Instituto Nacional de Salud Pública

Trabajo de Tesis titulado

Patrones dietarios y riesgo de enfermedad cardiovascular en población adulta mexicana: comparación de dos métodos de dieta.

Doctorado en Ciencias en Nutrición Poblacional

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I. Introducción

La enfermedad cardiovascular (ECV) es una causa importante de discapacidad y muerte prematura en todo el mundo (1). En México, la ECV es un problema de salud pública trascendental y la principal causa de mortalidad en población adulta (2).

La dieta es un determinante significativo de la enfermedad cardiovascular (3). Múltiples estudios epidemiológicos se han enfocado primordialmente en el efecto individual de varios nutrimentos o alimentos como factores de riesgo para ECV. Otros por su parte han demostrado que dietas ricas en ácidos grasos (n-3), frutas, verduras y cereales integrales reducen el riesgo de ECV (4-7).

Sin embargo, la evaluación dietética de un solo alimento o nutrimento puede estar confundida por el efecto de un patrón dietario en particular, porque las personas comen alimentos o grupos de alimentos que pueden representar el efecto combinado o la interacción de múltiples nutrimentos (8, 9). Por tanto, para capturar el efecto de la dieta completa, la evaluación de patrones dietarios se ha vuelto cada vez más popular como un método alternativo o complementario en epidemiología nutricional (10, 11). Este enfoque incorpora todos los alimentos e interacciones de los nutrimentos en la dieta y permite identificar las relaciones entre la dieta completa y la enfermedad (12, 13). Además, los patrones dietarios reflejan el consumo real, su análisis puede proporcionar información relevante sobre los cambios necesarios en la dieta y también puede ayudar a facilitar la traducción de los hallazgos en recomendaciones de salud pública (10, 11).

Dentro de los estudios que han adoptado este enfoque, han definido los patrones dietarios primordialmente a partir de cuestionarios de frecuencia de consumo de alimentos, aunque algunos pocos han empleado datos dietéticos derivados de recordatorios de 24 horas. Respecto al método estadístico empleado para la extracción de patrones dietarios se han utilizado diferentes abordajes metodológicos como el análisis factorial, el análisis por conglomerados, dos de las metodologías más utilizadas, y más recientemente, el análisis de regresión de rangos reducidos (8, 11, 14).

En general, estudios en varias poblaciones sugieren la presencia de dos a cinco grandes patrones dietarios: siendo recurrentes el patrón “saludable o prudente”, y el patrón “no saludable u occidentalizado". El patrón occidentalizado ha sido caracterizado por un alto consumo de cereales refinados, carnes rojas, alimentos industrializados, bebidas azucaradas, carnes procesadas, mantequilla y papas. Mientras que el patrón prudente se ha caracterizado por un alto consumo de frutas, verduras, cereales integrales, leguminosas, lácteos bajos en grasa, y pescado (15-18).

Estudios epidemiológicos realizados en países europeos, asiáticos y en Estados Unidos de Norteamérica, han evaluado la relación entre los patrones dietarios y la enfermedad cardiovascular (15-18). Sin embargo, en México, no existen estudios que evalúen la asociación entre los patrones dietarios y el riesgo de enfermedad cardiovascular.

Algunos estudios epidemiológicos han demostrado que el uso de análisis factorial es una herramienta útil para identificar patrones dietarios (8, 19). Además, se ha observado que la implementación de esta aproximación metodológica puede resultar en patrones dietarios interpretables y representativos de la población de estudio. A pesar de ello, probable que los patrones dietarios cambien a través de distintas poblaciones, lo que hace necesario determinar la validez del cuestionario de frecuencia de consumo de alimentos para derivar patrones dietarios (19). En este sentido, pocos estudios de validación sugieren la validez de los patrones dietarios identificados mediante análisis factorial usando datos dietéticos recolectados mediante un cuestionario de frecuencia de consumo de alimentos (8, 19-22). Sin embargo, en México carecemos de estudios de validación que indiquen que los patrones dietarios derivados mediante análisis factorial usando datos recolectados mediante frecuencia de consumo de alimentos son válidos para nuestra población.

Por lo tanto, el presente trabajo de investigación tuvo como objetivos: examinar la validez de los patrones dietarios derivados mediante análisis factorial usando datos dietéticos recolectados mediante cuestionario de frecuencia de consumo de alimentos; y evaluar la asociación entre los patrones dietarios, y el riesgo de enfermedad cardiovascular en adultos Mexicanos.

En el presente documento se incluyen dos artículos que responden a los objetivos arriba mencionados. Dichos artículos se titulan:

1. Validity of dietary patterns among adult Mexican population assessed by a food frequency questionnaire.
2. Association between dietary patterns and cardiovascular disease risk in an urban Mexican adult population.

Por último, dicho trabajo de investigación incluye el resumen y las conclusiones generales del estudio. Cabe indicar que los artículos contenidos en el documento se encuentran redactados en inglés dado que así serán sometidos para su publicación.

II. Resumen

Introducción. La enfermedad cardiovascular (ECV) es un problema de salud pública importante en el mundo. En México, es la principal causa de mortalidad en adultos. Múltiples estudios epidemiológicos sugieren que la dieta es un determinante importante de la ocurrencia de la ECV. Tradicionalmente, la investigación sobre el riesgo de ECV se ha enfocado primordialmente en el análisis de componentes dietéticos específicos (nutrimentos, alimentos, bebidas, entre otros). Sin embargo, estos componentes individuales solo explican parte de la relación de la dieta y la ECV. Por ello, en las últimas dos décadas, el análisis de patrones dietarios (principalmente el análisis factorial) se ha convertido en una herramienta útil en epidemiología nutricional. Sugiriéndose a estrategia metodológica como alternativa para evaluar las relaciones dieta-enfermedad.

Objetivos. Examinar la validez de los patrones dietarios derivados mediante análisis factorial usando datos dietéticos recolectados mediante cuestionario de frecuencia de consumo de alimentos; y evaluar la asociación entre los patrones dietarios, y el riesgo de enfermedad cardiovascular en adultos Mexicanos.

Métodos. Para el presente trabajo de investigación se utilizaron datos de dos estudios originales distintos, dependiendo del objetivo. Para el artículo titulado: "Validity of dietary patterns among adult Mexican population assessed by a food frequency questionnaire," que cumple con el primer objetivo; se utilizó información proveniente de una submuestra de 264 sujetos adultos (> 20 años) que participaron en el estudio de validación dietética de la Encuesta Nacional de Salud y Nutrición 2012 (ENSANUT-2012). En este estudio, se aplicó un cuestionario semi-cuantitativo de frecuencia de consumo de alimentos (FFQ, por sus siglas en inglés), de 140 reactivos, y 2 recordatorios de 24 horas (24-DR, por sus siglas en inglés) siguiendo el método automatizado de pasos múltiples (AMPM, por sus siglas en inglés). Usando información del consumo de alimentos y bebidas del FFQ y los 24-DRs, se generaron 29 grupos de alimentos en base al perfil de nutrimentos, la frecuencia de consumo y el uso culinario. Para derivar los patrones dietarios se utilizó análisis factorial (análisis de componentes principales) con rotación varimax. Finalmente, para determinar la validez de los patrones dietarios identificados mediante datos dietéticos de dos

métodos diferentes (FFQ vs 24-DR) se calcularon coeficientes de correlación de Spearman. Para el artículo titulado: "Association between dietary patterns and cardiovascular disease risk in an urban Mexican adult population," que responde al segundo objetivo; se utilizaron datos de la Cohorte de Trabajadores de la Salud. La Cohorte de Trabajadores de la Salud, es un estudio prospectivo que tiene como principal objetivo evaluar la relación entre el estilo de vida y múltiples desenlaces en salud. Dicho trabajo de investigación se inició en 2004 e incluye sujetos de 3 instituciones académicas y de salud distintas. De los 1,855 sujetos que participaron en la segunda medición de la Cohorte, solo 1,196 (> 20 años) fueron incluidos para el presente análisis. Se obtuvo información dietética utilizando un FFQ (116 alimentos) previamente validado para población adulta mexicana. Se realizaron mediciones antropométricas y bioquímicas utilizando procedimientos estandarizados. El riesgo de enfermedad cardiovascular a 10 años se calculó mediante los algoritmos de Framingham (recalibrados por D'Agostino para distintas poblaciones), considerándose como en riesgo de enfermedad cardiovascular a aquellos sujetos que tuvieron más del 10% de probabilidad en 10 años. Para derivar los patrones dietarios se utilizó análisis factorial (análisis de componentes principales) con rotación varimax. Por último, para evaluar la asociación entre los patrones dietarios y el riesgo de enfermedad cardiovascular se calcularon riesgos relativos utilizando análisis de regresión logística múltiple, que se aproxima a los riesgos proporcionales de Cox cuando un evento es raro.

Resultados. Nuestros hallazgos sugieren la existencia al menos de 3 patrones dietarios en población adulta mexicana en ambos análisis. Uno de los patrones dietarios, al que podríamos considerar para efectos de esta sección del documento como "patrón prudente", caracterizado de manera general por un alto consumo de frutas, verduras y granos integrales, un segundo patrón, al que para efectos de esta sección del documento podríamos etiquetar como "patrón occidentalizado", que mostró relación con altos consumos de cereales refinados, carnes procesadas, y bebidas azucaradas, y un tercer patrón menos consistente al comparar ambos análisis. Los coeficientes de correlación de Spearman sugieren una validez razonable de los patrones dietarios derivados mediante el FFQ ("patrón occidentalizado", $r = 0.66$, $P < 0.001$; "patrón prudente", $r = 0.41$, $P < 0.001$; y patrón dietario 3, r = 0.29, P = 0.193). Por otro lado, se encontró que después de ajustar por múltiples variables confusoras, los sujetos pertenecientes al quintil más alto del patrón prudente tuvieron un riesgo relativo de enfermedad cardiovascular a 10 años de 0.40 (IC 95% = 0.20 – 0.77), en comparación con los sujetos del quintil más bajo de consumo del patrón prudente. Mientras que, los sujetos del quintil más alto del patrón occidentalizado tuvieron 3 veces más riesgo de enfermedad cardiovascular a 10 años (IC 95% = 1.49 – 6.31), que aquellos sujetos del quintil más bajo de consumo del patrón occidentalizado.

Conclusiones. Nuestros datos sugieren una razonable validez de los patrones dietarios identificados mediante análisis factorial con datos dietéticos recolectados mediante FFQ. Además, apuntan a que una mayor adherencia al patrón prudente puede reducir el riesgo de enfermedad cardiovascular, mientras que, una mayor adherencia al patrón occidentalizado puede incrementar el riesgo de enfermedad cardiovascular a 10 años en población aparentemente sana.

III. Artículo 1

Validity of dietary patterns in an adult Mexican population assessed by a food frequency questionnaire.

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ABSTRACT

Background: Interest in dietary patterns derived by factor analysis has increased over the past two decades as an alternative method to examine diet-disease relationships.

Objective: We examined the validity of dietary patterns identified by factor analysis using dietary data collected with a food frequency questionnaire (FFQ) administered to an adult Mexican population.

Methods: The participants were a subsample of 243 adults (148 females and 95 males) from the Mexican National Health and Nutrition Survey 2012 (NHNS-2012) enrolled in a validation study. A 140-item FFQ and two 24-hour dietary recall (24-DR) surveys were administered. We calculated Spearman correlation coefficients between dietary pattern scores identified from the FFQ and 24-DRs.

Results: Factor analysis identified 3 major dietary patterns: pattern 1 was high in snacks, fast food, soft drinks, processed meats and refined grains, pattern 2 was high in fresh vegetables, fresh fruits, and dairy products), and pattern 3 was high in legumes, eggs and sweetened foods and sugars. The Spearman correlation coefficients between the FFQ and 24-DRs for these patterns were 0.66 (P<0.001), 0.41 (P<0.001) and 0.29 (P=0.193) respectively.

Conclusions: Our FFQ results indicate reasonable validity of the three dietary patterns defined by factor analysis.

INTRODUCTION

Nutritional epidemiology research has traditionally adopted a reductionist approach (1, 2), focusing on the relationships between individual nutrients or foods and disease (3). However, that approach has some important limitations. It fails to account for interactions among nutrients (3, 4) and cannot explain the synergistic effects of recognized or unrecognized constituents of daily food consumption (3, 5, 6). Further, intercorrelation between some nutrients makes it complicated to evaluate their effects independently (4). Finally, single nutrient assessment may be confounded by the effect of dietary patterns, with which consumption of specific nutrients is normally associated (7, 8). Thus, dietary pattern analysis has been proposed to account for the cumulative and complex effects of simultaneous consumption of multiple nutrients or foods on a daily basis (4, 9, 10), and to understand the role whole diets play in disease occurrence (11, 12).

Dietary patterns can be assessed with different statistical techniques: a priori techniques using score-based approaches, like the Mediterranean diet score or healthy eating index (13, 14), or a posteriori methods, implemented with data-driven techniques such as factor analysis, cluster analysis, and, more recently, by means of reduced rank regression (3, 9, 15, 16). Factor analysis, a data reduction method which creates linear combinations of foods or food groups to identify the principal factors behind the largest variation in food consumption, is one of the most commonly used of these a posteriori techniques (10, 17). Factors can be rotated (usually orthogonally) to enhance interpretability, factor scores are computed for each subject, factor scores often are not correlated; however, are not mutually exclusive (10, 17).

Assessment of dietary patterns by factor analysis involves subjective judgment in classification of food items, determination of the number of factors to retain, the method of rotation, and the labelling of dietary patterns (18). Furthermore, dietary patterns may vary across populations with respect to food availability, socioeconomic status, resident area, ethnic group, and culture. For those reasons, it might be necessary to evaluate the validity of the food frequency questionnaire (FFQ) assessing identification of dietary patterns in a particular study population (7).

While some studies have evaluated the reproducibility and validity of dietary patterns in various adult populations (6, 7, 19-21), the validity of dietary patterns in the Mexican population has not been evaluated yet. Therefore, we assessed the validity of dietary patterns identified by factor analysis using dietary data collected with a food frequency questionnaire among adult Mexican population.

METHODS

Design and study population

The present analysis was carried out using data from the Mexican National Health and Nutrition Survey of 2012 (NHNS-2012). The NHNS-2012 is a probabilistic population-based survey with multi-stage and stratified sampling, designed to be representative of the nation, its four main regions (North, Center, Mexico City, and South), and rural and urban areas. The survey design and sampling procedures have been described in detail previously (22). Briefly, the NHNS-2012 aims to monitor health and nutrition conditions, health program coverage, and access to health services cross-sectionally. The survey obtained information from 50,528 households, with a household response rate of 87%; 46,303 interviews with adults (≥ 20 years) were also conducted.

Here, we included information of a subsample of adults aged ≥ 20 years that were randomly selected for a validity study of the semi-quantitative food frequency questionnaire (FFQ) used in the NHNS-2012. The present analysis was conducted using a data set of 264 adults who completed one FFQ and two 24-hour dietary recall (24-HDRs). Participants with outlier energy intake values (n = 21) were eliminated using the SD method suggested by Rosner (23). Consequently, our final analysis included 243 participants (148 females and 95 males).

This study was managed according to Declaration of Helsinki guidelines, and written informed consent was obtained from all participants. The ethics committee of the Instituto Nacional de Salud Pública approved the study protocol (Number 13CEI1700736).

Dietary assessment

The semi-quantitative food frequency questionnaire

The FFQ used in the NHNS-2012 is an adapted version of the questionnaire employed in the NHNS-2006 (24). The questionnaire applied in the NHNS-2012 generates data describing the frequency of consumption of 140 foods during seven days prior to the date of the interview. Frequency of food items could be characterised by set categories ranging from never to six times a day. Participants also designated the portion size of the food items ingested using predefined categories. This data was converted to portions per day. To calculate the consumption of energy (kcal/day), the daily frequency of consumption (portions/day) of each food was multiplied by the food's energy content (using the food composition tables compiled by the INSP) (25) and the contributions of all the foods were totaled using Microsoft Visual FoxPro 7.0. The FFQ was managed by personnel trained in standardized data collection and entry procedures.

24-hour dietary recall

Participants in the validity study completed two 24-hour dietary recalls (24-DR) 2 days apart, distributed over all days of the week. Personnel trained in standardized methods collected all the required information through face-to-face interviews, using automated multiple pass method (AMPM) software developed by the US Department of Agriculture and adapted to the Mexican population (26). For each 24-DR, subjects in the study were asked about their food consumption during the previous day in detail. In brief, at the beginning of the interview, subjects listed the food items they had consumed during the previous day, with prompts from the interviewer about different possible eating occasions. A list of foods that are often forgotten was also used to elicit recall. Subsequently, detailed information on each food item was collected (such as brand names, recipes, preparation methods; time, occasion and amount eaten; and the food's source). Pictures of various food portion sizes were also used to help respondents to indicate the amounts of specific foods consumed. Finally, a trained assistant revised incomplete data from the 24-DR. Following data collection, we matched the 552 unique food codes in the 24-DR to food items in the FFQ to ensure that the food intakes quantified by each were comparable. A total of 486 food codes in the 24-DR were matched to the 140 food items on the FFQ, and the remaining 66 24-DR foods that did not match any of the FFQ items were removed because they were not consumed often in our study population.

Food grouping

The energy intake from each food was converted into a percentage of total energy intake per day and standardized by Z-score (27). Foods and beverages from the FFQ and the 24-DR were categorized into 29 food groups (**Table 2**) that were used to derive dietary patterns via factor analysis of principal components. Details of the food groupings used to derive the dietary patterns are described elsewhere (28, 29). Briefly, the basis for placing a food item in a certain food group was the similarity of nutrients. Some groups were defined according to the amount of sugar added (e.g. sweetened beverages). Other groups were defined according to their lipid profile (e.g. seeds or margarine). Finally, some food items were considered individually as a food group, because their nutrient profiles were unique, they were consumed especially frequently, or they had a unique culinary use (e.g. tortillas, eggs, and orange juice).

In order to derive the dietary patterns and to determine the factorial loads of each of the 29 groups, a factorial analysis of the main components was performed (30). The factors were orthogonally rotated (varimax rotation) in order to keep them uncorrelated and to improve their interpretation. Factors above 1.5 were retained after the assessment of eigenvalues, graphic analysis and interpretability. Each factor was defined by a subset of at least 5 food groups with an absolute ≥0.3 load factor (considering that ≥0.3 load factors contributed significantly to the dietary pattern) (27-29). Additionally, we considered the Scree test (31) and the interpretability of the factors. The factor scores for each dietary pattern were estimated by adding the consumption of the food groups weighted by their load factor, and each participant received a factorial score for each identified dietary patterns.

Other participant characteristics

Participants' sociodemographic characteristics (e.g. age, sex and socioeconomic status) were obtained using predefined questionnaires. Localities with less than 2500 residents were considered to be rural areas, and areas with more than 2500 residents were considered to be urban. Using principal components analysis, the socioeconomic index was created mainly centered on the household characteristics and family assets, then; the socioeconomic index was divided into tertiles with 1 being the lowest category.

Anthropometric measures (weight and height) were collected by means of validated and standardized methods (32). Body weight measurement was carried out with a previously calibrated electronic scale, with participants wearing minimal clothing and no shoes. Height was measured using a conventional stadiometer, on barefoot subjects standing with their shoulders in a normal position; measurements were taken with the tape in a horizontal plane perpendicular to the vertical scale, touching the top of the head at the moment of inspiration. Body mass index (BMI) was computed as a ratio of weight in kilograms divided by the height in meters squared. The definition for normal weight was BMI ≥ 18.5 and < 25.0, participants with BMI ≥ 25.0 - < 30.0 were classified as overweight, and those with a BMI ≥ 30.0 were categorized as obese.

Statistical analysis

We performed a descriptive analysis of the main characteristics of interest by sex, testing differences between groups with chi-squared tests or Student t tests as appropriate.

Mean daily intakes, expressed in grams/day, of the 29 food groups determined from the FFQ and from the average of the two 24-DRs were calculated. Spearman correlation coefficients comparing daily intakes of the food groups were assessed.

Spearman correlation coefficients were also used to evaluate the validity of dietary patterns derived from dietary data collected with the FFQ and the two 24-DRs. To reduce the within-person variation in food intake obtained from the 24-hour dietary recalls, we conducted factor analysis using the average consumption for each food group across the two 24-DRs.

For all comparisons, P < 0.05 was considered to indicate statistical significance. Expansion factors were calculated for the sample used in the analysis to account for the population distribution and maintain representativeness at the national and regional levels, as well as to improve the estimators shown here. The probabilistic design of the survey was controlled for by using the SVY module of Stata, version 13.0.

RESULTS

Included in this analysis were data from a sample of 243 adults older than 20 years, representing 31,980,307 adults in the broader Mexican population. Of these participants, 61% were females and 39% males. Of the females, the majority (71.4%) were between 20 and 49 years of age, 39.8% lived in central Mexico, and approximately 80% were overweight/obese. Of the males, 54.2% lived in urban areas, 61.7% were between 20 and 49 years of age, and 70.6% were overweight or obese (Table 1).

Factor analysis identified 3 major dietary patterns that we termed “dietary pattern 1”, “dietary pattern 2” and “dietary pattern 3.” These dietary patterns accounted for approximately 20.0% of the total variance; 20.4% in the FFQ and 19.5% in the 24-DR. Factor loading matrixes for the three major dietary patterns are presented in **Table 3**. A positive loading denotes a positive relationship with the factor, whereas a negative loading represents an inverse association with the factor. The greater the loading of a given food or food group to the factor, the higher the contribution of that food or food group to a specific factor (7). In general, the first two dietary patterns derived from the FFQ and the 24-DR were similar. However, the third pattern was less consistent across the two sources of data. Pattern 1, which reflected the correlated intakes of foods commonly considered to be unhealthy, was loaded heavily with snacks, fast food, soft drinks, processed meats and refined grains. Pattern 2 emphasized consumption of fresh vegetables, fresh fruits, and high fat dairy products. Finally, legumes, eggs and sweetened foods and sugars contributed heavily to pattern 3.

Mean daily consumption (grams/day) for 29 food groups in the validity study is shown in **Table 4**. Foods or food groups overestimated by the FFQ compared with the 24-DR (which is the gold standard) included corn tortilla, fast food, fresh vegetables, fresh fruits, fruit juices, fish and other sea food, soft drinks and low calorie drinks. Mexican foods, refined grains, potatoes, red meat, processed meat, legumes and sugary dairy products were underestimated by the FFQ. Spearman correlation coefficients comparing daily intakes of the foods or food groups originated from the FFQ and the 24-DR are also listed in **table 4**. Spearman correlation coefficients ranged from 0.03 from low calorie drinks to 0.80 for soft drinks for the comparison between FFQ and the 24-DR.

The correlation between the FFQ and the 24-DR was 0.66 (P <0.001) for dietary pattern 1 and 0.41 (P <0.001) for pattern 2. However, the correlation for dietary pattern 3 was less consistent and not statistically significant (r = 0.29; P = 0.193) (**Table 5**).

DISCUSSION

In recent times, there has been an increased attention in dietary patterns analyses as a method to examining diet-disease relationships, since dietary pattern approach offer some advantages over the nutrient or single food methodologies (17). In contrast with the conventional approach, dietary patterns represent a combination of nutrients or foods and other dietary components which can reflect the eating habits of the population. Some epidemiological studies, however, have evaluated the validity of dietary patterns (6, 7, 19-21). The aim of the present work was to evaluate the validity of dietary patterns obtained through food frequency questionnaire and 24-hour dietary recalls. In this validity study of adult Mexican population, using factor analysis, we derived three major dietary patterns, which were qualitatively similar across the two sources of dietary data.

The 3 dietary patterns that we derived from the FFQ and 24-DRs were different in some aspects, possibly because of methodological dissimilarities between the two dietary assessment methods (33) and random statistical variation. However, the correlation coefficients between the FFQ and the 24-DR ranged from 0.29 to 0.66, suggesting a reasonable comparability between the FFQ and 24-DR in typifying dietary patterns, and the utility of the FFQ in assessing dietary patterns relative to the 24-DR.

The dietary patterns derived in the present analysis are similar to patterns identified in other studies using applying factor analysis methodology to dietary data from different populations. Such studies have found a vegetable rich pattern similar to our pattern 2, generally labeled as "Healthy" or "Prudent" (7, 19, 21, 34), and a "Western" pattern with contents resembling those in our dietary patterns (7, 19). For example, in the Health Professionals Follow-up Study, Hu et al. (7) evaluated the reproducibility and validity of dietary patterns using dietary data collected by an FFQ and dietary records. In this study, "Prudent" and "Western" dietary patterns were identified. The correlation coefficients in the validity analysis between each of the patterns based on the FFQs and on dietary records were 0.45 – 0.74, comparable with the correlation coefficients that we observed (0.41 – 0.66). A similar analysis of data from the Swedish Cohort Study (19) identified 3 dietary patterns, including "Healthy" and "Western" patterns similar to our patterns 2 and 1. The correlation coefficients between the FFQs and dietary records for these patterns were 0.50 – 0.59.

Additionally, in our analysis we observed that factor loadings found with dietary data from the 24-DR were generally more weakly contrasted with the factor loadings observed with the FFQ. This most likely reveals methodological differences between the FFQ and 24-DR. The FFQ generally gathered information on usual dietary intake, in our case during the past 7 days, whereas the 24-DR measured food eaten the previous day, a smaller range of foods than that likely to be reported in an individual's FFQ. Additionally, since factor analysis solutions are influenced by the correlation matrix of food consumption, some discrepancies would be expected between factor loading matrixes from different dietary assessment methodologies.

There are some limitations in our data. First, dietary pattern analysis should be interpreted with caution because, although at least two major patterns ("Healthy" or "Prudent" and "Unhealthy or "Western") have commonly emerged in different populations (7, 19, 28, 29, 34), it depends on geographical, cultural, socioeconomic and ethnic status, and is influenced by methodological variation (including sampling, food grouping, number of variables used in factor analysis, number of factors and the rotation employed). The possibility of dietary patterns changing over time within populations, due to changing food preferences or availability, is another reason for cautious interpretation. Further, the 3 major dietary patterns identified in our study explicated only 20.4% of the total variance in the FFQ and 19.5% in the 24-DRs, suggesting the existence of other eating patterns, although other minor dietary patterns were less interpretable in our analysis. Dietary patterns aside from the “Western” and “Prudent”, have been shown to be highly variable across various dietary assessment methods, and may not be reproducible across populations (7). Finally, measurement errors may have occurred. Although the 24-DR is the current gold standard for evaluating food consumption, it is nevertheless susceptible to measurement error due to inaccurate recording (33). In addition, since we did not administer a second FFQ in the validity study, we cannot assess the reproducibility of the instrument. Future work needs to be done to evaluate the reproducibility of this FFQ.

In conclusion, our data indicate reasonable validity of the major dietary patterns identified by factor analysis using FFQ in comparison with two 24-DRs. These results suggest the potential use of factor analysis-based dietary pattern identification in epidemiological studies as an alternative dietary assessment method suitable for studying diet-disease relationships.

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Table 1. Distribution of characteristics of interest in the validation sample (n = 264)[1], data from the Mexican National Health and Nutrition Survey of 2012.

	Female (n = 160; N = 18586479)			Male (n = 104; N = 13393828)		
	n	N	%	n	N	%
Age groups						
20 – 34 years	44	4158777	22.4	20	4278265	31.9
35 – 49 years	56	9111516	49.0	33	3996515	29.8
50 – 64 years	24	3922033	21.1	22	1683166	12.6
≥ 65 years	36	1394153	7.5	29	3435882	25.7
Region						
North	32	2833246	15.2	29	3368574	25.2
Central	55	7398307	39.8	33	5364915	40.0
Mexico City	6	3284591	17.7	1	67904	0.5
South	67	5070335	27.3	41	4592435	34.3
Residence						
Urban	92	10200847	54.9	69	7263206	54.2
Rural	68	8385632	45.1	35	6130622	45.8
Socioeconomic status						
Tertile 1	60	5261998	28.3	40	4873530	36.4
Tertile 2	62	7053921	38.0	33	4856282	36.3
Tertile 3	38	6270560	33.7	31	3664016	27.4
Body mass index*						
Normal	43	3378059	18.2	33	3064629	29.4
Overweight	67	8293677	44.6	41	6597312	55.7
Obese	50	6914743	37.2	30	3731887	14.9

*Body mass index: Normal (< 25.0 kg/m^2), overweight (≥ 25 kg/m^2 - < 30.0 kg/m^2), obese (≥ 30.0 kg/m^2).
[1]For this analysis the full sample was included.

Table 2. Food grouping used in the dietary pattern analysis.

Main group	Basis for placing a food item	Food groups	Food items
Grains	Culinary use	1. Corn tortilla	Corn tortilla.
		2. Mexican food	Pozole, memela, quesadilla, sope, taco, tamal.
	Proportion of fiber	3. Whole grains	Whole bread, oatmeal, linseed, all Bran, multi bran, multigrain.
		4. Refined grains	White bread, wheat tortilla, rice, corn flakes, honey crunch, other cereals.
	Specific nutrient profile	5. Pastries	Pastries.
		6. Desserts	Cookies, cakes, doughnuts.
		7. Snacks	Potato chips, corn chips, pop corn, crackers.
		8. Fast food	Pizza, hot dogs, hamburgers.
Vegetables	Proportion of fiber	9. Fresh vegetables	Cauliflower, spinach, lettuce, carrots, tomato, nopal, onion, corn, cabbage, pea, green bean, chili, hot pepper, beet, mixed vegetables.
	Proportion of starch	10. Potatoes	Potatoes.
Fruits	Proportion of fiber	11. Fresh Fruits	Banana, prune, peach, apple, orange, grapes, strawberry, melon, watermelon, mango, tangerine, pear, papaya, pineapple, guava, prickly pear.
	Frequency of consumption	12. Fruit juice	Fruit juice.
Meats	Frequency of consumption	13. Eggs	Eggs.
	Specific nutrient profile	14. Poultry	Chicken with or without skin.
		15. Red meat	Pork, beef or lamb.
		16. Processed meat	Sausage, bacon, ham.
		17. Fish and other sea food	Canned tuna fish, sardines, fresh fish, octopus, and squid.
Dairy	Specific nutrient profile "proportion of fat"	18. Low-fat dairy products	Skim or low-fat milk, low-fat yogurt.
		19. High fat dairy products	Whole milk, chocolate milk, cream, high fat yogurt, cream cheese, other cheese, ice cream.
		20. Sugary dairy products	Chocolate milk, other flavored milk, danonino and yakult brand yogurt, other yogurt with added sugar.
Legumes	Frequency of consumption	21. Legumes	Lentils, dry beans.
Fat	Specific nutrient profile "proportion of fat and type of fat"	22. Oils and nuts	Peanuts, walnuts, almonds, pistachios, vegetable oils, avocados.
		23. Butter	Margarine, butter, mayonnaise, animal fats.
Sugar	Frequency of	24. Sweetened food	Sugar, chocolate, candies, jam,

	consumption "proportion of sugar"	and sugars	honey, jelly.
		25. Soft drinks	Soft drinks.
		26. Other sweetened beverages	Other sweetened beverages.
		27. Low calorie drinks	Low calorie carbonated beverages, other low calorie beverages.
Alcohol	Relative frequency of consumption	28. Alcohol	Wine, beer, brandy, whisky, tequila, rum, pulque, other hard liquor.
Tea and coffee	Relative frequency of consumption	29. Tea and coffee	Tea and coffee.

Tabla 3. Factor loading matrix for the 3 major dietary patterns identified from the food frequency questionnaire and 24-hour dietary recall.

Foods or food groups	Food frequency questionnaire			24-hour dietary recall		
	Dietary Pattern 1	Dietary Pattern 2	Dietary Pattern 3	Dietary Pattern 1	Dietary Pattern 2	Dietary Pattern 3
Corn tortilla	-0.79*	--	--	-0.67	--	--
Mexican food	--	--	--	0.52	--	--
Whole grains	--	--	--	--	--	--
Refined grains	--	--	--	0.31	--	--
Pastries	--	--	--	--	--	0.36
Desserts	--	--	--	--	--	--
Snacks	0.58	--	--	0.43	--	--
Fast food	0.47	-0.40	--	0.39	--	--
Fresh vegetables	--	0.42	--	--	0.31	--
Potatoes	--	--	--	--	--	--
Fresh fruits	--	0.59	--	--	0.53	--
Fruit juices	--	0.36	--	--	--	--
Eggs	--	--	0.51	--	-0.55	0.31
Poultry	0.38	--	--	--	--	0.59
Red meat	--	-0.32	--	--	-0.35	--
Processed meats	0.34	--	0.39	--	-0.32	--
Fish and other sea food	--	--	--	--	--	--
Low fat dairy products	--	--	--	--	--	--
High fat dairy products	--	0.31	--	--	0.42	--
Sugary dairy products	--	--	--	--	0.44	--
Legumes	--	--	0.33	-0.56	--	0.39
Oils and nuts	--	--	--	--	-0.40	--
Butter	--	--	--	--	--	-0.32
Sweetened food and sugars	---	--	0.55	--	--	0.39
Soft drinks	0.31	-0.56	--	0.52	--	--
Other sweetened beverages	--	--	--	--	--	0.54
Low-energy drinks	--	--	--	--	--	--
Alcohol	--	--	-0.35	--	--	--
Tea and coffee	--	--	0.48	--	--	--

*Absolute values <0.30 were excluded for simplicity.

Table 4. Daily intake of food groups assessed with FFQ and 24-DR by 243 participants in the Mexican National Health and Nutrition Survey 2012.

Foods or food groups	Grams/day		Spearman correlation coefficients	
	FFQ Mean (SE)	24-DR Mean (SE)	FFQ vs 24-DR	*P* value
Corn tortilla	237.3 (42.1)	172.6 (22.7)	0.53	<0.001
Mexican food	89.7 (14.9)	93.9 (13.9)	0.29	<0.001
Whole grains	9.1 (3.8)	8.3 (3.6)	0.09	0.219
Refined grains	92.8 (11.6)	99.5 (14.1)	0.44	<0.001
Pastries	33.5 (9.5)	32.4 (5.0)	0.40	<0.001
Desserts	29.7.9 (2.6)	33.3 (2.0)	0.19	0.008
Snacks	4.3 (0.9)	5.7 (2.1)	0.38	<0.001
Fast food	37.6 (8.4)	9.5 (3.4)	0.32	<0.001
Fresh vegetables	112.1 (14.2)	55.9 (34.0)	0.14	0.061
Potatoes	10.8 (1.6)	31.5 (38.6)	0.14	0.062
Fresh fruits	231.9 (23.6)	73.3 (10.4)	0.13	0.093
Fruit juices*	27.6 (8.6)	6.1 (4.1)	0.29	<0.001
Eggs	40.9 (3.7)	35.5 (5.1)	0.48	<0.001
Poultry	25.5 (2.8)	39.6 (8.6)	0.08	0.275
Red meat	33.7 (4.6)	46.4 (7.9)	0.08	0.268
Processed meats	12.1 (2.8)	13.8 (3.1)	0.16	0.032
Fish and other sea food	10.9 (2.7)	4.6 (1.4)	0.42	<0.001
Low fat dairy products*	14.9 (3.0)	23.6 (9.4)	0.26	<0.001
High fat dairy products*	145.3 (24.6)	85.1 (15.3)	0.47	<0.001
Sugary dairy products*	28.9 (10.1)	45.5 (12.6)	0.44	<0.001
Legumes	91.3 (11.0)	102.8 (18.3)	0.39	<0.001
Oils and nuts	15.2 (4.4)	10.9 (1.5)	0.06	0.439
Butter	5.6 (1.0)	11.2 (1.8)	0.22	0.001
Sweetened food and sugars	40.8 (8.0)	20.9 (4.7)	0.09	0.222
Soft drinks*	209.7 (28.5)	189.7 (28.8)	0.80	<0.001
Other sweetened beverages*	130.0 (28.4)	91.0 (20.3)	0.36	<0.001
Low-energy drinks*	23.3 (9.7)	6.8 (3.5)	0.03	0.727
Alcohol*	47.2 (16.2)	76.2 (32.6)	0.68	<0.001
Tea and coffee*	147.7 (27.5)	201.9 (30.7)	0.47	<0.001

* Intakes are presented in ml/day

Table 5. Spearman correlation coefficients for the 3 major dietary pattern scores between FFQ and the 24-DR.

	Dietary pattern 1	**Dietary pattern 2**	**Dietary pattern 3**
	r	r	r
FFQ vs 24-DR	0.66*	0.41*	0.29

*Values are Spearman correlation coefficients, all *P* <0.001

IV. Artículo 2

Association between dietary patterns and cardiovascular disease risk in an urban Mexican adult population.

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ABSTRACT

Background: Cardiovascular disease (CVD) is a major public health problem. Certain nutrients and foods have been recognized as risk or protective factors for CVD. Additionally, several studies have estimated the association between dietary patterns and CVD risk.

Objective: To evaluate the association between major dietary patterns and the development of > 10% risk of 10 year cardiovascular disease (based on the Framingham risk score) over 7 years of follow-up, in Mexican adults.

Methods: This was a prospective cohort study of 1196 men and women aged 20-80 years without diagnosis of CVD at baseline in 2004-2007.

Results: Using factor analysis, we identified 3 major dietary patterns in participants' dietary data collected with a food frequency questionnaire. Dietary pattern 1 was characterized by the occurrence of high positive loadings for the consumption of fresh fruit, vegetables, and whole grains. Dietary pattern 2 showed positive loadings for the consumption of red meat, processed meat, eggs, fats, fish and poultry. Finally, dietary pattern 3 featured positive loadings for corn tortillas, refined grains, soft drinks, and alcohol. After adjustment for potential confounders, compared with participants in the lowest quintile of the dietary pattern 1, those in the highest quintile had lower relative risks (RRs) of 10-year CVD (RR=0.40; 95% CI: 0.20-0.77; *P* for trend = 0.005). In contrast, participants in the highest quintile of the third dietary pattern had greater risk of an elevated 10-year CVD (RR=3.07; 95% CI: 1.49-6.31; *P* for trend = 0.012) than those in the lowest quintile.

Conclusion: Our data suggest that greater adherence to dietary pattern 1 may reduce the risk of CVD, whereas greater adherence to dietary pattern 3 may increase 10-year cardiovascular disease risk in initially apparently healthy people.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death and a major cause of disability worldwide (1), and the main cause of mortality in adult Mexicans (2).

Multiple epidemiological studies suggest that lifestyle, especially diet, significantly influences CVD occurrence (3). In response, traditional nutritional epidemiology research has focused primarily on investigating the CVD risk posed by specific dietary components (single foods, beverages or nutrients). This research revealed that fruits, vegetables, whole grains and nuts, play an important role in preventing CVD mainly by providing dietary fiber and antioxidants (3, 4). Similarly, monounsaturated and polyunsaturated fatty acid rich diets (featuring olive oil and fish) have been shown to have beneficial effects on lipid profiles and to reduce CVD risk (5-7). Trans fatty acids, saturated fats, dietary cholesterol, red meat, and other dietary components have been associated with increased CVD risk (3).

However, these individual dietary factors only explain part of the relationship between diet and CVD risk. Dietary intake is a complex exposure variable, as meals consist of multiple foods and have the combined effect of all those foods' constituent nutrients. This has made it difficult to investigate the separate effects of individual nutrients consumed simultaneously. As a result, dietary pattern analysis has emerged in nutritional epidemiology research. Assessing dietary patterns may shed clearer light on diet-disease relationships (8-11), and generate dietary advice more suited to real-world eating behavior (10).

Different multivariate techniques, such as cluster analysis, principal component analysis (PCA), and reduced rank regression (RRR) analysis have been proposed to evaluate the relationship between diet and disease (12, 13). Of these techniques, PCA has produced important and consistent results across studies. Briefly, PCA derives linear combinations of foods or food groups in order to identify principal patterns (factors) that elucidate the largest variation in food intake. The dietary patterns derived through this method describe how foods or food groups are consumed jointly in a population (9, 14).

Recently, studies from around the world have examined the role of specific dietary patterns on the risk of CVD (11, 15, 16) and its risk factors (17-21). Previous research in the Mexican population has documented significant associations between dietary patterns, defined using PCA, and metabolic syndrome, obesity, insulin resistance and gastric cancer (22-25). However, analysis of the relationship between dietary patterns and CVD risk in the Mexican population has not yet been conducted.

Therefore, the objective of the present study was to evaluate the association between major dietary patterns, derived by PCA, on risk of 10-year CVD in a Mexican population. We hypothesized that of the three dietary patterns we have previously identified in this population (22-25), the dietary pattern characterized by greater intake of whole grains, fruit, vegetables and legumes would be inversely associated with lower CVD risk, whereas the dietary pattern characterized by greater intake of red or processed meats, refined grain, pastries, and sweetened beverages would be positively associated with higher risk of cardiovascular disease, independently of demographic and life style factors.

METHODS

Study population

The Health Worker Cohort Study (HWCS) is a longitudinal study investigating relationships between lifestyle and health. It was established in 2004 when 10,769 Mexican employees and their relatives from 3 health and academic institutions in Morelos and Mexico States responded to a questionnaire on health related factors. Study design, methodology and participants' characteristics have been previously described (22, 26). Participants attending the second data collection phase of the cohort study (n=1855), which took place between 2012 and 2013, were eligible for the current investigation.

Data on socio-demographic, lifestyle and medical history factors were collected with a self-administered questionnaire, and anthropometric measurements and clinical evaluations were taken at baseline and at the end of follow-up. For the present analysis, we excluded participants with missing information on blood pressure, serum lipids, lipoprotein, and glucose concentrations, or with >10% blank items on their dietary intake information. We also excluded participants who reported history of type 2 diabetes, myocardial infarction, or stroke, because these diseases could have led them to alter their diet and lifestyle. We excluded those who were taking medications that would affect serum lipids, lipoprotein or glucose concentrations, or blood pressure. Participants with outlier energy intake values were eliminated using the SD method (27). Finally, we eliminated those whose follow up duration was equal to zero or missing. Consequently, our final analysis included 1196 participants (299 men and 897 women).

This study was planned and performed according to the guidelines of the Declaration of Helsinki. All participating institutions' research ethics committees approved the study protocol and informed consent forms, and written informed consent was obtained from all participants.

Dietary intake and dietary pattern assessment

Dietary information was obtained with a previously validated (28), semiquantitative food frequency questionnaire (FFQ). To test the FFQ's reproducibility, it was administered twice, at a 1-y interval, to 134 women residing in Mexico City and the results were then compared with those from the set of 4 24 hour recalls, given at 3-mo intervals, for validity (28). This questionnaire included data regarding the consumption of 116 food items. For each food, a commonly used portion size (e.g. 1 slice of bread or 1 cup of coffee) was specified and participants reported the frequency with which they had consumed each specific food during the previous year. Participants chose from 10 possible responses, ranging from "never" to "6 or more times per day." For our analysis, the reported frequency for each food item was converted into daily intake. Total energy intake was computed by summing the energy intakes from all foods (29).

The energy intake from each food was converted into a percentage of total energy intakes per day and standardized by Z-score (30). Foods and beverages from the FFQ were categorized into 28 food groups that were used to derive dietary patterns using PCA. Details of the food groupings used to derive the dietary patterns have been described elsewhere (22, 23). Briefly, the basis for placing a food item in a certain food group was the similarity of nutrients. Some groups were defined according to the amount of sugar added (e.g. sweetened beverages). Other groups were defined according to their lipid profile (e.g. seeds or margarine). Finally, some food items were considered individually as a food group, because their nutrient profiles were unique, were consumed especially frequently, or had a unique culinary use (e.g. tortilla, eggs, and orange juice).

In order to derive the dietary patterns and to determine the factor loadings of each of the 28 groups, a factor analysis of the main components was used (31). The factors were orthogonally rotated (varimax rotation) to keep them uncorrelated and to improve their interpretation. Factors with eigenvalues above 1.5 were retained after assessment of graphic analysis and interpretability. Each factor was defined by a subset of at least 5 food groups with an absolute loading ≥0.2 (considering that ≥0.2 loadings contributed significantly to the dietary pattern) (22, 23, 30). The factor scores for each dietary pattern were estimated by adding the consumption of the food groups weighted by their loading factor, and each participant received a score for each of the 3 identified patterns.

Assessment of anthropometric and clinical variables

Body weight was measured with a previously calibrated electronic scale (model BC-533; Tanita, Tokyo, Japan), with participants wearing minimal clothing and no shoes. Height was measured using a conventional stadiometer (SECA brand), on barefoot subjects standing with their shoulders in a normal position; measurements were taken with the tape in a horizontal plane perpendicular to the vertical scale, touching the top of the head at the moment of inspiration. Body mass index (BMI) was computed as a ratio of weight in kilograms divided by height in meters squared.

Blood pressure (BP) was measured with an automatic digital blood pressure monitor. Participants were seated with their right arm resting at heart level. BP categories were defined according to the Fifth Joint National Committee on Hypertension definition (JNC V) as follows (32): optimal BP (SBP < 120 and DBP < 80 mmHg); normal BP (SBP 120-129 or DBP 80-84 mmHg); high normal BP (SBP 130-139 or DBP 85-89 mmHg); hypertension stage

I (SBP 140-159 or DBP 90-99 mmHg), and hypertension stage II-IV (SBP ≥ 160 or DBP ≥ 100 mmHg).

All measurement procedures were performed by nurses trained to use standardized procedures (reproducibility was evaluated, resulting in concordance coefficients between 0.83–0.90).

Biomarker assessment

After a 12-hour fasting, a venous blood sample was collected from each participant at baseline and follow up evaluations. Plasma triglycerides were measured with a colorimetric method following enzymatic hydrolysis performed with the lipase technique. High-density lipoprotein cholesterol (HDL-C) was measured with the clearance method. This method shows excellent correlation with the reference method (r=0.99). Non HDL-C lipoprotein is removed in the first step of the reaction (clearance step). Low-density lipoprotein cholesterol (LDL-C) was measured with the clearance method; correlation studies on the LDL-C clearance method produced a coefficient of r = 0.985 with ultracentrifugation; total cholesterol was measured with the colorimetric method following enzymatic assay. All biomedical assays were performed using a Selectra XL instrument (Randox).

LDL cholesterol and HDL cholesterol were classified into the following categories: <100, 100-129, 130-159, 160-189 and ≥ 190 mg/dL for LDL cholesterol and < 35, 35-44, 45-49, 50-59 and ≥ 60 mg/dL for HDL cholesterol. Diabetes was diagnosed as fasting glucose ≥ 126 mg/dl or self-reported (33).

Assessment of other variables

Information on participants' sociodemographic characteristics (e.g. age, sex and education), medical history and lifestyle, including consumption of alcohol and tobacco, were collected using a self-administered questionnaire. Physical activity level was determined using a self-administered questionnaire. The participants reported the time they spent each week on activities such as running, and walking, during a typical week in the previous year. Each activity was given a value in metabolic equivalent tasks (METs) and total METs/week were computed.

Cardiovascular disease risk assessment

CVD risk was calculated using a recalibration of the Framingham coronary heart disease prediction scores (33, 34). We first estimated the predicted risk of total CVD, applying the β-coefficients of Cox proportional hazards model obtained from the Framingham population by Wilson et al. (33), which included age, current smoking, type 2 diabetes, blood pressure regardless of hypertension treatment (predefined BP categories), serum LDL cholesterol (predefined categories), and HDL-cholesterol (predefined categories). We used this equation to calculate each participant's 10-year predicted probability of CVD.

For the present study, we excluded subjects who had elevated cardiovascular disease risk (≥ 10 percent risk in ten years) predicted at baseline. The main outcome of the current analysis was the development of more than 10 percent risk of CVD in ten years between baseline and follow up data collection. We defined participants as at low CVD risk when they had less than 10 percent risk in 10 years (35).

Statistical Analysis

Descriptive analyses of the main variables of interest (including age, BMI, waist circumference, physical activity, and total energy intake) across quintiles of each dietary pattern score were performed. Analysis of variance (ANOVA) was used to evaluate mean differences across quintiles of each dietary pattern. The chi-square test was used to determine differences in the distribution of qualitative variables across quintiles of each dietary pattern.

To compute relative risk, we used pooled logistic regression with 2-year intervals (36), which is approximately equivalent to Cox regression for time dependent covariates when the event is rare. In our analysis, we fitted four different models. The first model was adjusted for age (< 30, 30-39, 40-49, 50-59, 60-69, ≥70 years), and sex. The second multivariate model added smoking (never, past, and current), physical activity (min/day), alcohol intake (nondrinker, moderate and heavy), postmenopausal hormone use (yes/no), the use of multivitamin supplements (yes/no), parental history of myocardial infarction (yes/no), history of hypertension (yes/no). The third model made additional adjustment for BMI (< 25 kg/m^2 and ≥ 25 kg/m^2). The final multivariate adjusted model further controlled for total energy intake (quintiles). Tests of linear trend across increasing quintiles of dietary patterns scores were calculated with the dietary pattern score variable modeled as a continuous variable.

All *P* values presented are two sided; *P*<0.05 was considered statistically significant. All the statistical analyses were performed using the STATA statistical software package, version 11.0 for Windows (Stata Corp. LP: College Station, TX).

RESULTS

We entered food intake data for 28 predefined food groups (online supplementary table) into the factor analysis procedure. According to the criteria indicated above, a 3-factor solution was obtained, which explained 21.9% of the total variance (Table 1). Dietary pattern 1 accounted for 9.6% of the variance and was characterized by high positive loadings for the consumption of fresh fruit (0.74), vegetables (0.60), and whole grains (0.37), and negative loadings for refined grains (-0.38) and soft drinks (-0.45). Dietary pattern 2 showed positive loadings for the consumption of red meat, processed meat, eggs, fats, fish and poultry, and negative loadings for pastries (-0.40) and corn tortilla (-0.42), accounting for 6.6% of the variance. Lastly, dietary pattern 3 accounted for 5.7% of the total variance and was represented mainly by negative loadings for high fat dairy products (-0.65) and red meat (-0.24), and a positive loadings for corn tortilla (0.60), refined grains (0.35), soft drinks (0.22), and alcohol (0.22).

Table 2 shows their sociodemographic information, body composition, clinical parameters, and dietary intakes, according to the quintiles of the dietary patterns. At baseline in 2004-2007, those in the highest quintile of dietary pattern 1 tended to be female, have a parental history of myocardial infarction, be current smokers, take multivitamins, have a lower likelihood of hypertension, hypertriglyceridemia, and > 10% risk of 10 year cardiovascular disease and be less likely to exercise, than those in the lowest quintile of dietary pattern 1. In addition, the adults in the highest, vs. the lowest, quintile had lower intakes of carbohydrates and higher intakes of protein, monounsaturated fat, polyunsaturated fat and folate. Those with a higher dietary pattern 2 score were slightly younger, and were more likely to be men, to smoke and to exercise. They had higher intakes of monounsaturated fat, polyunsaturated fat and protein, and lower intakes of fiber and folate than those in the lowest quintile. Finally, participants in the highest quintile of dietary pattern 3 were slightly younger, had a higher proportion of men, and greater likelihood of hypertension, hypercholesterolemia, hypertriglyceridemia and > 10% risk of 10 year cardiovascular disease than those in the lowest quintile of dietary pattern 3. These participants also had relatively higher intakes of carbohydrates and lower intakes of monounsaturated fat, polyunsaturated fat, protein, folate, and fiber than those in the lowest quintile.

After adjustment for age and sex, a higher dietary pattern 1 score was associated with lower 10 year CVD risk (Table 3). In model 1 (age-sex adjusted) the RRs across increasing quintiles of first dietary pattern score were 1.0 0.98, 0.86, 0.72, and 0.47 (95% CI: 0.26-0.87; *P* for trend = 0.012). Further adjustment for smoking, physical activity and other CVD risk factors did not change the results substantially. The multivariate RR crossway categories of dietary pattern 1 score were 1.0, 0.90, 0.81, 0.63, and 0.40 (95% CI: 0.20-0.77; *P* for trend = 0.005). Participants in the highest quintile of scores in the third dietary pattern were associated with greater development of elevated 10 year CVD risk, compared with those in the lowest quintile, (OR 1.96; 95% CI: 1.10-3.50), after controlling for age and sex. This association became stronger when we further adjusted for other potential confounders. In the multivariate analysis, participants in the highest (vs. lowest) category of the third dietary pattern score had an OR of 3.07 (95% CI: 1.49-6.31; *P* for trend = 0.12) for development of elevated 10-year CVD risk score. The second dietary pattern was not associated with risk of elevated CVD risk.

DISCUSION

In this cohort study, 3 major dietary patterns emerged through factor analysis. The first dietary pattern, characterized by high intake of whole grains, fresh fruit, fresh vegetables and lower consumption of refined grains, soft drinks and sugars, was significantly associated with lower 10-year cardiovascular disease risk in individuals with low CVD risk at baseline. In contrast, the third dietary pattern, reflecting high consumption of refined grains, corn tortilla, tomato juice, and soft drinks, was linked to higher 10-year cardiovascular disease risk. The second dietary pattern was not associated with 10-year cardiovascular disease risk.

The patterns we found are consistent with those identified in previous studies conducted in different populations. Such studies have found a vegetable rich pattern similar to our pattern 1, generally labeled as "Healthy" or "Prudent" (11, 16, 21, 37), and "Traditional" or "Western" patterns with contents resembling those in our dietary patterns 2 and 3 (11, 38).

The relationship of dietary patterns with cardiovascular disease has been analyzed in different countries around the world (11, 15, 16, 38). In the present study, dietary pattern 1 was associated with lower 10-year cardiovascular disease risk (RR = 0.40; 95% CI: 0.20-0.77; *P* for trend 0.005). This is consistent with results from the Health Professionals Follow-up Study (11), where the prudent dietary pattern (mainly represented by frequent consumption of fruit, vegetables and whole grains) was significantly associated with decreased risk of coronary heart disease (RR = 0.75; 95% CI: 0.59-0.95; *P* for trend 0.02). An inverse relationship between prudent or healthy dietary patterns and incident cardiovascular disease was also found in Swedish (39) and U.S. (38, 40) women. The dietary pattern approach cannot identify the particular nutrients accountable for the observed differences in disease risk. However, based on findings from previous single nutrient/food studies (4), we suggest that the protection afforded by dietary pattern 1 may derive from the dietary fiber and the antioxidants present in vegetables, fruit and whole grains.

Some foods loading positively in our dietary pattern 3 (refined grains, soft drinks, alcohol) were comparable to the Western diet found to correlate with greater CVD risk and incident coronary heart disease in the U.S. Nurses' Health Study (38) and Health Professionals Follow-up study (11). Our findings showing that dietary pattern 3 is linked to increased CVD risk is of considerable concern, as it is becoming increasingly common, due to the increasing accessibility and consumption of refined cereals and soft drinks. The adverse effect of dietary pattern 3 may come from added sugars and sodium, as these nutrients are highly present in the food groups that comprise that dietary pattern. This information is congruent with recent findings linking the consumption of added sugar to higher risk of cardiovascular disease (41, 42).

It is important to mention that there are some methodological limitations which affect the interpretation of our results. First, the use of PCA to estimate the dietary patterns has some weaknesses. It requires decisions regarding the number and type of foods that make up the groups and the cut-off points in the number of patterns. In addition, the use of the FFQ provides an indirect measure of eating patterns (43). However, the participants in our study were categorized into concrete groups of foods based on usual long-term intake and this method has been shown to be useful for evaluating the relationship of diet to a disease outcome (44). Second, measurement errors in dietary intakes are unavoidable; this error is likely random in prospective studies like this one, and thus not systematically related to the outcome of interest, but could have led to an underestimation of the association between dietary patterns and the cardiovascular disease risk. However, the FFQ used here has been validated (28) and can reasonably reflect long-term dietary intake. Third, participants might change their diets after they develop some intermediate diseases, leading to a conservative estimate. Nevertheless, excluding participants with histories of diabetes or cardiovascular disease reduced the possibility of bias from this source, and generated similar null associations. Furthermore, while we adjusted for potential confounding factors, the presence of residual or unmeasured confounding is possible. In addition, the participants in this cohort study are adults from a specific segment of the Mexican population: working class, seemingly healthy individuals. While these adults cannot be considered representative of the Mexican adult population as a whole, they may be considered representative of middle to low income adults residing in the urban areas of central Mexico. Finally, the prospective design of our study reduces the possibility of recall or selection bias.

In conclusion, a dietary pattern characterized by a high consumption of vegetables, fresh fruit and whole grains, and lower consumption of refined grains and soft drinks, was robustly associated with a lower 10-year cardiovascular disease risk. In contrast, a dietary pattern mainly represented by high consumption of refined grains (processed foods), corn tortilla, and soft drinks significantly predicted higher cardiovascular disease risk. Although causality remains an issue of debate, until large scale, primary prevention trials focused on dietary patterns are implemented, such observational findings are important bases for dietary recommendations, government programs, and negotiation with industry that can help Mexican people make healthy food choices.

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Table 1. Factor-loading matrix for major dietary patterns identified by using food consumption data from the food frequency questionnaire used in the Health Worker Cohort Study in 2004-2007.

Food groups	Dietary patterns		
	Patter 1	**Pattern 2**	**Pattern 3**
	Factor loading [1]	**Factor loading [1]**	**Factor loading [1]**
Corn tortilla	--	**-0.42**	**0.60**
Mexican food	--	--	--
Whole grains	**0.37**	--	--
Refined grains	**-0.38**	--	**0.35**
Pastries	--	**-0.36**	--
Desserts	--	--	--
Snacks	**-0.33**	--	--
Fresh vegetables	**0.60**	--	--
Tomato juice	**0.31**	--	**0.29**
Potatoes	--	--	--
Fresh Fruits	**0.74**	--	--
Orange juice	**0.43**	--	--
Eggs	--	**0.20**	--
Poultry	--	**0.33**	--
Red meat	--	**0.40**	**-0.24**
Processed meat	**-0.32**	**0.34**	--
Fish and other sea food	--	**0.50**	--
Low-fat dairy products	--	--	--
High fat dairy products	--	--	**-0.65**
Legumes	--	--	**0.30**
Oils and nuts	--	--	--
Butter	--	**0.34**	**-0.32**
Sweet food and sugars	**-0.40**	--	--
Soft drinks	**-0.45**	--	**0.22**
Other sweetened beverages	--	--	--
Low-energy drink	--	**0.34**	--
Alcohol	--	--	**0.22**

Tea and coffee	--	**--**	**0.35**
Eigenvalue	2.8	1.8	1.5
Variance explained (%)	9.6	6.6	5.7

[1]Absolute values <0.20 were omitted from the table for clarity.

Table 2. Characteristics according to quintiles (Q) within dietary pattern categories in the Health Workers Cohort Study in 2004-2007.

	Dietary Pattern 1				Dietary Pattern 2				Dietary pattern 3			
	Q1	**Q3**	**Q5**	***P*** [¤]	**Q1**	**Q3**	**Q5**	***P*** [¤]	**Q1**	**Q3**	**Q5**	***P*** [¤]
Variables	**n=240**	**n=239**	**n=239**		**n=240**	**n=239**	**n=239**		**n=240**	**n=239**	**n=239**	
Participant characteristics												
Women (%)	71.7	73.2	79.1	0.33	90.0	78.7	57.7	<0.001	82.9	73.6	64.9	<0.001
Age (years)[1]	41.1	39.9	41.9	0.19	45.0	42.0	34.6	<0.001	36.2	40.9	44.7	<0.001
Physical Activity (min/day)[1]	26.2	26.5	25.5	0.20	23.8	25.5	29.1	<0.001	26.9	26.2	25.6	0.019
Current smoker (%)	15.0	16.7	19.3	<0.001	14.2	13.0	27.6	<0.001	15.4	18.8	20.5	0.089
Multivitamin supplement use (%)	29.1	41.2	43.7	0.013	44.3	33.7	32.7	0.13	41.5	36.4	35.4	0.53
Parental history of MI[2] (%)	17.5	20.5	20.5	0.14	23.3	23.9	16.7	0.019	19.2	21.8	15.1	0.25
Body Mass Index (Kg/m^2)[1]	25.7	25.6	25.7	0.22	25.7	25.7	25.5	0.58	24.4	26.0	26.1	<0.001
Hypertension (%)[Ɛ]	8.3	6.7	5.0	0.68	6.7	6.7	7.5	0.68	3.8	8.4	11.3	0.001
Hypercholesterolemia (%)[Ω]	37.5	40.1	39.7	0.96	49.2	36.8	28.0	<0.001	31.7	39.8	44.4	0.077
Hypertriglyceridemia (%)∞	40.8	35.9	33.5	0.33	38.8	37.2	32.2	0.32	25.0	38.1	50.2	<0.001
Cardiovascular disease risk (%)¶	20.8	16.7	9.6	<0.001	16.2	13.8	15.5	0.79	9.2	17.2	24.3	<0.001
Dietary intake												

Energy (kcal/day) [1]	2329	2192	1936	<0.001	2281	2205	2222	0.017	2480	2162	1866	<0.001
Carbohydrate (% of energy)[1]	66.1	61.4	54.0	<0.001	68.0	60.2	54.2	<0.001	56.9	62.5	63.2	<0.01
Protein (% of energy)[1]	12.8	14.6	16.3	0.67	13.6	14.2	14.4	0.079	14.9	13.9	13.5	<0.001
Total fat (% of energy)[1]	21.1	24.0	29.7	0.61	18.4	25.6	31.4	<0.001	28.2	23.6	23.3	<0.001
Saturated fat (g/day) [1]	20.9	21.5	20.8	0.76	17.6	22.4	25.4	<0.001	30.6	20.3	14.8	<0.001
Monounsaturated fat (g/day) [1]	21.4	24.4	25.1	0.016	21.3	24.5	28.9	<0.001	31.9	22.8	18.4	<0.001
Polyunsaturated fat (g/day) [1]	9.1	10.5	10.6	<0.01	9.7	10.1	12.3	<0.001	11.4	10.0	9.2	<0.001
Alcohol use (g/day) [1]	2.4	4.9	5.5	<0.001	2.4	4.9	5.5	<0.01	2.0	3.7	5.8	<0.001
Dietary folate (µg/day) [1]	390	394	408	0.63	589	380	290	<0.001	446	415	323	<0.001
Fiber (g/day)[1]	16.7	17.3	15.9	0.35	22.7	17.1	13.2	<0.001	17.8	16.7	16.6	0.59

[1]Values expressed as means.
[2]MI; Myocardial infarction.
[ε]Hypertension; systolic blood pressure ≥ 140 mm Hg or/and diastolic blood pressure ≥ 90 mm Hg.
[Ω]Hypercolesterolemia; total cholesterol ≥ 200 mg/dL.
∞Hypertriglyceridemia; triglycerides ≥ 150 mg/dL.
¶ Cardiovascular disease risk; > 10% risk of 10 year cardiovascular disease (based on the Framingham risk score).
[¤] ANOVA test was used for quantitative variables, Chi2 test was used for qualitative variables.

Table 3. Relative risk (95% CIs) of developing a Framingham CVD risk score greater than 10%, by dietary pattern quintile.

	Dietary pattern quintile scores			
	Q1	Q3	Q5	*P* trend*
	RR (IC 95%)	RR (IC 95%)	RR (IC 95%)	
Dietary pattern 1				
Model I[1]	1.0	0.86 (0.60-1.62)	0.47 (0.26-0.87)	0.012
Model II[2]	1.0	0.81 (0.47-1.39)	0.43 (0.23-0.82)	0.007
Model III[3]	1.0	0.76 (0.44 -1.31)	0.42 (0.22-0.79)	0.006
Model IV[4]	1.0	0.80 (0.47-1.39)	0.40 (0.20-0.77)	0.005
Dietary pattern 2				
Model I[1]	1.0	0.90 (0.51-1.57)	1.09 (0.64-1.88)	0.801
Model II[2]	1.0	0.98 (0.55-1.75)	1.09 (0.61-1.93)	0.894
Model III[3]	1.0	0.96 (0.54-1.72)	1.07 (0.60-1.89)	0.812
Model IV[4]	1.0	0.99 (0.53-1.85)	1.20 (0.63-2.31)	0.925
Dietary pattern 3				
Model I[1]	1.0	1.81 (1.00-3.29)	1.96 (1.10-3.50)	0.115
Model II[2]	1.0	2.38 (1.18-4.84)	3.01 (1.51-3.03)	0.014
Model III[3]	1.0	2.39 (1.18-4.84)	3.02 (1.51-6.03)	0.014
Model IV[4]	1.0	2.35 (1.15-4.81)	3.07 (1.49-6.31)	0.012

[1]Adjusted for: Age (<30, 30-39, 40-49, 50-59, 60-69, ≥ 70 years), sex, time period (four 2 year periods);
[2]Additionally adjusted by: smoking status (never, past and current smoking), alcohol consumption (nondrinker, moderate and heavy), multivitamin use (yes or no), parental history of myocardial infarction (yes or no), history of hypertension (yes or no), physical activity (min/day), and postmenopausal hormone use (yes or no);
[3]Additionally adjusted by: BMI (< 25 kg/m2 or ≥ 25kg/m 2);
[4]Additionally adjusted by: energy intake (quintiles).

Online Supplementary Table. Food grouping used in the dietary pattern analysis.

Main group	Basis for placing a food item	Food groups	Food items
Grains	Culinary use	30. Corn tortilla	Corn tortilla.
		31. Mexican food	Pozole, memela, quesadilla, sope, taco.
	Proportion of fiber	32. Whole grains	Whole bread, oatmeal, linseed, all. Bran, multi bran, multigrain.
		33. Refined grains	White bread, wheat tortilla, rice, Corn flakes, honey crunch, other cereals.
	Specific nutrient profile	34. Pastries	Pastries.
		35. Desserts	Cookies, cakes.
		36. Snacks	Potato chips, crackers.
Vegetables	Proportion of fiber	37. Fresh vegetables	Cauliflower, spinach, lettuce, carrots, tomato, nopal, onion, corn, cabbage, pea, green bean, chili, hot pepper, beet, mixed vegetables .
	Culinary use	38. Tomato juice	Tomato juice.
	Proportion of starch	39. Potatoes	Potatoes.
Fruit	Proportion of fiber	40. Fresh Fruit	Banana, prune, peach, apple, orange, avocado, grapes, strawberry, melon, watermelon, mango, tangerine, pear, mamey, zapote, papaya, pineapple, guava, prickly pear.

	Frequency of consumption	41. Orange juice	Orange juice.
Meats	Frequency of consumption	42. Eggs	Eggs.
		43. Poultry	Chicken with or without skin.
	Specific nutrient profile	44. Red meat	Pork, beef or lamb.
		45. Processed meat	Sausage, bacon, ham.
		46. Fish and other sea food	Canned tuna fish, sardine, fresh fish, octopus, and squid.
Dairy	Specific nutrient profile "proportion of fat"	47. Low-fat dairy products	Skim or low-fat milk, low-fat yogurt.
		48. High fat dairy products	Whole milk, chocolate milk, cream, high fat yogurt, cream cheese, other cheese, ice cream.
Legumes	Frequency of consumption	49. Legumes	Lentils, dry beans.
Fat	Specific nutrient profile "proportion of fat and type of fat"	50. Oils and nuts	Peanut, walnut, almond, pistachios, vegetable oils.
		51. Butter	Margarine, butter, mayonnaise, animal fats.
Sugar	Frequency of consumption "proportion of sugar"	52. Sweet food and sugars	Sugar, chocolate, candies, jam, honey, "ate", jelly.
		53. Soft drinks	Soft drinks.
		54. Other sweetened	Sweetened beverages.
		55. Low-energy drink	Low-energy carbonated beverages.
Alcohol	Relative frequency of consumption	56. Alcohol	Coolers, spirit, wine, beer, brandy, whisky, tequila, rum, hard liquor,

			pulque.
Tea and coffee	Relative frequency of consumption	57. Tea and coffee	Tea and coffee.

V. Conclusiones generales

Nuestros hallazgos sugieren la existencia de al menos de 3 patrones dietarios en población adulta mexicana. Uno de los patrones dietarios, al que anteriormente etiquetamos como "patrón prudente", caracterizado de manera general por un alto consumo de frutas, verduras y granos integrales, un segundo patrón, al que denominamos antes como "patrón occidentalizado", que mostró relación con altos consumos de cereales refinados, carnes procesadas, y bebidas azucaradas, y un tercer patrón menos consistente al comparar ambos análisis dentro de nuestro estudio. Los primeros dos patrones encontrados en este estudio han sido consistentes con patrones dietarios encontrados en estudios realizados en distintas poblaciones. Tales estudios han identificado un patrón rico en vegetales (etiquetado como "saludable o prudente") similar a nuestro patrón "prudente" y un patrón no saludable, rico en carnes procesadas, cereales refinados y bebidas azucaradas (etiquetado como "occidental"), comparable con el patrón que hemos etiquetado como occidentalizado para fines de este trabajo de investigación.

Por otro lado, nuestros resultados muestran una razonable validez (coeficientes de correlación de Spearman entre 0.29 y 0.66) de los patrones dietarios identificados mediante análisis factorial con datos dietéticos recolectados mediante FFQ, específicamente para población adulta mexicana. Aunque, los principales patrones dietarios observados fueron diferentes en algunos aspectos, posiblemente por las diferencias metodológicas entre los dos métodos de evaluación dietética y por variación estadística de tipo aleatorio; podemos sugerir que la metodología de patrones dietarios mediante análisis factorial puede ser una herramienta útil para tratar de explicar parte de la relación dieta-enfermedad en población adulta mexicana.

Finalmente, nuestros datos apuntan a que una mayor adherencia al patrón prudente puede reducir el riesgo de enfermedad cardiovascular, mientras que, una mayor adherencia al patrón occidentalizado puede incrementar el riesgo de enfermedad cardiovascular a 10 años en población aparentemente sana.

A pesar de que la evidencia contenida en este trabajo de investigación proviene de estudios observacionales, y de que no existen ensayos de prevención primaria enfocados en patrones dietarios, tales hallazgos observacionales son base importante para recomendaciones dietéticas, programas gubernamentales, y posiblemente como evidencia para negociar con la industria con la finalidad de ofrecer opciones más saludables a la población mexicana.

VI. Referencias

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