Nutrición Hospitalaria

La adherencia al patrón alimentario DASH se relaciona con la presión arterial y los indicadores antropométricos en adultos mexicanos

Adherence to the DASH dietary pattern is associated with blood pressure and anthropometric indicators in Mexican adults

10.20960/nh.03728

01/31/2022

OR 3728

Adherence to the DASH dietary pattern is associated with blood pressure and anthropometric indicators in Mexican adults

La adherencia al patrón alimentario DASH se relaciona con la presión arterial y los indicadores antropométricos en adultos mexicanos

Xochitl Ponce-Martínez[1], Eloisa Colín-Ramirez[2], Sonia Rodríguez-Ramirez[3], Susana Rivera-Mancía[2], Raúl Cartas-Rosado[4], and Maite Vallejo-Allende[5]

[1]Universidad Nacional Autónoma de México (UNAM). Mexico City, Mexico. [2]Cátedras CONACYT, Consejo Nacional de Ciencia y Tecnología. Instituto Nacional de Cardiología Ignacio Chávez. Mexico City, Mexico. [3]Centro de Investigación en Nutrición y Salud. Instituto Nacional de Salud Pública (INSP). Cuernavaca, Morelos. Mexico. [4]Electromechanical Instrumentation Department. Instituto Nacional de Cardiología Ignacio Chávez. Mexico City, Mexico. [5]Sociomedicine Department. Instituto Nacional de Cardiología Ignacio Chávez. Mexico City, Mexico

Received: 05/06/2021
Accepted: 05/09/2021
Correspondence: Eloísa Colín-Ramírez. Faculty of Medicine and Dentistry. University of Alberta. 2J2.00 Walter C Mackenzie Health Sciences Centre. 8440 112 St. NW. Edmonton, Alberta. Canada
e-mail: eloisa@ualberta.ca

Conflicts of interest: the authors declare no conflicts of interest.

Acknowledgments: we sincerely thank Dr. Manlio F. Márquez-Murillo for critically reviewing this manuscript.

Funding: this work was supported by the National Council of Science and Technology (CONACYT, México) under the CONACYT Research Fellow program (Cátedras CONACYT) and AstraZeneca Mexico (collaboration agreement without number). X.P.M was supported by a post-graduate CONACYT scholarship. E.C.R. and S.R.M. were supported as research fellows of the program "Cátedras CONACYT" (project No. 1591) during the conduction of this study.

Authorship: X.P-M, conceptualization and design of the study, analysis and interpretation of data, drafting the article. E-C-R, design of the study, acquisition and interpretation of data, drafting the article. S.R-R, design of the study, interpretation of data, revising article critically for important intellectual content. S.R-M, acquisition and interpretation of data, revising article critically for important intellectual content. R.C-R, acquisition of data, data management (software programming for further processing of dietary intake data), revising article critically for important intellectual content. M.V-A, acquisition and interpretation of data, revising article critically for important intellectual content. All authors have approved the final version to be submitted.

ABSTRACT

Background: adherence to Dietary Approach to Stop Hypertension (DASH) has demonstrated to be effective in lowering blood pressure and other cardiovascular risk markers in different populations, but has never been evaluated in the Mexican population.

Aim of the study: to assess adherence to the DASH dietary pattern by using an adapted DASH adequacy index (DASH-AI), and to evaluate its association with cardiovascular risk markers in an adult Mexican population.

Methods: we conducted a cross-sectional analysis of data of 1,490 adults aged 20-50 years. Diet was assessed with a Food Frequency Questionnaire and sodium intake by 24-hour urinary sodium excretion; the DASH-AI score was calculated based on the DASH nutrient targets. Multivariable linear and logistic regression analyses were performed to estimate the association between the DASH-AI score and cardiovascular risk markers (body mass index (BMI), waist circumferences, systolic (SBP) and diastolic blood pressure (DBP), glucose, triglycerides, total cholesterol, and high- and low-density lipoproteins).

Results: we observed an association of the DASH-AI score with BMI, WC and DBP in the linear (BMI, β: -0.55, 95 % CI: -0.77, -0.33; WC, β: -1.66, 95 % CI: -2.19, -1.13; DBP, β: -0.65, 95 % CI: -1.07, -0.24), and logistic (BMI > 25 kg/m^2, OR: 0.82, 95 % CI: 0.74, 0.93; elevated WC, OR: 0.72, 95 % CI: 0.64, 0.81; DBP, OR: 0.83, 95 % CI: 0.72, 0 .95) models.

Conclusion: compliance to the DASH-style diet was inversely associated with BMI, WC and DBP in this Mexican population. Promoting adherence to this dietary pattern in the context of Mexican diet is needed to improve cardiovascular health in this population.

Keywords: DASH diet. Cardiovascular risk. Dietary intake. Diet quality. Mexican population.

RESUMEN

Antecedentes: la adherencia al patrón de alimentación DASH ha mostrado ser eficaz para reducir la presión arterial y los marcadores de riesgo cardiovascular en diferentes poblaciones, pero nunca en la mexicana.
Objetivo: evaluar la adherencia al patrón de alimentación DASH mediante un índice adapatado a los lineamientos DASH (DASH-AI) y evaluar su asociación con marcadores de riesgo.
Métodos: análisis transversal de datos de 1490 adultos de entre 20 y 50 años de edad. La ingesta dietética se evaluó utilizando un cuestionario de frecuencia de consumo de alimentos y el sodio a través de la excresión urinaria en 24 horas; la puntuación DASH-AI se calculó de acuerdo con la adherencia a las recomendaciones DASH. Se realizaron modelos logísticos y lineales para estimar la asociación entre el puntaje DASH-AI y los marcadores de riesgo cardiovascular (índice de masa corporal, circunferencia de cintura (CC), presión arterial sistólica (PAS) y diastólica (PAD), glucosa, triglicéridos, colesterol total, lipoproteínas de alta y baja densidad).
Resultados: observamos una asociación del DASH-AI con el IMC, la CC y la PAD en los modelos lineales (IMC β: -0,55, IC del 95 %: -0,77, -0,33; CC β: -1,66, IC del 95 %: -2,19, -1,33; PAD, β: -0,65, IC del 95 %: -1,07, -0,24) y logístico (IMC > 25 kg/m^2, OR: 0,82, IC del 95 %: 0,74, 0,93; CC elevado, OR: 0,72; IC del 95 %: 0,64, 0,81; PAD, OR: 0,83, IC del 95 %: 0,72, 0,95).
Conclusiones: la adherencia a la dieta DASH se asoció inversamente con el IMC, la CC y la PAD en la población estudiada. Es necesario promover la adherencia a este patrón dietético para mejorar la salud cardiovascular.

Palabras clave: Dieta DASH. Riesgo cardiovascular. Ingesta dietética. Calidad de la dieta. Población mexicana.

BACKGROUND

Cardiovascular disease (CVD) is the main cause of death worldwide (1). In 2017, it was calculated that 20.1 % of the Mexican population would die from heart disease (2). Furthermore, its prevalence has increased in the last decades in our country. In 2008, the mortality rate associated with heart disease was estimated at 8.4 per 10,000 individuals, while in 2017 it was reported to be 11.4 per 10,000 individuals (3).

Obesity, impaired fasting glucose, high blood pressure, and dyslipidemia are major risk factors for the development of CVD (4), while a high consumption of saturated fats, sodium, and refined carbohydrates is the main behavioral factor associated with this condition (5). Mexico has experienced important dietary changes over the last decades (6,7) with an increase in consumption of sweetened beverages and saturated fat, and a decrease in intake of fiber, fruits and vegetables (8), as well as excessive dietary sodium intake (9).

There is growing evidence that adherence to certain dietary patterns such as the Mediterranean diet (10,11) or the Dietary Approach to Stop Hypertension (DASH) (12-14) decreases the risk of developing CVD. The DASH dietary pattern was first suggested to prevent and treat hypertension (15,16); it promotes a high consumption of vegetables, fruits, whole grains, skim dairy products, fish, poultry, and seeds, and limits the intake of red meat, sugar, sweetened beverages, total and saturated fat, as well as cholesterol and sodium (17). In adult populations adherence to the DASH-style diet has demonstrated its ability not only to lower blood pressure (18) but also to improve lipid profile (19), glucose (20, 21), insulin resistance (20-22), proinflammatory proteins (23), body mass index (BMI), and waist circumference (24,23). It has also been associated with a reduced incidence of CVD, ischemic heart disease (IHD) and stroke (12-14).

The impact of adherence to the DASH dietary pattern on diverse health outcomes has been evaluated in many populations; however, it has not been well studied among the Mexican population, whose diet is characterized by a diversity of traditional foods and preparation methods that may differ from those observed in the North American population, for which this dietary pattern was initially developed. Thus, the aim of this study was to assess adherence to the DASH dietary pattern by using an adapted DASH adequacy index (DASH-AI), and to evaluate its association with CVD risk markers among Mexican adults living in Mexico City.

MATERIAL AND METHODS

Subjects and study design

This is a sub-analysis of baseline data from participants enrolled in the Tlalpan 2020 cohort, which is an ongoing observational, prospective, longitudinal study of risk factors for hypertension incidence in a Mexico City population aged 20-50 years. This study is being conducted by the National Institute of Cardiology Ignacio Chávez (INCICh, from its acronym in Spanish: Instituto Nacional de Cardiología Ignacio Chávez). Methodology details of the Tlalpan 2020 cohort were published elsewhere (25). Overall, subjects with hypertension, diabetes mellitus, dysthyroidism, cerebrovascular disease, ischemic cardiomyopathy, acute coronary syndrome, active cancer with an effect on survival, cognitive or mental disability, pregnant women, and those taking medications that modify blood pressure were excluded from the cohort. For the purpose of this cross-sectional analysis, participants recruited in the cohort between September 2014 and June 2017 were included. Additionally, subjects who were screened but excluded from the Tlalpan 2020 cohort due to hypertension (SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, n = 88) or diabetes mellitus (DM) (fasting glucose ≥ 126 mg/dL, n = 24) or both (n = 6) were included in this analysis. Subjects with incomplete dietary data (n = 8), extreme energy intake (n = 15) or incomplete urinary samples (n =

541), as described below, were excluded from the analysis. All participants provided their written informed consent to be recruited in the cohort. The study was approved by the Institutional Research and Bioethics Committees of the INCICh (REF:13-802). Clinical assessments and the collection of biologic samples and all data related to this study were conducted at the INCICh.

Anthropometric assessment

Weight, height, and WC assessments were conducted by trained personnel according to the procedures described by The International Society for the Advancement of Kinanthropometry (26). Patients were fasting, shoeless, and wearing a hospital gown. We used a mechanical column scale (SECA 700) with a capacity of 220 kg (0.05-kg precision) to measure weight, and a stadiometer SECA 220 (1-mm precision) to assess height. WC was measured with a measuring tape made of glass fiber (BodyFlex) with a length of 150 cm (1-mm precision). BMI was computed by dividing body weight (kilograms) by the square of the height (squared meters).

Biochemical data

Twelve-hour fasting blood samples were drawn from all participants. Serum levels of glucose, triglycerides (27), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), and low-density lipoprotein cholesterol (LDL-c) were determined by using automated analyzers at the Central Lab of the INCICh.

Twenty-four-hour urinary sodium excretion

Urinary sodium excretion was analyzed as a proxy of sodium intake. Participants were asked to collect a 24 h urine sample the day prior to their baseline visit at the INCICh. They were provided with a preservative-free container and were instructed on the correct form of collecting a urine sample (discard the first urine in the morning and collect all urine for a period of 24 h, including the first void of the day of the visit). Participants were also asked to store the collected urine in a cool place during the collection period. Urinary sodium was determined using the ion selective electrode method, and urinary creatinine was measured by Jaffe's colorimetric assay in automated analyzers. Urine samples were considered as complete when urinary creatinine levels were within the standard creatinine excretion rate interval according to sex (15-25 mg/kg/24 h for men and 10-20 mg/kg/24 h for women) (9).

Dietary information

Dietary information was collected by trained personnel using a semiquantitative food frequency questionnaire (FFQ) previously validated for the Mexican population (28). This FFQ comprises 116 foods and beverages categorized into ten different food groups: 1) Dairy products; 2) Fruits; 3) Eggs, meat, fish, poultry, and processed meat; 4) Vegetables; 5) Legumes; 6) Cereal products; 7) Sweets and candies; 8) Beverages; 9) Oils; and 10) Mexican foods. The FFQ evaluates ten frequencies of consumption of a standardized portion of each food or beverage during one year prior to the interview: never, less than once per month, 1-3 times per month, once per week, 2-4 times per week, 5-6 times per week, once per day, 2-3 times per day, 4-5 times per day, and 6 or more times per day. Energy and daily nutrient intake were estimated by using the software program 'Sistema de Evaluación de Hábitos Nutricionales y Consumo de Nutrimentos' (Evaluation System of Nutritional Habits and Nutrient Consumption) (29), developed by the National Institute of Public Health of Mexico.

Participants with incomplete FFQ or extreme energy intake were excluded from the analysis. FFQ was considered incomplete when there were one or more missing answers. An individual's energy intake was considered as extreme when its value was 3 standard deviations (30) below or above the mean value according to sex. Individuals with an energy intake < 500 kcal/day were also excluded from the analysis.

Other covariates

Other variables such as education level, physical activity, alcohol consumption and tobacco use were also collected during face-to-face interviews conducted by trained research personnel. Education level was documented as the last academic degree held. Physical activity was determined using the long version (7 days) of the “International Physical Activity Questionnaire” (IPAQ) for people aged between 15 and 69 years (31). This questionnaire evaluates three specific characteristics of physical activity: intensity, frequency and duration through questions that consider work-, home-, transportation- and exercise-related activities. Metabolic equivalents (METs, measured as minutes/week) were estimated and physical activity was categorized as low, middle and high according to the IPAQ criteria (31). Current alcohol consumers were all participants who, at the time of the interview, reported to currently consume alcohol regardless of frequency of consumption (daily, every other day, every weekend, every two weeks, once a month, or less than once a month). Current smokers were those persons who reported to have smoked at least 100 cigarettes in their lifetime and that, at the time of the interview, smoked either every day or some days (32).

DASH adequacy index (DASH-AI)

To assess adherence of the diet to the nutrient intake recommendations of the DASH dietary pattern (15), we adapted the DASH adequacy index (DASH-AI) from the work of Gao et al. (33). Gao’s index considers 8 of the 10 DASH nutrient intake recommendations: total fat: ≤ 27 % of total energy per day

(%TE)/day; saturated fatty acids: ≤ 6 %TE/day; proteins: ≥ 18 %TE/day; sodium < 2300 mg/day, potassium: ≥ 4700 mg/day, calcium: ≥ 1250 mg/day, magnesium: ≥ 500 mg/day, and fiber: ≥ 30 g/day. One point is granted to each nutrient if the person reaches the corresponding recommendation, and zero points otherwise. We adapted this index by including the two remaining DASH dietary recommendations for cholesterol (≤ 27 mg/day) and carbohydrates ≤ 55 %TE/day), and considering three levels of compliance instead of two to add flexibility to the scoring system. In our DASH-AI, one point is granted to each dietary factor when its intake complies with the DASH recommendation, 0.5 points if it does not meet the DASH recommendation but is within a range between the DASH recommendation and another recommendation proposed by a health organization, and 0 points if the intake is out of that range. The health organizations considered included: The National Institutes of Health (Adult Treatment Panel III) (4) for proteins, carbohydrates, total fat, and cholesterol; the World Health Organization (34) for saturated fat and potassium; and the Institute of Medicine of United States for calcium (35) and magnesium (36). For dietary sodium, we considered the level of intake at which people with heart failure presented a higher risk for an acute decompensated heart failure event (37). The DASH-AI total score is the sum of the points obtained from the 10 dietary factors. The higher the score of the DASH-AI, the better the diet quality index (Table I).

Outcomes: CVD risk markers

The studied CVD risk markers were BMI, WC, glucose, Tg, TC, HDL-c, and LDL-c. For the purpose of the analysis, they were studied in their continuous and categorical forms, according to the following cutoff points, to be considered elevated or altered: BMI: ≥ 25 kg/m^2; WC: ≥ 90 cm for men and ≥ 80 cm for women (38); glucose: ≥ 100 mg/dL (38); Tg: ≥ 150 mg/dL (4); TC: ≥ 200 mg/dL (4); HDL-c: < 40 mg/dL (4); LDL-c: ≥ 130 mg/dL (4).

Statistical analysis

Descriptive statistics of the study sample were presented as means ± SD, and compared between men and women by using the Student's *t*-test. Categorical variables were described as percentages and compared between men and women by employing the χ^2 test.

Multivariable linear regression analyses were performed to test the linear association between total DASH-AI score and cardiovascular risk markers. A set of two models was computed for each studied outcome, except for BMI and WC. Model 1 was adjusted for relevant covariates for all outcomes: age, sex, physical activity, education level and daily energy intake. Model 2 encompassed all variables included in Model 1 plus other relevant covariates for each outcome. In this fully adjusted model, SBP and DBP were further adjusted for BMI, alcohol consumption and tobacco use; glucose, total cholesterol, HDL-c and LDL-c were further adjusted for BMI; and Tg for BMI and alcohol consumption. Model 1 was considered as the fully adjusted model for BMI and WC. Regression coefficients (β) and 95 % confidence intervals (CI) were estimated for the association between the DASH-AI score and each CVD risk marker. Additionally, multivariable logistic analyses were performed to estimate adjusted odds ratio (OR) and 95 % CI of having altered values of the studied CVD risk markers. A set of two models was computed for each studied outcome, except for BMI and WC as described above.

A *p*-value < 0.05 was considered statistically significant for all analyses. All statistical analyses and data processing were performed using STATA, version 14 (Stata Corp., College Station, TX, USA) for Mac (39).

RESULTS

Overall, 1490 participants were included in the analysis, of which 505 (33.9 %) were men. Table II shows the general characteristics of the study sample by sex. Men were younger than women, and there was a higher proportion of participants with a post-secondary education or higher, tobacco use and alcohol consumption, as well as a higher calorie intake among men. We observed no significant differences in the categories of physical activity or total DASH-AI between sexes.

Table III shows the anthropometric, clinical, and biochemical characteristics of the study sample. Mean WC, SBP and DBP were significantly higher among men when compared to women. Biochemical indicators also showed mean values significantly higher among men compared to women, except for HDL-c, which was higher in women.

Mean 24-h urinary sodium excretion in the overall study sample was 3119.5 ± 1280.9 mg/24 h, and it was significantly higher in men as compared to women.

Figure 1 shows the proportion of participants that scored 0, 0.5 or 1 point for each dietary factor included in the DASH-AI. More than half of the studied sample did not score any points for intake of proteins (64.6 %), total lipids (53.7 %), saturated fatty acids (57.6 %), cholesterol (70.3 %), calcium (69.5 %), potassium (73.0 %) and sodium (54.1 %). Carbohydrate intake was the DASH-AI component with the highest degree of adherence to DASH dietary recommendations, showing the largest proportion of participants achieving one point within the DASH-AI (79.3 %); the opposite was observed for saturated fatty acids, with the lowest proportion of participants achieving one point (1.5 %).

Table IV shows the multivariable association (β and 95 % CI) between the DASH-AI score and each of the studied cardiovascular risk markers. For every one-unit increase in the DASH-AI score, BMI significantly decreased 0.55 units, WC 1.66 cm, SBP 0.54 and DBP 0.65 mmHg after adjustment for sex, age, physical activity, education level, and energy intake (Model 1). No significant associations were observed in the fully adjusted models; however, DBP exhibited a trend towards a 0.35-mmHg decrease per one unit increase in the DASH-AI score.

Table V shows the multivariable-adjusted ORs (95 % CI) for the association between each cardiovascular risk marker and the DASH-AI score. The risk of having BMI ≥ 25 kg/m^2, WC ≥ 90 cm in men and ≥ 80 cm in women, DBP ≥ 80 mmHg, and HDL-c < 40 mg/dL decreases by 18 %, 28 %, 17 %, and 13 % per each unit increase in the DASH-AI score, respectively, in Model 1. We observed no significant association in the fully adjusted models for SBP, DBP and biochemical parameters.

DISCUSSION

In this study conducted in an adult population living in Mexico City we found an inverse association of the DASH-AI score with BMI, WC, and DBP. We also reported an overall low adherence to DASH dietary recommendations, with a mean DASH-AI score in this studied sample of 3.3 ± 1.2 points from a total of 10 points, with potassium being the dietary component of the DASH-AI with the highest proportion of participants with no adherence. To our knowledge, this is the first study that evaluates adherence to the DASH dietary pattern through a score based on its nutrient intake goals and its association with cardiovascular risk markers in an adult Mexican population.

Other studies have also reported low adherence to the DASH dietary pattern. Lemon et al. (40) found a low percentage of individuals who adhered to the DASH nutrient intake recommendations for potassium (3.1 %), calcium (11.6 %), magnesium (2.5 %) and fiber (3.8 %) in an adult population from the United States. In our study, we observed a low adherence to the DASH nutrient intake recommendations for potassium (4.3 %), magnesium (4.8 %), calcium (4.2 %), saturated fatty acids (1.9 %), total lipids (6.2 %) and proteins (8.3 %). Gao et al. (33), in a study conducted in the United States, observed that Hispanics were less likely to adhere to the calcium recommendation (OR: 0.79, 95 % CI: 0.68 to 0.91) when compared to white, Chinese, and African participants, but more likely to comply with the fiber recommendation (OR: 2.23, 95 % CI: 1.53 to 3.23) when compared to other ethnicities. In our study, we found that 33.1 % of the studied population adhered to the fiber recommendation.

The DASH dietary pattern promotes a high consumption of vegetables, fruits, whole grains, skim dairy products, fish, poultry and seeds, and limits the intake of red meat, sugar, sweetened beverages, total and saturated fat, cholesterol and sodium (17). Low adherence to the DASH dietary pattern may be related to its strict nutrient intake daily goals (15); for instance, the DASH recommendation for potassium is 4700 mg/day, while the WHO recommendation for this nutrient is 3510 mg/day (41); similarly, the recommendation for calcium consumption proposed by DASH is 1250 mg/d, while the US Institute of Medicine recommends an intake of 800 mg/day (35). In addition, the low adherence to the DASH nutrient intake recommendations may reflect the lack of a regional-specific adaptation of these dietary guidelines that includes local foods to achieve the DASH nutrient intake goals.

In this sense, a recent study in Mexican women evaluated the association between the DASH dietary pattern, among others, and anthropometric measures (42). The DASH score used was based on 8 food components rather than the DASH daily nutrient intake goals as in our study. After adjustment for age, education, center, energy intake, and physical activity, no significant association between the DASH score and anthropometric measures was observed (42). In our study, which included women and men, we found an adjusted negative association of the DASH-AI score with BMI, WC, SBP and DBP, controlling for sex, age, physical activity, education level and energy intake; also, we observed an adjusted 17 % decreased risk of having elevated DBP (≥ 80 mmHg) per one-point increase in the DASH-AI score when adjusting for the same covariates, supporting the blood pressure lowering effects of this dietary pattern, although this association was attenuated when BMI, alcohol consumption, and tobacco use were also included in the model. Differences in the results of these two studies might be related to the fact that the first one used an index based on food components of the DASH dietary patterns while we used an index based on the DASH daily nutrient goals. Thus, we considered nutrients instead of the foods endorsed by the DASH diet, and this might have helped take into consideration local foods during the assessment of adherence to the DASH dietary pattern. This points out the need for a local adaptation of this a priori-defined dietary pattern.

Other studies that evaluated adherence to the DASH diet using scores based on daily nutrient intake goals have reported similar results to those observed in our study. Saneei et al. (43) informed that the adherence to this dietary pattern significantly decreased the risk of having a WC greater than 80 cm (OR: 0.32; 95 % CI: 0.10, 0.68) and blood pressure greater than 130/85 mm Hg (OR: 0.20; 95 % CI: 0.09, 0.67) in adult women from Iran. Staffileno et al. (44) also found that a lower compliance with the DASH nutrient intake recommendations increased the probability of presenting blood pressure ≥ 140/90 mm Hg by 37 % (OR: 1.37; 95 % CI: 1.06, 1.77) in a Latino population living in the United States.

In this study, we adapted the index proposed by Gao et al. (33) by including the DASH recommendation for carbohydrates and cholesterol, and considering three levels of adherence to each dietary factor (full adherence: 1 point; intermediate adherence: 0.5 points; and no adherence at all: 0 points) in order to allow more flexibility for the scoring system. We opted for using an index based on the DASH nutrient intake goals rather than the DASH food components under the premise that the DASH nutrient intake goals may be assessed worldwide regardless of local dietary patterns, while the food intake and meal plan proposed by the DASH dietary pattern may not suit local food availability, and thus mislead the assessment of adherence to the DASH dietary pattern in populations such as the Mexican one. Additionally, it has been reported that the DASH diet foods tend to be less available among patients with a low socioeconomic status (45). Mackenbach et al. (46) studied the association between complying with the DASH food groups and socioeconomic level; the authors found that persons with a lower socioeconomic status were less likely to comply with the DASH food group recommendations when compared to those with a higher socioeconomic status (OR: 0.59; 95 % CI: 0.52 to 0.68) (45).

This study has some limitations that should be considered. Firstly, the cross-sectional design does not allow establishing causality between adherence to the DASH dietary pattern and cardiovascular risk markers. However, the FFQ used in this study collects information on dietary intake over the last year, which makes it possible to assess exposure to food during this period. Secondly, the FFQ does not include the consumption of certain foods such as fast food (hamburgers and hot dogs), skim milk, and oilseeds. These foods could be relevant in the assessment of adherence to the DASH diet. However, this study has the strength of having estimated sodium consumption through its excretion in 24-hour urine. Finally, the study population was composed of volunteers living in Mexico City who enrolled in a cohort study, and those excluded due to hypertension and/or diabetes, thus the results obtained in this study may not be extrapolated to the general Mexican population. Also, participants identified as having hypertension and/or diabetes were not aware of their having these conditions, thus they had not changed their diet based on this finding at the time of assessments.

CONCLUSION

The results of this study showed an association of BMI, WC, and DBP with adherence to the DASH dietary pattern as measured by an index based on the DASH nutrient intake goals (DASH-AI). We also observed an overall low adherence to DASH dietary recommendations, with the lowest rates of adherence observed for calcium, magnesium, potassium, and total fat. This study highlights the urgency there is to develop evidence-based dietary guidelines for the Mexican population aiming to reduce cardiovascular risk in our population.

REFERENCES

1. World Health Organization (WHO). World health statistics 2018: monitoring health for the SDGs, sustainable development goals. Geneva: WHO; 2018.
2. Principales causas de muerte 2017 [Internet]; 2018 [cited 03 de abril de 2019]. Available from: http://www.beta.inegi.org.mx/contenidos/saladeprensa/boletines/2018/EstSociodemo/DEFUNCIONES2017.pdf.
3. Instituto Nacional de Estadistica y Geografia. Características de las defunciones registradas en méxico durante 2017. México: INEGI; 2018.
4. National Heart Lung and Blood Institute. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). National Institutes of Health; 2002. Report No.: 02-5215.
5. Eilat-Adar S, Sinai T, Yosefy C. Nutritional recommendations for cardiovascular disease prevention. Nutrients 2013;5(9):3646-83. DOI: 10.3390/nu5093646
6. Popkin BM. The nutrition transition: an overview of world patterns of change. Nutr Rev 2004;62(7 Pt 2):S140-3. DOI: 10.1111/j.1753-4887.2004.tb00084.x
7. Moreno-Altamirano L, Hernandez-Montoya D, Silberman M, Capraro S, García-García JJ, Soto-Estrada G, et al. The nutrition transition and the double burden of malnutrition: changes in dietary patterns 1961-2009 in the Mexican socioeconomic context. Arch Latinoam Nutr 2014;64(4):231-40.

8. Instituto Nacional de Salud Pública. Enuesta Nacional de Salud y Nutrición 2016 Medio Camino. (ENSANUT MC 2016). Cuernavaca, Morelos; 2017.
9. Vallejo M, Colin-Ramirez E, Rivera Mancía S, Cartas Rosado R, Madero M, Infante Vázquez O, et al. Assessment of Sodium and Potassium Intake by 24 h Urinary Excretion in a Healthy Mexican Cohort. Arch Med Res 2017;48(2):195-202. DOI: 10.1016/j.arcmed.2017.03.012
10. Sofi F, Abbate R, Gensini GF, Casini A. Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. Am J Clin Nutr 2010;92(5):1189-96. DOI: 10.3945/ajcn.2010.29673
11. Martinez-Gonzalez MA, Gea A, Ruiz-Canela M. The Mediterranean Diet and Cardiovascular Health. Circ Res 2019;124(5):779-98. DOI: 10.1161/CIRCRESAHA.118.313348
12. Folsom AR, Parker ED, Harnack LJ. Degree of concordance with DASH diet guidelines and incidence of hypertension and fatal cardiovascular disease. Am J Hypertens 2007;20(3):225-32. DOI: 10.1016/j.amjhyper.2006.09.003
13. Struijk EA, May AM, Wezenbeek NL, Fransen HP, Soedamah-Muthu SS, Geelen A, et al. Adherence to dietary guidelines and cardiovascular disease risk in the EPIC-NL cohort. Int J Cardiol 2014;176(2):354-9. DOI: 10.1016/j.ijcard.2014.07.017
14. Larsson SC, Wallin A, Wolk A. Dietary Approaches to Stop Hypertension Diet and Incidence of Stroke: Results From 2 Prospective Cohorts. Stroke 2016;47(4):986-90.
15. National Heart Lung and Blood Institute. Your Guide to Lowering Your Blood Pressure with DASH. Bethesada, MD: National Heart, Lung, and Blood Institute; 2006. Contract No.: 06-4082.

16. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sachs FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. N Engl J Med 1997;336(16):1117-24. DOI: 10.1056/NEJM199704173361601
17. Sacks FM, Obarzanek E, Windhauser MM, Svetkey LP, Vollmer WM, McCullough M, et al. Rationale and design of the Dietary Approaches to Stop Hypertension trial (DASH). A multicenter controlled-feeding study of dietary patterns to lower blood pressure. Ann Epidemiol 1995;5(2):108-18. DOI: 10.1016/1047-2797(94)00055-x
18. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med 2001;344(1):3-10. DOI: 10.1056/NEJM200101043440101
19. Siervo M, Lara J, Chowdhury S, Ashor A, Oggioni C, Mathers JC. Effects of the Dietary Approach to Stop Hypertension (DASH) diet on cardiovascular risk factors: a systematic review and meta-analysis. Br J Nutr 2015;113(1):1-15. DOI: 10.1017/S0007114514003341
20. Shirani F, Salehi-Abargouei A, Azadbakht L. Effects of Dietary Approaches to Stop Hypertension (DASH) diet on some risk for developing type 2 diabetes: a systematic review and meta-analysis on controlled clinical trials. Nutrition 2013;29(7-8):939-47. DOI: 10.1016/j.nut.2012.12.021
21. Jacobs S, Boushey CJ, Franke AA, Shvetsov YB, Monroe KR, Haiman CA, et al. A priori-defined diet quality indices, biomarkers and risk for type 2 diabetes in five ethnic groups: the Multiethnic Cohort. Br J Nutr 2017;118(4):312-20. DOI: 10.1017/S0007114517002033
22. Esfandiari S, Bahadoran Z, Mirmiran P, Tohidi M, Azizi F. Adherence to the dietary approaches to stop hypertension trial (DASH)

diet is inversely associated with incidence of insulin resistance in adults: the Tehran lipid and glucose study. J Clin Biochem Nutr 2017;61(2):123-9. DOI: 10.3164/jcbn.16-95

23. Asemi Z, Samimi M, Tabassi Z, Sabisi S-S, Esmaillzadeh A. A randomized controlled clinical trial investigating the effect of DASH diet on insulin resistance, inflammation, and oxidative stress in gestational diabetes. Nutrition 2013;29(4):619-24. DOI: 10.1016/j.nut.2012.11.020

24. Bhupathiraju SN, Tobias DK, Malik VS, Pan A, Hruby A, Manson JE, et al. Glycemic index, glycemic load, and risk of type 2 diabetes: results from 3 large US cohorts and an updated meta-analysis. Am J Clin Nutr 2014;100(1):218-32. DOI: 10.3945/ajcn.113.079533

25. Colin-Ramirez E, Rivera-Mancia S, Infante-Vazquez O, Cartas-Rosado R, Vargas-Barrón J, Madero M, et al. Protocol for a prospective longitudinal study of risk factors for hypertension incidence in a Mexico City population: the Tlalpan 2020 cohort. BMJ Open 2017;7(7):e016773. DOI: 10.1136/bmjopen-2017-016773

26. The International Society for the Advancement of Kinanthropometry (ISAK). International standards for anthropometric assessment. Australia; 2001.

27. Montgomery KS. Soy protein. J Perinat Educ 2003;12(3):42-5. DOI: 10.1624/105812403X106946

28. Hernandez-Avila M, Romieu I, Parra S, Hernández Ávila J, Madrigal H, Willett W. Validity and reproducibility of a food frequency questionnaire to assess dietary intake of women living in Mexico City. Salud Publica Mex 1998;40(2):133-40. DOI: 10.1590/s0036-36341998000200005

29. Hernández-Avila M, Resoles M, Parra S. SNUT Sistema de Evaluacion de Hábitos Nutricionales y Consumo de Nutrimentos. Cuernavaca, México: Instituto Nacional de Salud Pública; 2003.

30. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. Journal of the J Am Coll Cardiol 2017;70(1):1-25. DOI: 10.1016/j.jacc.2017.04.052
31. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35(8):1381-95. DOI: 10.1249/01.MSS.0000078924.61453.FB
32. Odani S, Armour BS, Graffunder CM, Willis G, Hartman AM, Agaku IT. State-Specific Prevalence of Tobacco Product Use Among Adults - United States, 2014-2015. MMWR Morb Mortal Wkly Rep 2018;67(3):97-102. DOI: 10.15585/mmwr.mm6703a3
33. Gao SK, Fitzpatrick AL, Psaty B, Jiang R, Post W, Cutler J, et al. Suboptimal nutritional intake for hypertension control in 4 ethnic groups. Arch Intern Med. 2009 Apr 13;169(7):702-7. DOI: 10.1001/archinternmed.2009.17
34. World Health Organization. Prevención de las enfermedades cardiovasculares. Directrices para la evaluación y el manejo del riesgo cardiovascular. Geneve: WHO/FAO; 2010.
35. Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium. Dietary Reference Intakes for Adequacy: Calcium and Vitamin D. Washington (DC): National Academy Press; 2011.
36. Institute of Medicine (US) Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington (DC): National Academy Press; 1997.
37. Arcand J, Ivanov J, Sasson A, Floras V, Al-Hesayen A, Azevedo ER, et al. A high-sodium diet is associated with acute decompensated heart

failure in ambulatory heart failure patients: a prospective follow-up study. Am J Clin Nutr 2011;93(2):332-7. DOI: 10.3945/ajcn.110.000174

38. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120(16):1640-5. DOI: 10.1161/CIRCULATIONAHA.109.192644

39. Stata Statistical Software: Release 14. College Station TSL. StataCorp; 2015.

40. Lemon SC, Olendzki B, Magner R, Li W, Culver AL, Ockene I, et al. The dietary quality of persons with heart failure in NHANES 1999-2006. J Gen Intern Med 2010;25(2):135-40. DOI: 10.1007/s11606-009-1139-x

41. World Health Organization. Guideline: Potassium intake for adults and children. Gèneve: WHO; 2012.

42. Sahrai MS, Huybrechts I, Biessy C, Gunter MJ, Romieu I, Torres-Mejía G, et al. Association of a Priori-Defined Dietary Patterns with Anthropometric Measurements: A Cross-Sectional Study in Mexican Women. Nutrients 2019;11(3):603. DOI: 10.3390/nu11030603

43. Saneei P, Fallahi E, Barak F, Ghasemifard N, Keshteli AH, Yazdannik AR, et al. Adherence to the DASH diet and prevalence of the metabolic syndrome among Iranian women. Eur J Nutr 2015;54(3):421-8. DOI: 10.1007/s00394-014-0723-y

44. Staffileno BA, Tangney CC, Wilbur J, Márquez DX, Fogg L, Manning A, et al. Dietary approaches to stop hypertension patterns in older Latinos with or at risk for hypertension. J Cardiovasc Nurs 2013;28(4):338-47. DOI: 10.1097/JCN.0b013e3182563892

45. Young CM, Batch BC, Svetkey LP. Effect of socioeconomic status on food availability and cost of the Dietary Approaches to Stop Hypertension (DASH) dietary pattern. J Clin Hypertens (Greenwich) 2008;10(8):603-11. DOI: 10.1111/j.1751-7176.2008.08199.x
46. 46. Mackenbach JD, Burgoine T, Lakerveld J, et al. Accessibility and Affordability of Supermarkets: Associations With the DASH Diet. American journal of preventive medicine. 2017;53(1):55-62.

Table I. DASH adequacy index (DASH-AI)

Nutrient	Score		
	1 point	0.5 points	0 points
Protein (%TE/day)	≥ 18	17.9 to 15	< 15
Carbohydrates (%TE/day)	≤ 55	55.1 to 60	> 60
Total fat (%TE/day)	≤ 27	27.1 to 35	> 35
Saturated fatty acids (SFA) (%ET/day)	≤ 6	6.1 to 10	> 10
Cholesterol (mg/day)	≤ 150	150.1 to 200	> 200
Fiber (g/day)	≥ 30	29.9 to 20	< 20
Calcium (mg/day)	≥ 1250	1249.9 to 800	< 800
Magnesium (mg/day)	≥ 500	499.9 to 320	< 320
Potassium (mg/day)	≥ 4700	4699.9 to 3510	< 3510
Sodium (mg/day)*	≤ 2300	2300.1 to 2800	> 2800

%TE/day: percentages of total energy per day; SFA: saturated fatty acids.

*Determined by 24 h urinary sodium excretion.

Table II. General characteristics of the studied sample

	Total (n = 1490)	Men (n = 505)	Women (n = 985)	p
	Mean ± SD	Mean ± SD	Mean ± SD	
Age, yrs*	37.9 ± 8.9	37.2 ± 8.9	38.4 ± 8.8	0.012
Education level (%)†				
< High school	16.6	17.2	16.2	0.045
High school	36.3	31.9	50.9	
≥ Post-secondary education	47.2	50.9	45.3	
Current tobacco use (%)†	38.4	51.1	31.9	< 0.001
Energy intake (kcal)*	2198 ± 627	2395 ± 673	2097 ± 577	< 0.001
Current alcohol consumption (%)†	70.9	80	66.3	< 0.001
Physical activity category (%)†				
Low	47.7	46	48.5	0.697
Moderate	14.6	15	14.4	
High	37.6	39	37.1	
Total DASH-AI score*	3.3 ± 1.2	3.3 ± 1.2	3.4 ± 1.2	0.157

DASH-AI: DASH adequacy index. *Student's t-test to compare continuous variables between men and women. †χ^2 test to compare categorical variables between men and women.

Table III. Anthropometric, clinical, and biochemical characteristics of the studied population grouped by sex*

	Total (n = 1490)	Men (n = 505)	Women (n = 985)	
	Mean ± SD	Mean ± SD	Mean ± SD	p
BMI (kg/m^2)	27.2 ± 4.5	27.4 ± 4.4	27.0 ± 4.6	0.097
WC (cm)	90.5 ± 11.7	94.6 ± 11.5	88.3 ± 11.2	< 0.001
SBP (mmHg)	107.6 ± 12.3	112.5 ± 12.6	105.2 ± 11.4	< 0.001
DBP (mmHg)	72.3 ± 9.3	75.5 ± 9.3	70.6 ± 8.8	< 0.001
Glucose (mg/dL)	92.8 ± 11.2	94.6 ± 10.7	91.7 ± 11.3	< 0.001
Total cholesterol (mg/dL)	186.6 ± 34.7	189.5 ± 37.9	185.1 ± 32.8	0.018
HDL-c (mg/dL)	48.9 ± 12.8	42.8 ± 9.87	52.0 ± 13.0	< 0.001
LDL-c (mg/dL)	122.4 ± 30.9	127.3 ± 33.2	119.9 ± 29.4	< 0.001
Tg (mg/dL)	144.6 ± 96.9	176.5 ± 132.9	128.2 ± 66.3	< 0.001
Urinary sodium (mg/24 h)	3119.5 ± 1280.9	3675.5 ± 1424.2	2834.4 ± 1097.3	< 0.001

BMI: body mass index (kg/m^2); WC: waist circumference (cm); SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL-c: high-density lipoprotein cholesterol; LDL-c: low-density lipoprotein cholesterol; Tg: triglycerides. *t-test for comparison between men and women.

Table IV. Linear association (β (95 % CI)) between the DASH-AI score and cardiovascular risk markers

Cardiovascular risk markers	Model 1			Model 2		
	β	95 % CI	p	β	95 % CI	p
BMI (kg/m^2)	*-0.55*	*-0.77, -0.33*	*< 0.001*		-	
WC (cm)	*-1.66*	*-2.19, -1.13*	*< 0.001*		-	
SBP (mm Hg)	*-0.54*	*-1.08, -0.01*	*0.047*	-0.09	-0.62, 0.42	0.712
DBP (mm Hg)	*-0.65*	*-1.07, -0.24*	*0.002*	-0.35	-0.75, 0.05	0.090
Glucose (mg/dL)	0.41	-0.95, 0.13	0.134	-0.04	-0.56, 0.49	0.894
Total cholesterol (mg/dL)	-0.12	-1.76, 1.52	0.886	-0.01	-1.64, 1.67	0.989
HDL-c (mg/dL)	-0.52	-0.85, 1.12	0.092	-0.02	-0.56, 0.59	0.959
LDL-c (mg/dL)	-0.15	-1.62, 1.32	0.841	0.18	-1.29, 1.66	0.809
Tg (mg/dL)	-2.36	-6.99, 2.28	0.319	0.25	-4.35, 4.85	0.916

BMI: body mass index (kg/m^2); WC: waist circumferences (cm); SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL-c: high-density lipoprotein cholesterol; LDL-c: low-density lipoprotein cholesterol; Tg: triglycerides. Model 1: adjusted for sex, age, physical activity, education level and energy intake. Model 2 for SBP and DBP: variables included in Model 1 plus BMI, alcohol consumption and tobacco use. Model 2 for glucose, total cholesterol, HDL-c and LDL-c: variables included in Model 1 plus BMI. Model 2 for Tg: variables included in Model 1 plus BMI and alcohol consumption.

Table V. Logistic regression analysis for the association between DASH-AI score and cardiovascular risk markers

Cardiovascular risk markers	Model 1			Model 2		
	OR	95 % CI	p	OR	95 % CI	p
BMI > 25 (kg/m^2)	*0.82*	*0.74, 0.93*	*0.006*			
WC ≥ 80 cm women ≥ 90 cm men	*0.72*	*0.64, 0.81*	*< 0.001*			
SBP ≥ 120 mm Hg	0.94	0.80, 1.09	0.424	1.03	0.87, 1.22	0.699
DBP ≥ 80 mm Hg	*0.83*	*0.72, 0.95*	*0.008*	0.88	0.77, 1.02	0.103
Glucose ≥ 100 mg/dL	0.94	0.82, 1.08	0.359	1.03	0.89, 1.20	0.690
Cholesterol ≥ 200 mg/dL	0.99	0.88, 1.11	0.802	0.99	0.88, 1.11	0.859
HDL-c < 40 mg/dL	*0.87*	*0.76, 0.98*	*0.026*	0.93	0.82, 1.06	0.303
LDL-c ≥ 130 mg/dL	1.01	0.91, 1.13	0.848	1.03	0.92, 1.15	0.571
Tg ≥ 150 mg/dL	0.93	0.83, 1.04	0.202	0.98	0.87, 1.09	0.712

BMI: body mass index (kg/m^2); WC: waist circumferences (cm); SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL-c: high-density lipoprotein cholesterol; LDL-c: low-density lipoprotein cholesterol; Tg: triglycerides. Model 1: adjusted for sex, age, physical activity, education level and energy intake. Model 2 for SBP and DBP: variables included in Model 1 plus BMI, alcohol consumption and tobacco use. Model 2 for glucose, total cholesterol, HDL-c and LDL-c: variables included in Model 1 plus BMI. Model 2 for Tg: variables included in Model 1 plus BMI and alcohol consumption.

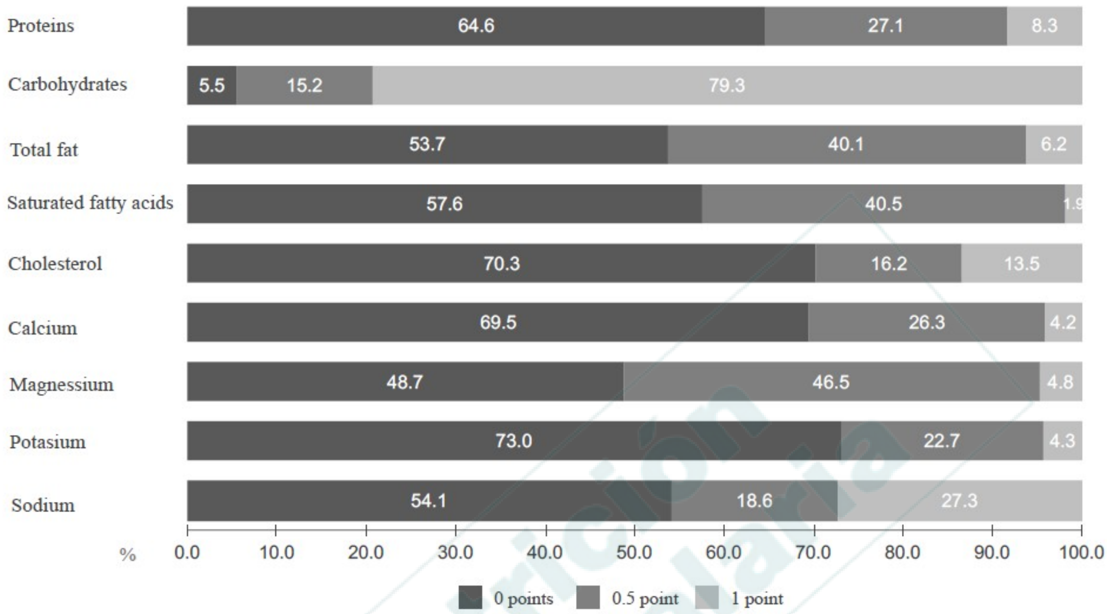

Fig. 1. Percentage of subjects in each DASH-AI score.