3" entertained a greater risk of MetS, hypertriglyceridemia, and insulin resistance, while "DP2" possessed a greater risk of abdominal obesity among adolescent males.

Keywords: metabolic syndrome; dietary patterns; fast foods; sugar-sweetened beverages; adolescents

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Resumen
Objetivo. Evaluar la asociación de patrones dietarios (PD) con síndrome metabólico (SM) y marcadores metabólicos. **Material y métodos.** Estudio transversal con 654 adolescentes. Dieta evaluada con el cuestionario "frecuencia de consumos de alimentos"; se identificaron 24 grupos de alimentos, para obtener PD mediante análisis de conglomerados. SM se definió según los criterios: Federación de Diabetes Internacional (IDF), Cook y colaboradores, Ford y colaboradores y Ferranti y colaboradores. **Resultados.** Se identificaron tres PD: "PD1", "PD2" y "PD3". En hombres, "PD3" se asoció con SM (Cook y colaboradores) (RM, 12.14; IC95%, 1.66-89.05), hipertrigliceridemia (RM, 3.89; IC95%, 1.01-15.07) y resistencia a insulina (RM, 6.66; IC95%, 1.12-39.70). El patrón "PD2" se asoció con obesidad abdominal (RM, 5.11; IC95%, 1.57-16.66). **Conclusiones.** El patrón "PD3" aumenta el riesgo de SM, hipertrigliceridemia y resistencia a insulina y el "PD2" el riesgo de obesidad abdominal en adolescentes hombres.

Palabras clave: síndrome metabólico; patrones dietarios; comida rápida; bebidas endulzadas; adolescentes

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The prevalence of metabolic syndrome (MetS) in Mexican adolescents is higher (6.5-19.2%)[1,2] than in other ethnic groups (4.5%).[3] Diet and physical activity play a role in the development of MetS.[4]

Dietary patterns (DP) are defined as "nutritional variables grouped according to some nutritional criteria, in which variables are reduced into a smaller number of variables through statistical manipulation".[5] DP have the advantage of evaluating the potential synergistic effects of foods and nutrients and of reducing epidemiological limitations in comparison with single-food or nutrient approaches. Dietary guidelines might be focused on a food-based approach and not only on a nutrient-based approach that is unclear and favors the consumption of industrialized products designed to meet individual nutrient goals rather than achieving a healthy diet.[6]

In adults, DP predict obesity, MetS, and other chronic diseases; nevertheless, some inconsistencies exist.[5,7,8] In adolescents, some reports suggest that a "Western" or "obesogenic" DP is positively associated with overweight.[9] Others failed to detect such association[10] or with MetS.[11] Moreover, an inverse association between the "fast food and sweet" DP and obesity was reported.[12] More studies are needed in adolescents because they have unique nutritional needs and cultural particularities and the still existing inconsistencies require further evaluation. We evaluated the association of DP with MetS and metabolic markers (insulin resistance [IR] and lipids) in adolescents.

Materials and methods

We conducted a cross-sectional study in public high schools in Guadalajara, Jalisco, Mexico. Adolescents who were willing to participate were included in the study (*n*= 681). Participation rate was 89.3%. Participants with incomplete data (*n*= 9), or with implausible total energy intake (<800 kcal/day or >6 000 kcal/day) (*n*= 18) were excluded from analysis. Finally, 654 participants were included. Previous studies including some of these participants have been reported.[13] The Institutional Review Board of the Mexican Institute of Social Security approved the protocol. Written informed consent was obtained from all the participants and their parents.

Questionnaires and anthropometric measurements were performed by nutritionists. After five minutes of rest, two systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings were taken with a digital baumanometer (Omron HEM–751; Vernon Hills, IL, USA).

A venipuncture blood sample was collected after a 12-h fast. Serum samples were centrifuged and stored at –80º C until analysis. Glucose levels were determined with the hexokinase method in an automated system (Synchron CX4; Beckman Coulter, Inc., Brea, CA, USA) and insulin with an immunometric method utilizing an Immulite 2000 analyzer (Diagnostic Products Co., Los Angeles CA, USA). IR was estimated with HOMA-IR= fasting insulin (μU/ml) × fasting glucose (mmol/l)/22.5. Total cholesterol and triglycerides were estimated by conventional enzymatic procedures. High-density lipoprotein-cholesterol (HDL-C) and low-density lipoprotein-cholesterol (LDL-C) were determined directly by immunochemical methods utilizing an ILab 300 Plus analyzer (Instrumentation Laboratory, Ltd., Birchwood, Warrington, UK).

Assessment of exposure variables

Diet was assessed using a semi-quantitative food-frequency questionnaire (FFQ).[14] The questionnaire included 116 food items with eight options of frequency consumption (ranging from never to four or more times per day) in the previous year. For each food item, a commonly used portion was used. Food or beverage intake was computed multiplying food frequency consumption by the specific portion size of each food item. Food and beverages were converted into total daily energy, macro and micronutrient intake with the Evaluation System of Nutritional Habits and Nutrient Intake.[15]

In order to identify the DP, foods were first integrated into 24 mutually exclusive food groups; the criteria for integrating a food group was based on macronutrient composition, as well as on other components (dietary fiber, sucrose content, culinary aspects, or traditional foods). The food groups employed are listed in table I. DP were derived using cluster analysis, which allows reducing data into patterns according to individual differences in mean intakes.[5] Energy percent values were obtained for each food group as follows: percentage of energy intake for a food group = ∑ (energy intake of each food in a food group X 100/daily total energy intake).[7] The percentage of energy intake value for each food group was standardized (z-scores) for their entry into cluster analysis. We used a k-means method, which partitions subjects into clusters that maximize the Euclidian distance among clusters. We selected a three-cluster solution based on its size, ease of dietary interpretation, and according to our knowledge of the Mexican diet.

The following items concerning eating habits were included at the last part of the FFQ: How often did you have breakfast on average last year? (<1 a week, 1-2 times a week, 3-4 times a week, 5-6 times a week, daily). Do you eat while watching TV? (yes/no). How

Table I
FOOD GROUPS USED IN DIETARY PATTERN ANALYSIS. GUADALAJARA, JALISCO, 2003

Food group	*Food items*
Fast food	Hamburger, hot dog, pizza, sandwich, *torta*
Mexican food	Hot maize beverage *(atole), quesadilla, pozole, tacos, tamal, tostada*
Whole-fat dairy product	Whole-fat cheese, whole-fat milk, whole-fat yoghurt
Meat	Beef, ham, lamb, liver, pork, sausage, shrimp
Sweetened beverages	Soda, sweetened beverages, sweetened juice
Sweet baked goods	Cake, cookie, french toast, hot cake, pastry
Tortilla	Maize *tortilla*
Fruits	Apple, banana, grapes, guava, jicama, lime, mandarine, mango, melon, orange, orange juice, papaya, peach, pear, pineapple, plum, prickly pear, strawberry, watermelon
Legumes and seeds	Beans, chickpea, lentils, peanuts
Refined grains	Breakfast cereal, pasta, potato, rice, wheat tortilla, white bread
Milk beverages	*Biónico*, milkshake
Sweets with fat	Chocolate bar, powder chocolate, ice cream
Snacks	Chips, potato chips
Sweets	Candy, *cajeta*, jam, jelly
Vegetables	Beetroot, broccoli, carrot, cauliflower, chilli, courgette, cucumber, lettuce, *nopal*, onion, pea, spinach, string bean, tomato, zucchini
Wholegrains	Corn, high-fibre ready-to-eat cereal, oat, wholemeal bread, wholemeal *tortilla*
Egg	Eggs
Fish	Canned tuna, sardine, other fish
Butter	Bacon, butter, cream, cream cheese, margarine
Poultry	Chicken
Low-fat dairy product	Low-fat cheese, low-fat milk
Alcohol	Beer, wine, spirits
Avocado	Avocado
Low-energy soda	Diet soda

often did you eat away from home last year? (<1 a week, 1-3 times a week, 4-6 times a week, daily). During the last year, did you take vitamins? (yes/no). Where did you more frequently eat hamburgers, hot dogs, pizza? (home, fast-food restaurant, school, another place). When you eat chicken, do you remove its skin? (yes/no). When you eat meat, do you remove its fat? (yes/no). How many teaspoons of sugar do you add to your drinks to sweeten them?

Assessment of covariates

Smoking was defined as at least one cigarette/day during the past month.[16] Pubertal development was defined according to Tanner stages.[17] Overweight and obesity were defined according to International Obesity Task Force criteria and body fat percentage, with the Slaughter equation.[18] Physical activity was evaluated with a Questionnaire on Physical Activity and Inactivity in Mexican Children.[19]

Assessment of outcome variables

MetS was defined according to International Diabetes Federation (IDF) criteria. For adolescents aged 10-15 years, abdominal obesity (AO) (waist circumference [WC] ≥90th percentile for age and sex), and two or more of the following: glucose ≥100 mg/dl; triglycerides ≥150 mg/dl; HDL-C <40 mg/dl, and SBP >130 mmHg or DBP >85 mmHg. For adolescents aged ≥16 years, AO

(WC ≥90 cm [males] and ≥80 cm [females]), and two or more of the following: glucose ≥100 mg/dl; triglycerides ≥150 mg/dl; HDL-C <40 mg/dl (males) or <50 mg/dl (females), and SBP >130 mmHg or DBP >85 mmHg.[20]

Other MetS definitions for adolescents were used; these include three or more of the following criteria. Cook and collaborators definition: WC ≥90th percentile for age and sex; glucose ≥110 mg/dl; triglycerides ≥110 mg/dl; HDL-C ≥40 mg/dl, and SBP or DBP, ≥90th percentile for age, sex, and height.[21] De Ferranti and collaborators definition: WC >75th percentile for age and sex; glucose ≥110 mg/dl; triglycerides ≥100 mg/dl; HDL-C <45 mg/dl (15-19 years, males) and <50 mg/dl (everyone else), and SBP or DBP >90th percentile for age, sex, and height.[22] Ford and collaborators definition: WC ≥90th percentile for age and sex; glucose ≥100 mg/dl; triglycerides ≥110 mg/dl; HDL-C ≤40 mg/dl, and SBP or DBP, ≥90th percentile for age, sex and height.[23]

Metabolic markers. High total cholesterol was defined as ≥200 mg/dl, high LDL-C as ≥130 mg/dl,[24] high insulin as ≥15.05 µU/ml, and HOMA-IR as ≥3.43.[25]

Statistical analysis

Descriptive analysis included means (SD), medians (25th percentile, 75th percentile) and percentages. Student's *t* test to evaluate mean differences, Kruskal-Wallis to evaluate median differences and Dunn´s test for multiple comparisons. Chi-squared test or Fisher exact test to evaluate differences in percentages. The associations of DP with MetS and with metabolic markers were evaluated using crude and multivariate logistic regression analyses. First, interactions of DP with covariates were evaluated using logistic regression models. If an effect modifier was identified, multiple logistic regressions were run after stratifying by the specific effect modifier. Adjustments were performed by sexual development, smoking, body fat, total physical activity, and energy consumption. Statistical analyses were realized with STATA v9.2 (Stata Corp., TX, USA) and SigmaSTAT 4.0 (Systat Software Inc., CA, USA). A *p* value of <0.05 was considered as statistically significant.

Results

Mean age of the participants was 15.8 ± 1.0 years, 51.7% were women, 28.8% were overweight or obese. MetS prevalence according to different definitions was: 5.1% (IDF); 7.2% (Cook and collaborators); 8.1% (Ford and collaborators), and 16.4% (Ferranti and collaborators).

Three DP were identified (table II): 1) "DP1", characterized by lower energy intake and lower consumption of cholesterol; 2) "DP2", characterized by higher intake of protein, cholesterol, saturated fats, sodium, dietary fiber, vitamins, and minerals, and 3) "DP3", characterized by higher energy, carbohydrate, sucrose, fructose, and alcohol intake and lower protein intake (table III). Regarding food composition, the "DP1" was characterized by *tortilla*, the "DP2" by whole fat dairy products, meat, refined grains, fruits, and milk beverages, and, the "DP3", by Mexican food, sweetened beverages, sweet baked goods, sweets with fat, snacks, sweets, and alcohol. It is noteworthy that the energy intake of unhealthy foods (fast foods, sweetened beverages, sweet baked goods, sweets with fat, snacks, sweets, and alcohol) was high in the three DP, being highest in the "DP3" (49.3%), then the "DP1" (40.2%), and finally, the "DP2" (36.9%). Contrariwise, the energy intake of healthy foods (legumes and nuts, fruits, vegetables, wholegrains, *tortilla*, eggs, fish, poultry, low-fat dairy products, and avocado) was low in the three DP: 17.1% in the "DP3", 21.2% in the "DP1", and finally, 20.1% in the "DP2".

Adolescents consuming mainly the "DP3" were older, mainly female, smokers and physically active (p<0.05 for all, data not shown).

Unhealthy eating habits were different according to DP; more than one half of adolescents who skipped breakfast were in the "DP1" or in the "DP3". Moreover, lunch away-from-home, fast food consumption away-from-home, eating chicken skin and adding ≥3 teaspoons of sugar to beverages was higher in the "DP3" (p<0.05 for all) (table IV). The remaining eating habits did not differ among dietary groups.

Finally, interactions between sex and DP were found (p<0.05); therefore, multiple logistic regression analyses were performed after stratifying by sex. Among males, the "DP3" was associated with MetS (Cook and colleagues OR, 12.14; 95%CI, 1.66-89.05; de Ferranti and colleagues OR, 5.10; 95%CI, 1.20-21.72, and Ford and colleagues OR, 9.29; 95%CI, 1.44-59.73), high triglycerides (OR, 3.89; 95%CI, 1.01-15.07), and HOMA-IR (OR, 6.66; 95%CI, 1.12-39.70). Also, the "DP2" was associated with AO (OR, 5.11; 95%CI, 1.57-16.66). Females showed no statistically significant association (table V).

Discussion

Our results suggest that DP are associated in different ways with obesity and MetS, and the "DP3" has the greatest risk of MetS, hypertriglyceridemia, and IR, while the "DP2" exhibits a greater risk of AO among adolescent males, but not among females.

The "DP3" was associated with MetS (defined by Cook and colleagues, de Ferranti and colleagues, and Ford and colleagues), hypertriglyceridemia, and IR in

Table II
Percentage of energy contribution of food groups by dietary patterns.* Guadalajara, Jalisco, 2003

	DP1 n= 497	DP2 n=103	DP3 n= 54	p value‡	p value§		
					DP1 vs. DP2	DP1 vs. DP3	DP2 vs. DP3
Fast food	15.5 (10.6-21,6)	15.5 (10.9-23.8)	13.7 (9.2-17.8)	0.147	-	-	-
Mexican food	9.4 (6.8-14.0)	10.0 (5.4-14.2)	11.5 (7.1-15.2)	0.234	-	-	-
Whole-fat dairy products	9.1 (5.8-13.8)	9.8 (6.0-14.7)	6.9 (4.7-9.0)	<0.001	0.430	0.003	<0.001
Meat	6.9 (5.4-9.2)	7.4 (4.9-9.5)	5.9 (4.4-7.9)	0.052	-	-	-
Sweetened beverages	8.3 (5.8-11.8)	6.0 (4.5-8.1)	13.2 (9.5-18.0)	<0.001	<0.001	<0.001	<0.001
Sweet baked goods	5.5 (3.2-8.5)	5.7 (3.3-8.3)	7.8 (4.0-9.6)	0.062	-	-	-
Tortilla	5.0 (2.2-7.3)	4.0 (1.6-5.5)	3.8 (1.4-4.6)	0.002	0.047	0.013	1.000
Fruits	4.1 (2.8-6.4)	4.4 (2.9-7.5)	3.5 (2.6-5.4)	0.081	-	-	-
Legumes and nuts	4.0 (2.5-5.9)	4.0 (2.7-6.2)	3.7 (1.7-7.3)	0.453	-	-	-
Refined grains	4.4 (2.9-6.3)	5.2 (3.6-6.7)	3.9 (2.7-5.5)	0.008	0.017	0.875	0.022
Milk beverages	2.2 (1.1-4.8)	3.8 (1.4-6.7)	1.3 (0.8-5.1)	<0.001	0.016	0.019	<0.001
Sweets with fat	2.3 (1.2-3.7)	2.3 (1.2-3.6)	3.4 (1.9-6.1)	0.005	1.000	0.005	0.008
Snacks	1.7 (1.0-3.6)	1.7 (0.7-3.0)	3.9 (2.0-6.5)	<0.001	0.140	<0.001	<0.001
Sweets	1.4 (0.7-2.7)	1.3 (0.9-2.4)	3.5 (2.5-5.5)	<0.001	1.000	<0.001	<0.001
Vegetables	1.7 (1.2-2.4)	2.0 (1.4-2.8)	1.4 (1.0-1.8)	<0.001	0.043	0.016	<0.001
Wholegrains	0.6 (0.4-1.1)	1.0 (0.5-1.7)	0.4 (0.2-0.7)	<0.001	<0.001	<0.001	<0.001
Eggs	0.8 (0.3-1.5)	0.9 (0.7-1.5)	0.7 (0.1-1.1)	0.002	0.037	0.090	0.002
Fish	0.7 (0.5-1.0)	0.6 (0.4-1.2)	0.4 (0.2-0.6)	<0.001	1.000	<0.001	<0.001
Butter	0.6 (0.4-0.9)	0.7 (0.5-1.1)	0.7 (0.4-1.0)	0.015	0.060	0.133	1.000
Poultry	0.4 (0.3-0.9)	0.7 (0.3-0.9)	0.3 (0.2-0.8)	0.002	0.193	0.018	0.001
Low-fat dairy products	0.15 (0.09-0.26)	0.14 (0.07-0.35)	0.09 (0.06-0.30)	0.050	-	-	-
Alcohol	0.12 (0.09-0.39)	0.07 (0.06-0.32)	0.28 (0.05-1.09)	<0.001	<0.001	1.000	<0.001
Avocado	0.12 (0.07-0.21)	0.27 (0.10-0.39)	0.08 (0.03-0.25)	<0.001	<0.001	0.120	<0.001
Low-energy soda	0.0004 (0.003-0.0006)	0.003 (0.002-0.003)	0.004 (0.003-0.005)	<0.001	<0.001	<0.001	0.665

Values are medians (25th percentile, 75th percentile).
* Dietary patterns were derived using cluster analysis. DP1: lower in energy and cholesterol. DP2: higher in protein, cholesterol, saturated fat, sodium, dietary fiber, vitamins and minerals. DP3: higher in energy, carbohydrate, sucrose, fructose, alcohol and lower in protein intake.
‡ Kruskal-Wallis test
§ Dunn´s test.

this study. Sucrose consumption was higher in the 75th percentile (11.9% of total energy). In this DP, compared with the other two, sucrose consumption exceeds the World Health Organization recommendation (≤10% of total energy intake).[26] In the Mexican adolescents studied in Ensanut 2006, high-energy beverages (soft drinks, sweetened juices, *aguas frescas*) accounted for 12.7% of the total kcal/day,[27] a figure lower than in our findings (13.2%) in the "DP3". In Mexican adolescents studied in the Health Workers Cohort Study, a Western DP (characterized by soft drinks, snacks, and corn tortillas) was found to be associated with IR.[28] Some studies in adult populations suggest that unfavorable diets (rich in sugar-sweetened beverages, fried potatoes, and red and processed meats) are associated with glucose and insulin;[29] the consumption of fructose-sweetened beverages decreases insulin sensitivity and increases postprandial hypertriglyceridemia.[30] In addition, one or two servings/day of sugar-sweetened beverages increase the risk for diabetes and MetS.[31] We do not know the mechanism of the relationship between the "DP3" with IR and with triglycerides; however, fructose

Table III

ENERGY AND NUTRIENTS DAILY INTAKE ACCORDING TO DIETARY PATTERNS. GUADALAJARA, JALISCO, 2003

	DP1 n= 497	*DP2 n= 103*	*DP3 n= 54*	*p value**	*p value*‡		
					DP1 vs. DP2	*DP1 vs. DP3*	*DP2 vs. DP3*
Energy, kcal	2337 (1900-2811)	3827 (3348-4306)	3995 (3609-4313)	<0.001	<0.001	<0.001	1.000
Carbohydrate, % of total energy	53.9 (51.2-57.1)	52.2 (49.5-55.3)	56.7 (53.8-59.3)	<0.001	0.003	<0.001	<0.001
Protein, % of total energy	13.9 (13.0-14.8)	14.3 (13.4-15.0)	12.1 (11.0-13.0)	<0.001	0.037	<0.001	<0.001
Fats, % of total energy	30.6 (28.0-32.9)	31.3 (28.6-34.1)	30.3 (27.6-32.6)	0.192	-	-	-
Saturated fat, % of total energy	10.9 (9.8-12.1)	11.6 (10.6-12.7)	10.1 (9.0-11.1)	<0.001	0.019	<0.001	0.022
Polyunsaturated fat, % of total energy	5.3 (4.6-6.0)	5.4 (4.8-6.1)	5.3 (4.8-6.0)	0.640	-	-	-
Monounsaturated fat, % of total energy	13.2 (12.0-14.7)	14.4 (12.5-15.9)	13.0 (11.9-15.1)	0.017	0.014	0.184	1.000
Cholesterol, mg	254 (192-324)	443 (383-522)	343 (278-426)	<0.001	<0.001	<0.001	<0.001
Sucrose, % of energy	7.3 (5.9-8.8)	7.4 (6.3-8.2)	9.7 (7.8-11.9)	<0.001	1.000	<0.001	<0.001
Fructose, % of energy	3.9 (2.9-4.9)	3.4 (2.7-4.2)	4.9 (3.2-6.7)	<0.001	0.002	0.007	<0.001
Dietary fiber, g	17.5 (13.8-20.7)	27.5 (24.0-32.3)	23.6 (19.5-26.5)	<0.001	0.003	<0.001	<0.001
Dietary fiber ≥14 g/1 000 kcal,§ %	20.7	26.2	16.7	0.320	-	-	-
Calcium, mg	973 (745-1292)	1738 (1416-1974)	1368 (1117-1549)	<0.001	<0.001	<0.001	0.003
Iron, mg	13.5 (11.3-16.6)	22.9 (20.3-27.0)	21.0 (18.5-23.1)	<0.001	<0.001	<0.001	0.703
Heme iron, mg	0.6 (0.5-0.8)	1.0 (0.7-1.3)	0.9 (0.6-1.3)	<0.001	<0.001	<0.001	0.647
Magnesium, mg	329 (264-395)	548 (472-607)	497 (426-584)	<0.001	<0.001	<0.001	0.419
Selenium, mg	0.9 (0.5-1.3)	1.4 (0.8-2.2)	1.4 (0.8-2.0)	<0.001	<0.001	<0.001	1.000
Zinc, mg	10.4 (8.4-12.6)	17.7 (15.4-20.4)	15.0 (13.8-17.0)	<0.001	<0.001	<0.001	0.370
Sodium, mg	2737 (2162-3520)	4751 (4033-6055)	3965 (3586-4702)	<0.001	<0.001	<0.001	0.246
Retinol, mg	867 (621-1188)	1624 (1296-1937)	1214 (886-1577)	<0.001	<0.001	<0.001	<0.001
Thiamin, mg	1.9 (1.5-2.3)	3.2 (2.8-3.8)	2.7 (2.5-3.2)	<0.001	<0.001	<0.001	0.157
Riboflavin, mg	2.0 (1.5-2.5)	3.6 (3.1-4.0)	2.8 (2.5-3.2)	<0.001	<0.001	<0.001	0.002
Niacin, mg	18.0 (14.7-21.7)	30.0 (26.5,34.9)	27.2 (24.5-30.7)	<0.001	<0.001	<0.001	0.631
Vitamin B_6, mg	1.6 (1.3-1.9)	2.7 (2.4-3.1)	2.3 (2.0-2.6)	<0.001	<0.001	<0.001	0.049
Vitamin B_{12}, mg	4.3 (3.2-5.5)	7.2 (5.9-9.0)	5.7 (4.4-7.5)	<0.001	<0.001	<0.001	0.008
Folate, mg	300 (236-379)	509 (447-604)	412 (343-504)	<0.001	<0.001	<0.001	0.004
Vitamin C, mg	140 (95-191)	242 (197-312)	201 (159-278)	<0.001	<0.001	<0.001	0.070
Vitamin D, IU	218 (149-319)	413 (302-534)	281 (188-354)	<0.001	<0.001	0.012	<0.001
Alcohol, g	0.2 (0.2-0.9)	0.2 (0.2-0.9)	0.9 (0.2-1.8)	<0.001	1.000	<0.001	0.004

Values are medians (25^{th} percentile, 75^{th} percentile).
* Kruskal-Wallis test
‡ Dunn´s test
§ Chi square test

might play a key role in hepatic IR through activation of the carbohydrate-responsive element-binding protein which prevents insulin from suppressing glucose production and stimulates *de novo* lipogenesis.[32]

Furthermore, in our study, only 21.3% of adolescents consumed the dietary fiber recommendation of at least 14 g /1 000 kcal[33] and no differences were found between dietary patterns ("DP1"= 20.7%, "DP2" = 26.2% and "DP3"= 16.7%; p= 0.320). These results are similar to a study in Mexican adolescents in which almost 80% did not consume the recommended dietary fiber.[28]

Fast food accounted for highest energy consumption in the three DP in our study (13.7-15.5%). This reached 16.8% in males from "DP2", which may explain, in part, the association of this DP with AO. Similar to our study, fast food energy intake in adolescents of the

Table IV
Eating habits by dietary pattern. Guadalajara, Jalisco, 2003

	DP1 *n= 495*	*DP2* *n= 103*	*DP3* *n= 54*	*p**
Daily breakfast consumption (yes)	55.7	72.8	55.6	0.005
Eat while watching TV (yes)	69.0	71.0	77.8	0.410
Lunch away-from-home ≥1/week (yes)	45.1	42.7	63.0	0.032
Supplements intake last year (yes)	39.8	48.0	42.6	0.300
Fast food intake away-from-home (yes)	58.3	64.4	75.5	0.037
Eat chicken skin (yes)	20.7	30.7	33.3	0.020
Eat fat meat (yes)	18.4	22.6	18.9	0.620
Sugar added to beverages (no. teaspoons):				
0	1.2	1.0	0	0.024
1	13.6	11.7	9.3	
2	55.8	48.5	37	
≥ 3	29.4	38.8	53.7	

Values are percentages.
*Chi square test or Fisher´s exact test

NHANES 2011-2012 study was 16.9% and increased to 18.6% in obese.[34] A study in Iranian adolescents found that fast food consumption in the highest vs. the lowest quartile increased the incidence of AO.[35]

On the other hand, we found that sodium and sucrose intakes in the "DP3" were higher than in the "DP1". Previously, a three-times higher risk of developing MetS in the highest vs. the lowest quartile of sweet and salty snacks was found in children and adolescents.[36] Additionally, Mexican school-children, consuming a Western DP (high in sweetened beverages, salty snacks, cakes, and sweets) had more overweight.[37] Moreover, in USA adolescents, sweetened beverage consumption increased 74 g/day per each additional 1g/salt/day.[38] In a study in children from Mexico City, salty-food consumption was mentioned as one of the reasons for drinking soft sweetened drinks.[39] Unfortunately energy-dense food consumption has increased in children and adolescents; not only because these foods are inexpensive, good-tasting, and available,[40] but because of their ability to exert an effect on hedonic and motivational processes.[41]

Additionally, unhealthy eating habits (skipping breakfast, eating away-from-home, fast food consumption away-from-home, eating chicken skin, and sugar added to beverages) were higher in the "DP3" in our study. An increase in the consumption of calories in USA children and adolescents was found between 1977 and 2006: consumption away-from-home increased 255% during this period and fast foods contributed to the largest energy intake from foods prepared away-from-home.[42] In Mexican children, the availability of unhealthy foods (snacks, chocolates, sweets, sugary drinks, and *antojitos*) on the way to school ranged from 22-31%, and foods and beverages eaten away-from-home contributed to obesity increase.[43] On the other hand, Lebanese adolescents consuming a Western DP were more likely to eat away-from-home and to skip breakfast than the traditional DP.[44] In our study, such behaviors were more frequent in the "DP3".

Sample size was higher in females than in males, nevertheless, only significant associations were found in males. We cannot establish a biological reason for this, but in our adolescents MetS prevalence according to Cook and colleagues, was higher in males than females (12.1 vs. 7.6%; $p= 0.090$), as well as according to Ford and colleagues (11.1 vs. 5.3%; $p= 0.007$) and de Ferranti and colleagues (19.7 vs. 14.2%; $p= 0.061$). Energy intake was also higher among males than females (2 795 vs. 2 464 kcal/day; $p<0.001$). Others have found that, only among males, an increase in the percentage of energy from fat was associated with AO, and a Western DP was associated with a higher risk of overweight and hypertriglyceridemia.[9] To the contrary, among Korean prepubertal girls, a balanced DP was negatively associated with triglycerides and a Western DP was positively associated with MetS.[45] More studies evaluating these associations according to sex are needed.

We must be careful in the interpretation of our results, because the nature of our cross-sectional analy-

Table V

Adjusted association between metabolic syndrome and dietary patterns by sex. Guadalajara, Jalisco, 2003

	DP1	*DP2*		*DP3*	
	Reference	$OR_{adjusted}$	*95%CI*	$OR_{adjusted}$	*95%CI*
Males (*n*= 315)					
MetS components, IDF:					
Abdominal obesity*	1.00	5.11	1.57-16.66‡	3.33	0.50-22.13
High glucose§	1.00	0.65	0.08-5.57	3.61	0.42-31.30
High triglycerides#	1.00	1.31	0.47-3.67	3.89	1.01-15.0&
Low HDL-C#	1.00	0.61	0.25-1.47	1.04	0.32-3.43
High blood pressure#	1.00	1.63	0.58-4.57	3.58	0.88-14.62
MetS definition:					
IDF#	1.00	2.94	0.72-12.02	5.99	0.42-84.87
Cook *et al.*§	1.00	0.81	0.16-4.16	12.14	1.66-89.0&
de Ferranti *et al.*∞	1.00	1.22	0.47-3.18	5.10	1.20-21.7&
Ford *et al.*§	1.00	0.81	0.17-3.79	9.29	1.44-59.7&
Other metabolic markers:					
HOMA-IR#	1.00	1.60	0.43-5.93	6.66	1.12-39.70&
High insulin#	1.00	1.48	0.40-5.48	3.12	0.44-21.84
High total cholesterol#	1.00	0.50	0.13-1.88	0.71	0.12-4.29
High LDL-C#	1.00	0.60	0.17-2.08	0.26	0.03-2.53
Females (*n*= 334)					
MetS components, IDF:					
Abdominal obesity#	1.00	0.97	0.16-5.67	2.06	0.37-11.65
High glucose#	1.00	∅	∅	5.48	0.27-113
High triglycerides#	1.00	0.33	0.08-1.28	0.22	0.04-1.18
Low HDL-C#	1.00	0.90	0.36-2.24	1.50	0.58-3.92
High blood pressure#	1.00	0.53	0.11-2.47	0.23	0.02-2.13
MetS definition:					
IDF#	1.00	0.50	0.03-9.32	2.24	0.14-34.70
Cook *et al.*	1.00	∅	∅	∅	∅
de Ferranti *et al.*#	1.00	0.39	0.06-2.43	∅	∅
Ford *et al.*	1.00	∅	∅	∅	∅
Other metabolic markers:					
HOMA-IR#	1.00	0.27	0.06-1.21	1.52	0.46-5.05
High insulin#	1.00	0.30	0.07-1.16	1.25	0.38-4.05
High total cholesterol∞	1.00	0.60	0.24-1.50	0.34	0.10-1.18
High LDL-C#	1.00	0.36	0.12-1.13	0.36	0.11-1.21

MetS: metabolic syndrome; IDF: International Diabetes Federation; HDL-C: high density lipoprotein cholesterol; HOMA-IR: homeostatic model assessment index of insulin resistance; LDL-C: low density lipoprotein cholesterol.

*Adjusted by sexual development (II-IV/V), total physical activity (h/day), energy intake (kcal/day), and smoking (one or more cigarettes/day).
‡ $p<0.01$.
§ Adjusted by sexual development (II-IV/V), body fat (%), total physical activity (h/day), and energy intake (kcal/day).
# Adjusted by sexual development (II-IV/V), body fat (%), total physical activity (h/day), energy intake (kcal/day), and smoking (one or more cigarettes/day).
& $p<0.05$
∞ Adjusted by sexual development (II-IV/V), body fat (%), total physical activity (h/day), and smoking (one or more cigarettes/day).
∅ OR was not calculated because of the small sample size for one comparison group in these cells.

sis cannot establish causal relationships. Thus, future studies are required to answer this question. The FFQ is widely used in epidemiological studies due to its advantages; however, it overestimates consumption; therefore, interpretation of results should be conducted with caution. Although food groups were formed according to their nutritional value, it is possible that complete objectivity might not been achieved. Despite such limitations, we found associations between obesity (and MetS) and DP that are similar to those of previous studies. On the other hand, the strengths of the study are that confounders were controlled with multiple logistic regressions.

In conclusion, we found that the "DP3" increased the risk of MetS, hypertriglyceridemia, and IR, and that the "DP2" increased the risk of AO in male adolescents. Moreover, unhealthy eating habits were higher among "DP3" consumers. Promotion of a healthy DP is needed in order to reduce obesity and MetS in adolescents.

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Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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