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Cross-sectional study of dietary fatty acid intake and its association to high blood pressure in a group of mexican adolescents

Manuel A Gómez-Martínez[1], Lilia Castillo-Martínez[2], Carolina Velázquez-Aguilar[3], Arely Vergara-Castañeda[4], Maria del Pilar Milke-García[5] and Arturo Orea-Tejeda[6]

[1]Universidad Nacional Autónoma de México, Public Health Department; [2]Clinical Nutrition Department, Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubiran; [3]Clinical Nutrition Department, Medical Sur Hospital; [4]Chemical Science Department, La Salle University; [5]Nutrition Division, Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán; [6]Heart and Respiratory Failure Clinic, Cardiology Department, Instituto Nacional de Enfermedades Respiratorias Ismael Cosío Villegas. Mexico City, Mexico

ABSTRACT:

Objective: To examine the relationship between fatty acid consumption and blood pressure in high school adolescents. **Methods**: A cross-sectional study was conducted in 247 adolescents (low-income families) attending public schools in Mexico City. Blood pressure was measured according to the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents recommendations. Hypertension was defined as a blood pressure above the 95th percentile for the age, gender, and height. Also weight, height, and waist circumference were measured and the waist-to-height ratio was calculated accordingly. Dietary intake was estimated by analyzing a 24-hour recall through the Food Processor ESHA research Software. Body mass index was calculated and subjects were classified in categories according to the CDC percentiles. **Results**: The frequency of hypertension was 15.39%. The dietary intake variables did not differ between the individuals having high blood pressure or normal blood pressure, except for the ratio of omega 6/3. High blood pressure was associated to body mass index and total fat intake > 30%, disregarding age, waist-to-height ratio, dietary kilocalories or omega 6/3 ratio.

RESUMEN

Objetivo: El estudio tuvo como propósito examinar la relación entre el consumo de ácidos grasos y la presión arterial elevada en un grupo de adolescentes. **Métodos:** Se realizó un estudio transversal en 247 participantes que acudían a escuelas secundarias en la Ciudad de México. La presión arterial fue medida de acuerdo a las recomendaciones de la *National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents*. Se definió hipertensión cuando la tensión sanguínea era mayor al percentil 95 para la edad, el sexo y la talla. Además, se midieron el peso, la talla y la circunferencia de la cintura, calculando así el índice cintura-altura. La dieta se analizó usando un recordatorio de 24 h de alimentos por medio del programa informatizado *Food Processor* ESHA para conocer la cantidad de macro y micronutrimentos de la dieta. El índice de masa corporal (IMC) se clasificó en categorías de acuerdo a los percentiles de los CDC. **Resultados:** La frecuencia de hipertensión fue del 15.39%. Las variables dietéticas no difirieron entre hipertensos y normotensos, excepto la relación ω6/ω3. La presión arterial elevada se asoció con el IMC y la ingestión

Dirección para correspondencia:
*Corresponding author:
Lilia Castillo-Martínez
Vasco de Quiroga, 15
C.P. 14000, Ciudad de México, México
E-mail: cam7125@gmail.com

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Conclusions: High blood pressure was frequent in school adolescents of low socioeconomic status living in Mexico City. Body mass index and dietary fat consumption > 30% of the caloric intake were associated to high blood pressure in this population. (REV MEX ENDOCRINOL METAB NUTR. 2017;4:58-64)
Corresponding author: Lilia Castillo-Martínez, cam7125@gmail.com

Key words: Adolescents. Hypertension. Omega 6/3 ratio. Fatty acid intake.

de grasa total > 30% del valor energético total, sin tomar en cuenta la edad, el IMC, el aporte energético de la dieta o la relación ω6/ω3.

Palabras clave: Adolescentes. Hipertensión. Ingestión de ácidos grasos. Relación ω6/ω3.

INTRODUCTION

In recent decades, the role of dietary habits on the development of chronic diseases has been recognized, not only in the adult population, but also in younger people, particularly in terms of hypertension[1]. Food habits may be related to hypertension both with respect to micronutrient intake, such as sodium, and macronutrient intake, such as the amount and type of dietary fats. This relationship can be explained firstly because of the atherogenic potential of fatty acids, which reduce the size of the arterial lumen, and secondly, because the intake of omega 6 (ω6) and omega 3 (ω3) fatty acids may modify the atherogenic potential of fatty acids by increasing a proinflammatory status and concomitantly by decreasing the anti-inflammatory pathways by inducing significant micro-viscosity, increasing proinflammatory cytokine synthesis, and promoting arterial smooth muscle hypertrophy[2,3].

Some studies have described a higher ratio of saturated-to-polyunsaturated fats within the endothelium, which increases the tissue sensitivity to catecholamines and decreases the endothelium-dependent relaxation of mesenteric arteries. Saturated fats produce a progressive increase in systolic blood pressure (SBP)[1]. Additionally, other studies have reported that fatty acids may influence blood pressure (BP) control. In particular, SBP has been shown to correlate inversely to the polyunsaturated fatty acid intake, and the diastolic blood pressure (DBP) to the long-chain ω3 intake[4]. However, other nutritional factors related to hypertension have not been ruled out, such as the ratio of ω6 to ω3 polyunsaturated fatty acid (PUFA) intake[5,6], which can be as high as 30/1, whereas the recommended ratio is 4/1 according to the WHO[6].

Previous studies linked to the dietary fatty acid composition and BP have focused on laboratory models or adult human populations; however, few have contributed with information regarding the role of fatty acids on the BP of adolescents[2,4,7-16].

In this study, we examined the relationship between the intake of dietary fat and the different types of fatty acids, and the frequency of high BP in high school adolescents living in Mexico City.

MATERIALS AND METHODS

Subjects

Adolescents of low socioeconomic status between 10 and 15 years old attending two public schools in Mexico City from February 2013 to July 2013 were included after having signed (their parents or tutors) the informed consent form. Subjects presenting gastrointestinal, hormonal (hyperthyroidism or hypothyroidism), kidney, or heart disorders (as referred by parents) were excluded from the study. Subjects who refused to be measured at any moment of the study or whose dietary questionnaire was incomplete were excluded from the study (missing information above 20%).

The elementary population comprised two grades (5th grade, three groups; 6th grade, three groups), and the high school population comprised three grades (1st grade, one group; 2nd grade, one group; and 3rd grade, two groups), with a total of 332 students. However, 85 students refused to participate or did not complete the evaluation. Finally, 247 adolescents completed the requirements and were thus included in our cross-sectional study.

Figure 1 depicts the process of recruitment and reasons underlying the exclusion, loss, or elimination of some adolescents from the final results.

This protocol was approved by the Ethics Committee of the Faculty of Medicine (La Salle University). This Committee has been fully accredited by the Federal Commission for the Protection against Sanitary Risks.

Blood pressure measurement

Measurements were performed using an aneroid sphygmomanometer (Welch Allyn®, Skaneateles Falls, NY, USA) according to the recommendations of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents[17-19]. The BP was measured at least three times per subject and was averaged. The subject was in a well-supported, seated position, the arm on which the measurement was performed placed at chest level, with the feet flat on the floor, and took a resting period of five minutes between each measurement. A Welch Allyn® sphygmomanometer with interchangeable cuff (adult and pediatric sizes) and a Littmann® (Steele Supply Company, Saint Joseph, MI, USA) stethoscope were used.

The percentile of height of each participant was obtained according to the Center for Disease Control and Prevention (CDC) growth tables. In order to classify the subjects as normotensive or hypertensive, the BP tables from the National High Blood Pressure Education Program (NHBPEP) adjusted for height, age, and sex were used. The BP ranges were as follows: values equal or above the 90th percentile but below the 95th percentile were considered as normal BP, and values corresponding to the 95th percentile or above were considered as high BP[17].

Anthropometric measurements

The anthropometric measurements (weight, height, and waist circumference) of each subject were obtained by standardized dietitians (Habicht method)[19]. Waist circumference was measured at the midpoint between the iliac crest and the last rib. Body mass index (BMI) and the waist-to-height ratio (WtHR) were calculated accordingly. A Tanita (Professional Scale 558, Arlington Heights, USA) scale was used to weigh subjects, and a stadiometer (Seca 206 Portable, Chino, CA, USA) for the height measurement, and a Seca 201 fiberglass tape for the waist measurement. All of these were performed with the subject wearing light clothes.

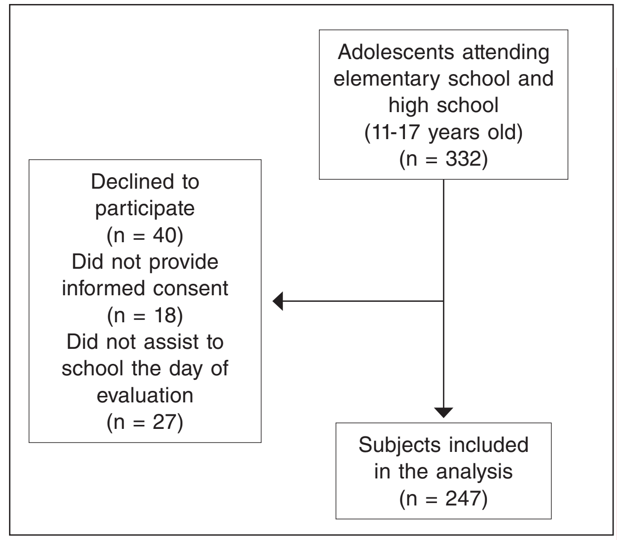

Figure 1. Flowchart of the study.

A WtHR ≥ 0.5 was considered as a risk factor for cardiometabolic events[20]. Subjects with a BMI between the 85th and 95th percentiles were classified as overweight, and those with a BMI above the 95th percentile were classified as obese, according to the cutoff points provided by the CDC[21].

Dietary intake

Dietary intake was assessed by standardized dietitians using the multiple-pass 24-hour recall. This recall was performed on Tuesdays (a typical day, not weekend). Fat used for cooking was also assessed; however, most subjects ignored the kind of oil or fat (lard, butter) used. Data from the multiple-pass method 24-hour recall were analyzed using the Food Processor ESHA research software version 17[23], which included the nutritional values of 1,779 food items, including those of Mexican origin. We focused on macronutrients (fat, protein, and carbohydrates), expressed as grams per day and as percentages of total caloric intake; dietary fat consumption (total fat; saturated; monounsaturated and polyunsaturated; trans; w3 and w6 fatty acids) and micronutrients (calcium, potassium, sodium), which were reported as milligrams per day.

Statistical analysis

The normality of the distribution of continuous variables was tested by the Kolmogorov-Smirnoff test. Since most variables did not have a normal distribution, medians and interquartile ranges were used. The Mann-Whitney U test was performed to evaluate differences among groups (high vs. normal BP) for continuous variables, and the chi-square test or Fisher's exact test were used to assess categorical data. The statistical analysis was performed using commercially available software (SPSS 21.0 for Windows, SPSS, Inc., Chicago, IL, USA). Differences were considered statistically significant when the p-value was < 0.05.

A logistic regression analysis was performed using the enter method, and included variables accounting for a $p < 0.20$ in the bivariate analysis, in order to establish the independent contribution of each variable on the presence of hypertension. A p-value < 0.05 was considered statistically significant, and 95% confidence intervals (95% CI) were calculated for adjusted OR.

RESULTS

A total of 247 subjects were included (Fig. 1), of which 124 were males and 123 were females, with a median age of 11.5 (25^{th} 10 - 75^{th} 14) years. The anthropometric characteristics and BP characteristics of the study population are described in table 1. High BP was found in 38 subjects (15, 38%): 25 (65.8 %) corresponded to diastolic hypertension, eight (21%) to systolic and five (12.15%) to both systolic and diastolic hypertension. Subjects with high BP were older and had greater weight, BMI, waist circumference, WtHR, and frequency of obesity compared with normotensive subjects (Table 1).

Dietary intake did not differ between high BP and normotensive individuals, except for the ratio of ω6/ω3 that was higher in subjects with high BP; the frequency of total fat intake > 30% of the total caloric intake was also higher, but this difference was not statistically significant (Table 2).

The logistic regression analysis showed that the only variables associated with high BP pressure were BMI and a total fat intake > 30%, regardless of the age, WtHR, dietary kilocalories, or ω6/ω3 ratio (Table 3).

DISCUSSION

The main finding of this study was that high BP was only related to BMI and total fat intake and not to age, WtHR, kilocalories, or ω6/ω3 ratio.

Our results reveal a greater frequency of high BP (15.38%) among adolescents than that reported in a study performed in Buenos Aires, Argentina of 7.7%[24], and in Leon Guanajuato of 3.7% among 12-16-year-old adolescents[25]; however, in another study, Colin found a prevalence of 22.8% among 8-10-year-old students in Mexico City[16].

Riley, et al.[26] and Silaste, et al.[27] showed that a higher intake of saturated fat significantly increases BP; however, these authors did not specify whether the increase occurred in the SBP or DBP. Other studies have emphasized that the intake of mono- and polyunsaturated fats as total polyunsaturated fat, ω3, EPA, and ω6 lead to lower BP levels[4]. Similarly, DHA and EPA consumption may reduce DBP and SBP in children. However, the multivariate analysis in our study showed no association between a high BP and the ω6/ω3 ratio. Similarly, O'Sullivan, et al. studied the effect of specific long-chain ω3 (docosahexaenoic and eicosapentaenoic acid) on BP and reported a non-significant decrease on systolic BP, and no significant association regarding the ω6/ω3 ratio[4].

Table 1. Anthropometric measurements according to blood pressure

Variables	High blood pressure (n = 38)	Normal blood pressure (n = 209)	p
Age (years)	13 (11.0-14.0)	11 (10.0-13.0)	0.015
Male, n (%)	19 (50)	105 (50.2)	0.98
Weight (kg)	51.15 (45.77-69.8)	43.95 (35.8-52.4)	< 0.0001
Height (cm)	154.1 (148.9-161.1)	148.9 (140.6-157.1)	0.003
Body mass index (kg/m^2)	22.1 (20.11-26.3)	19.5 (17.02-22.6)	< 0.0001
Obesity, n (%)	19 (50)	61 (29.2)	0.01
Waist circumference (cm)	77.7 (72.9-90.0)	70.1 (63.7-78.0)	< 0.0001
WtHR	0.52 (0.47-0.58)	0.46 (0.42-0.52)	< 0.0001
WtHR ≥ 0.5, n (%)	19 (50)	60 (28.6)	0.01
SBP (mmHg)	120 (110-120)	100 (90-103)	< 0.0001
DBP (mmHg)	80 (77-80)	60 (60-70)	< 0.0001

Mann and Whitney U test. Data are presented as medians (P25th-P75th) or n (%).
DBP; diastolic blood pressure; SBP: systolic blood pressure; WtHR: waist to height ratio.

Table 2. Dietary intake according to blood pressure

Variables	High blood pressure (n = 38)	Normal blood pressure (n = 209)	p
Energy (kcal/d)	1,875.7 (1,277.2-2,439.9)	1,658 (1,258-2,190)	0.85
Protein (% of total kcal)	14.7 (11.9-17.2)	14.6 (12.0-17.2)	0.90
Carbohydrates (% of total kcal)	50.5 (46.1-62.5)	52.8 (45.6-61.9)	0.94
Total fat (% of total kcal)	34.5 (27.8-40.2)	32.1 (24.5-39.8)	0.48
Total fat intake > 30%, n (%)	28 (73.7)	123 (59.0)	0.08
Saturated fat (% of total kcal)	11.3 (7.3-14.5)	10.8 (8.4-13.4)	0.30
Saturated fats (g)	22.9 (13.5-30.8)	20.6 (13.5-28.5)	0.48
Monounsaturated fats (g)	22.82 (12.4-28.9)	21.30 (13.3-32.3)	0.32
Polyunsaturated fats (g)	10.13 (6.11-13.5)	9.83 (4.9-17.1)	0.89
ω3 fatty acids (g)	0.87(0.58-2.05)	0.9 (0.55-2.7)	0.99
ω6 fatty acids (g)	7.43 (5.1-10.5)	7.6 (7.3-12.9)	0.99
Trans fatty acids (g)	0.54 (0.23-1.2)	0.62 (0.43-1.1)	0.77
ω6/ω3 ratio	9.8 (4.18-15.7)	6.6 (3.4-9.6)	0.045*
Calcium (mg)	729.4 (430.1-965.4)	774.4 (561.3-1,015.6)	0.35
Potassium (mg)	1,979.6 (1,444.0-2,395.3)	1,827.3 (1,368.5-2,362.8)	0.51
Sodium (mg)	1,588.6 (943.1-2,750.1)	1,581.3 (1,090-2,315.3)	0.8

Mann and Whitney U test. Data are presented as the median (P25th-P75th) or n (%).
ω6/ω3: omega 6/3 ratio.

The importance of fat intake as a risk factor for the development of high BP is well known. For this reason, Giddin, et al.[28] formulated dietary fat recommendations for adolescents and children according to the American Heart Association (AHA) guidelines, suggesting a total fat consumption of less than 30% of the total kilocalories intake[29]. In this regard, many of the adolescents we studied usually consumed more than 30% of the total kilocalories intake as fat. The high BP frequency found in our study may be explained by the atherogenic potential of the different fatty acids, which reduce the arterial lumen, and also because the ω6/ω3 ratio certainly modifies the atherogenic potential of fatty acids by increasing a proinflammatory status accompanied by the synthesis of proinflammatory cytokine synthesis and concomitantly decreasing the

Table 3. Logistic regression analysis associating hypertension with anthropometric and dietary variables

Variables	Exp(B)	95% CI for Exp (B)		P value
		Lower	Upper	
Age (years)	1.23	0.99	1.54	0.06
Body mass index (kg/m^2)	1.17	1.04	1.31	0.01
WtHR ≥ 0.5	0.78	0.26	2.31	0.66
Energy (kcal/d)	1.0	1.0	1.01	0.65
Total fat intake > 30%	2.38	1.03	5.52	0.04
ω6/ω3 ratio	0.99	0.97	1.03	0.94

Logistic regression; WtHR: waist to height ratio; ω6/ω3 ratio: omega 6/3 ratio.

anti-inflammatory pathways, thus promoting arterial smooth muscle hypertrophy[3]. Also a higher ratio of saturated fats increases the sensitivity to catecholamines within the endothelium, thus decreasing the mesenteric arteries-dependent relaxation. Finally, saturated fats produce a progressive increase in the systolic blood pressure[1].

LIMITATIONS

The main limitation of this study was the reliance on the 24-hour recall, performed only once a week on Tuesdays. To obtain reliable information, it is advisable to apply the dietary recall at least three times, as a single 24-hour recall typically underestimates the percentage of kilocalories from protein intake by about 77.7%, while three 24-hour recalls may underestimate this protein intake around 50.2%. If this 24-hour recall is applied an infinite number of times, the underestimation would be around 19.2%. Thus, some authors have mentioned there is no consensus on a gold standard tool for the assessment of nutritional intake in epidemiologic studies[30].

A study performed by the National Institute of Public Health compared the estimation of kilocalories, macronutrients and micronutrients of a food frequency (FF) questionnaire vs. 24-hour recall and concluded that the food frequency slightly overestimates the intake, and nutrients such as polyunsaturated fatty acids, cholesterol, vitamin E, and folic acid are wrongly estimated[30].

Moreover, this was an observational study with a cross-sectional design, so we cannot make any causal inference, in contrast to what a longitudinal study would have allowed. Our sample size was also small, and we examined a reduced group of hypertensive subjects.

High BP was frequent in school adolescents of low socioeconomic status living in Mexico City. BMI and dietary fat consumption > 30% were associated with high BP in this population.

We might conclude that fatty acid consumption was not associated to hypertension in this set of Mexican subjects. Research in a cohort with a more accurate tool in order to assess fatty acid consumption would be needed in order to rule out the influence of fatty acids on hypertension.

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DECLARATION OF INTEREST

The authors declare no conflicts of interest.

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