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ASSOCIATION BETWEEN DIABETES MELLITUS AND HYPERTENSION WITH ANTHROPOMETRIC INDICATORS IN OLDER ADULTS: RESULTS OF THE MEXICAN HEALTH SURVEY, 2000

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Abstract: *Objective:* To determine the association between anthropometric indicators of adiposity with type 2 diabetes mellitus (T2DM) and hypertension (HTN) in older adults. *Design:* Cross-sectional study of participants of the Mexican Health Survey 2000 (MHS). *Setting:* Mexico, subjects recruited from the general community. *Participants:* The analytic sample included 7,322 adults who were ≥60 years of age at the time of the survey. T2DM data were available on 6,994 individuals, who represent 95.5% of the original sample; data on HTN was available on 6,268 subjects, which accounted for 86.5% of the original sample. *Measurements:* Type 2 diabetes mellitus and hypertension, as well as anthropometric indicators including body mass index (BMI), waist circumference (WC), and conicity index (CI). *Results:* The prevalence of T2DM and HTN in this age group was 34.3% and 73.9%, respectively. After adjusting for other variables, the association between high WC and T2DM (OR=1.59 95%CI=1.26-2.01, P <0.001) was stronger than the association with overweight (OR=1.26, 95%CI= 1.01-1.58, P=0.04) and obesity (OR=1.38, 95%CI= 1.08-1.79, P<0.01) using BMI, and slightly higher than tertile 2 of the CI (OR=1.49, 95%CI=1.20-1.88, P< 0.01), while tertile 3 showed a stronger association with T2DM (OR=1.60, 95%CI=1.22-2.08, P<0.001). However, the association between obesity and HTN measured by BMI (OR=1.98, 95%CI=1.48-2.65, P< 0.001) was stronger than what was observed with overweight (OR=1.42, 95%CI 1.13-1.77, P<0.01), with high WC (OR=1.62, 95%CI=1.25-2.10, P<0.001) and tertiles 2 and 3 of the CI (OR=1.23, 95%CI=0.99-1.55, P= 0.09); (OR=1.53, 95%CI= 1.16-2.03, P< 0.01) respectively. *Conclusions:* BMI and abdominal obesity are significantly and independently associated with an increase in the prevalence of T2DM and HTN among older Mexican adults.

Key words: Diabetes mellitus, hypertension, obesity, elderly, Mexico.

Introduction

According to data from the XII National Population and Household Census of Mexico (INEGI, 2000), there are 6.9 million adults aged 60 years and older in Mexico, number that represents 7.1% of the population. It is expected that this population will continue to grow over the years (1). Although chronic disease in this fast growing population results in elevated costs, little attention has been paid to the health status of aging adults (2-3).

Aging leads to multiple changes in body composition including diminished muscle mass and increased central adiposity. An important relationship between these changes and the risk of developing some type of chronic disease has been observed (4-5). The problem of overweight and obesity has become common among the elderly population, influencing the overall health status of this group as the risk for cardiovascular disease, hypertension, diabetes mellitus and dyslipidemia increases (6-9).

The World Health Organization (10) identified anthropometry as a fundamental component of physical evaluation in the field of geriatrics. Anthropometry is a practical and simple technique to utilize among older adults and offers the advantage of being not invasive, and low-cost (11). This tool also provides a satisfactory estimation of the amounts of total lean and fat mass.

The Body Mass Index (BMI) is commonly used to identify overweight and obesity, however, it fails to account for the wide variation of body fat distribution in individuals (12). Waist Circumference (WC) is an indicator associated to visceral fat depots, which are considered to be an important risk factor for cardiovascular disease among the elderly (13). It is not correlated with height but correlates closely with BMI and total body fat. It is considered to be a risk factor for cardiovascular disease independently from BMI.

Therefore, WC can be an effective clinical tool to evaluate the risk for chronic disease (12).

Other techniques have been proposed to assess abdominal adiposity. One of them is the Conicity Index (CI). The rationale for the development of this index is that as fat accumulates at the center of the body, its shape changes from cylindrical to that of two cones with a common base at the waist level. The CI has a built-in adjustment for height and weight (14). This index appears to have a strong relationship with the risk of

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cardiovascular disease (15).

In 1998, the United States National Institutes of Health (NIH) published the Clinical Guidelines for the Identification, Evaluation, and Treatment of Overweight and Obesity among adults (16). These include a systematic classification for the evaluation of health risks based on the BMI and WC. In this classification system the patient is assigned to one of six BMI categories (underweight, normal weight, overweight, and obesity I, II or III) and one of two WC categories (normal or high). Although the established cut points have generally been accepted for BMI and WC, these guides are based on middle age individuals and their relevance to older adults is controversial (17).

Hence, it is necessary to improve our understanding of the association of adiposity and the health status of aging adults in order to face the unavoidable challenges posed by this emerging group in Mexico.

The objective of the present study is to determine the association between anthropometric measures such as Body Mass Index (BMI), Waist Circumference (WC) and the Conicity Index (CI) and type 2 diabetes mellitus (T2DM) and hypertension (HTN) in older adults who participated in the Mexican Health Survey 2000 (MHS 2000)

Materials and Methods

The present study is based on a nationally representative, cross-sectional sample from the MHS 2000, the percentage of adults older than 60 years was similar to the one reported by the corresponding national census (18). A detailed description of the sampling design and data collection is available from previous publications (19). Consent for participation was obtained from all participants. The project was approved by the scientific and ethics committees of the National Institute of Public Health. In addition, data collection was implemented considering the confidentiality and reserve rights stipulated by the Mexican Statistical and Geographic information law (20).

Briefly, a total of 45,726 households were identified and a total of 24,856 men and 26,747 women over the age of twenty years who participated in the survey. Structured interviews were used to gather sociodemographic data, family history, lifestyles, clinical symptoms, and medical treatment for various chronic diseases. For the purpose of this study alone all individuals at or over 60 years of age were selected and more comprehensive information on the variables of interest was gathered from them. The sample of people with known T2DM status consisted of 6,994 individuals or 95.5% of the total sample of older adults, while the HTN status was known for 6,268 individuals, or 85.6%, of the total sample of older adults. The expansion factors were recalculated taking into account the non-response and missing values of the final sample.

Glucose and Type 2 Diabetes Mellitus (T2DM)

Blood samples were collected by trained personnel and blood glucose was assessed with a previously validated capillary glucose test (Accutrend Sensor Comfort, Lakeside; Roche Diagnostic Corporation, Indianapolis, IN). The American Diabetes Association's criteria (21) were utilized to identify T2DM, defined as the presence of diabetes symptoms along with a casual glucose concentration on plasma ≥200 mg/dl or a fasting glucose ≥126 mg/dl and/or a previous diagnosis by a physician.

Blood pressure and Hypertension (HTN)

Blood pressure was measured twice. The first reading was carried out after at least five minutes of rest in a seated position. The same trained nurse took both measures within five minutes of each other on the subjects' right arm using a previously validated aneroid sphygmomanometer (TJX-10, ADEX Products, Mexico City, Mexico). The first Korotkoff sound marked the systolic blood pressure and the fifth sound the diastolic blood pressure. Criteria from the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) (22) were utilized to identify HTN documented if the subject presented a systolic blood pressure ≥130 mm Hg on the first reading and/or if the diastolic blood pressure was ≥ 85 mm Hg, and they were confirmed by means of a second measure. In addition, all patients who said to have been previously diagnosed with hypertension by a physician were considered to have HTN.

Anthropometric Variables

Following international standards (23-24) trained personnel measured height with a professional stadiometer (SECA ADEX Products, Mexico City, Mexico) and weight with a digital solar scale (Tanita Corporation of America, Inc., Arlington Heights, IL) to the nearest 5mm and 0.1kg, respectively. WC was measured at the mid point between the highest part of the iliac crest and the lowest part of the ribs margin of the median axial line. The BMI was calculated by dividing the weight in kilograms by the height in m^2. The CI was calculated using the following equation (14): $CI = \frac{Waist\ Circumference(m)}{0.109\left(\sqrt{\frac{weight(kg)}{height(m)}}\right)}$

Socioeconomic status

The MHS collected socioeconomic information on the household (floor material, structure of ceilings and walls and number of persons in the household), availability of basic services (drinking water and sewage disposal), and ownership of electric appliances (radio, television, refrigerator). A principal components analysis was performed according to previously published methodology (25). Based on this information, the first component explained 40.4% of the variation in the socio-economic status variables. This component was divided into tertiles and used as a proxy for low, medium and high socioeconomic level.

Statistical Analysis

Due to the characteristics of the survey design, in the present study the estimates were calculated using the complex survey

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"SVY" module of STATA 8.2 (26). This program makes adjustments based on the sample design and allows for the results to be generalized to those individuals in the population. First, a descriptive analysis of the population was conducted. Means and standard deviations were calculated for continuous variables. For categorical variables absolute values and percentages are reported. The prevalence of T2DM and HTN were estimated by sex, age, BMI and WC categories, and tertile of CI. Subsequently, nonconditional bivariate, binary logistic regression analyses were performed using diabetes and hypertension as dependent variables.

BMI (in kg/m^2) was categorized according to WHO (27) and NIH guidelines (16). The categories are: normal (18.5-24.9), overweight (25-29.9) and obesity (≥30). The WC (in cm) classification was made based on current NIH guidelines: normal (males ≤102, females ≤ 88) and high (males ≥ 102, females ≥ 88). CI categories were grouped into tertiles. The values of this index are expected to vary between 1 (perfect cylinder) and 1.73 (perfect double cone) (15). Other variables for which categories were made include: age (decade groups); family history (none, mother or father and both parents with the condition); socioeconomic status (low, medium and high); region (north, center, Mexico city and south); high cholesterol (self-reported with or without a previous diagnosis made by a physician); smoking (number of cigarettes smoked/day) and alcohol consumption (never, previously, and currently).

Six non-conditional multivariate regression models (28) were generated to analyze the prevalence of T2DM and HTN. BMI, WC, and CI, were the main independent variables. Age, sex, family history, socioeconomic status, high cholesterol, smoking, and alcohol consumption were included as covariates. In the final multivariate model only those variables that had p values < 0.25 in the bivariate analysis were included (28). Interactions (e.g., height by region) were tested, however, none of the interactions were significant at a p < 0.15 level. Family history was obtained in a smaller set of observations; for that reason, when included in our models, between 25 and 32% of the sample cases were excluded from the analyses. Since the estimates with and without this variable were similar we maintained the models without this information. An analysis of Variance Inflation Factor (VIF) was conducted to detect and avoid multicolinearity between independent variables (28). The model's adjustment was carried out with the Maximum Likelihood estimates using a p > 0.10 cut point as an indicator of a proper adjustment.

Results

These results apply exclusively to the Mexican population 60 years of age and older as represented in the MHS 2000. There are not differences between the attributes of responders and non-responders. Of the individuals in this age group, 47.2% were male and 52.8% were female. The age range was 60 - 103 years and the average age was 70.0 ±7.8 years (69.5±7.7 in males and 69.8±8.0 in females). Fifty-two percent lived in urban areas and 48% in rural areas. Also in this group, 19.2% lived in the northern region of the country; 39.3% lived in the central region, 10.3% lived in the Mexico City and 31.2% in the southern region. In terms of schooling, 8.6% of participants had either no schooling or did not complete elementary school, 73.2 % had completed elementary school, 18.2% had studies beyond high school. Smoking was a prevalent habit among 14.2% of the subjects and habitual alcohol consumption was reported by 26.4% of those interviewed. Tables 1 and 2 show the descriptive characteristics analyzed of the total sample of older adults by sex and the prevalence of overweight, obesity, T2DM, and HTN, respectively. Taking into account previous medical diagnosis and/or the capillary glucose levels, 34.3% of older adults were classified having diabetes, 52.6% of them were diagnosed at the time of the survey. It was also determined that 73.9% of this population presented HTN, of which 55.4% were identified by the survey. Of the 4737 subjects who had HTN, 36.6% also had T2DM, and of the 2341 person with diabetes 74.1% also had HTN. The prevalence of overweight in the population was 38.7%, obesity was present in 25.6%, and abdominal obesity in 58.6% of the population.

Table 1
Descriptive characteristics of the sample of older adults, by sex*

Variable	Mean ± SD		
	Men	Women	Total
Age (in years)	69.52 ± 7.65	69.77 ± 8.01	69.65± 7.84
Weight (kg)	69.93 ± 13.59 ‡	61.98 ± 14.02 ‡	65.74 ± 14.37
Height (m)	1.62± 0.07 ‡	1.49± 0.07 ‡	1.55 ± 0.10
BMI (kg/m2)	26.47± 4.41 ‡	27.93± 5.58 ‡	27.24 ± 5.11
Waist Circumference (cm)	97.24 ± 11.72 ‡	100.42±13.48 ‡	98.92 ± 12.78
Conicity Index (IC)	1.37± 0.10 ‡	1.44± 0.12 ‡	1.40 ± 0.12
Systolic Blood Pressure (mm Hg)	133.29± 18.40 †	135.14± 19.24 †	134.27 ± 18.87
Diastolic Blood Pressure (mm Hg)	83.46± 11.26 *	84.30± 11.69 *	83.90 ± 11.49
Capillary Glucose (mg/dl)	124.63± 57.65 †	131.49± 63.24 †	127.86 ± 60.68

* Data adjusted for the complex design effect; CI = waist (m)/0.109 [√weight (kg) / height (m)]. Range: 1.00-1.73; Men n = 2651; N= 2 925 851, Women n = 4343; N = 3 299 363 t test; *p < 0.05, †p <0.01, ‡p < 0.001

In general, the prevalence of T2DM and HTN, obesity and abdominal obesity is higher in women than men. The prevalence of overweight was higher in men than women (Table 2). The prevalence of T2DM or HTN rises in the 70-79 group and declines in those 80 years old or older (Table 3).

Table 2
Descriptive characteristics of the sample of older adults, by sex*

Variable	Prevalence (%) Men (47.1%)	Women (52.9%)	Total
Age in years			
60-69	57.3	56.7	57.0
70-79	30.2	29.3	29.7
≥ 80	12.5	14.0	13.3
BMI (kg/m2)			
18.5 – 24.9 (normal)	39.0 ‡	32.3 ‡	35.4
25-29.9 (overweight)	41.0 ‡	36.4 ‡	38.7
≥ 30 (obesity)	20.0 ‡	31.3 ‡	25.6
Waist Circumference			
Low risk			
Men ≤102 cm Women≤88 cm	67.1 ‡	18.7 ‡	41.4
High risk			
Men >102 cm Women>88 cm	32.9 ‡	81.3 ‡	58.6
Conicity Index			
Tertile 1 < 1.36	46.9 ‡	25.4‡	36.2
Tertile 2 (1.36-1.46)	41.6 ‡	28.1‡	34.8
Tertile 3 (1.47-2.30)	11.5 ‡	46.5‡	29.0
Diabetes Mellitus			
Yes	31.5 †	36.8 †	34.3
No	68.5 †	63.2 †	65.8
Hypertension			
Yes	70.7‡	76.6 ‡	73.9
No	29.3‡	23.4 ‡	26.4

* Data adjusted for the complex survey design effect. †=p<0.01, ‡=p<0.001; Men n=2651 N= 2 925 851, Women n=4343 N= 3 299 363; Diabetes Mellitus= casual capillary glucose ≥ 200 mg/dl or fasting glucose ≥ 126 mg/dl and/or previous diagnosis by a physician. Hypertension= systolic blood pressure ≥ 130 mm Hg and/or diastolic blood pressure ≥ 85 mmHg and/or previous diagnosis by a physician.

The prevalence of T2DM and HTN increases with BMI, WC and CI tertiles and are higher in women than in men (Table 3). Table 4 shows the distribution of socioeconomic and metabolic variables by BMI, WI and CI. Of the entire diabetic population, 28.1% has a normal BMI, 41.5% is overweight, and 30.4% is obese. Of those who had HTN, 29.9% have a normal BMI, 40.1% are overweight, and 30% are obese. Sixty-seven percent (67%) of persons with diabetes and 64.9% of individuals with HTN had abdominal obesity. Among those individuals with T2DM, 29.3%, 35.6% and 35.1% belonged to tertiles 1, 2, and 3 of the CI, respectively. Similarly, among all hypertensive individuals, 31.8%, 35.1% and 33.1% belonged to tertiles 1, 2, and 3 of the CI, respectively.

The Pearson correlation coefficients among the three anthropometric indices were all significant: (r = 0.76, P < 0.001) between BMI and WC; (r = 0.12, P < 0.001) between the CI and BMI; and (r = 0.68, P < 0.001) between the CI and WC. Table 5 shows the results of the logistic regression models designed to test the associations between T2DM or HTN with BMI, WC, and CI categories independently. Elderly people with high WC were more likely to have T2DM (OR=1.59, 95%CI=1.26-2.01, P<0.001) than those with normal WC. Similarly, elderly obese individuals were more likely to have T2DM (OR=1.38, 95%CI=1.08-1.79, P<0.01) than those of normal BMI. Elderly people in the upper tertile of CI were more likely to have T2DM (OR=1.60, 95%CI=1.22-2.08, P<0.001) than those in the lower tertile. Regarding the associations with HTN, obese elderly individuals were more likely to have HTN (OR=1.98, 95%CI=1.48-2.65, P<0.001)

Table 3
Prevalence of Type 2 diabetes mellitus 2 and hypertension, by age and anthropometric measures

Variable	T2DM (%) Men n= 823 N=938 018	T2DM (%) Women n= 1 518 N=1 218 746	T2DM (%) Total n= 2341 N=2 156 764	HTN (%) Men n= 1 663 N=1 806 904	HTN (%) Women n= 3 074 N= 2 340 620	HTN (%) Total n=4 737 N=4 147 524
Age in years						
60-69	31.9	36.9	34.5	68.5	73.6	71.3
70-79	32.1	40.8	36.7	74.1	81.7	78.2
≥ 80	28.3	28.2	28.3	72.2	78.0	75.5
BMI (kg/m2)						†
18.5 – 24.9 (normal)	25.2	29.7	27.4	61.9	69.3	65.6
25-29.9 (overweight)	35.3	39.3	37.3	74.7	76.7	75.7
≥ 30 (obesity)	37.0	42.5	40.5	76.5	83.5	81.0
Waist circumference						
Low risk			†			†
Men ≤102 cm Women ≤ 88 cm	28.2	24.4	27.3	65.8	63.7	65.2
High risk						
Men >102 cm Women >88 cm	38.9	39.7	39.5	78.7	78.8	78.8
Conicity Index			†			†
Tertile 1 < 1.36	27.7	30.0	28.6	65.8	71.5	68.1
Tertile 2 (1.36-1.46)	36.0	35.5	35.8	72.0	76.0	73.8
Tertile 3 (1.47-2.30)	34.5	41.8	40.5	80.1	79.4	79.5
Region	†					
North	32.3	39.2	35.9	78.8	81.3	80.1
Central	29.2	35.0	32.2	69.7	79.1	74.9
Mexico City	37.6	41.0	39.5	69.5	71.7	70.8
South	32.2	36.2	34.3	66.8	72.0	69.6

* Test for trend p < 0.05, † Test for trend p < 0.01

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Table 4
Characteristics of the population by Body Mass Index (BMI), Waist Circumference (WC) and Conicity Index tertile (CI)

Variable	BMI			WC		CI		
	Normal (%)	Overweight (%)	Obesity (%)	Normal (%)	High (%)	Tertile 1 (%)	Tertile 2 (%)	Tertile 3 (%)
Sex								
Men	39.0	41.0	20.0	67.1	32.9	46.9	41.6	11.5
Women	32.3	36.4	31.3	18.7	81.3	25.4	28.1	46.5
Age in years								
60-69	29.8	39.5	30.7	39.1	60.9	38.7	35.1	26.2
70-79	39.6	38.5	21.9	42.8	57.2	32.0	34.5	33.5
≥ 80	53.0	34.1	12.9	49.1	50.9	29.0	31.0	40.0
Schooling								
< Primary	33.3	39.1	27.6	38.8	61.2	26.5	43.4	30.1
<Secondary	34.0	39.9	26.1	40.4	59.6	35.0	35.3	29.7
≥ Secondary	25.1	40.9	34.0	37.4	62.6	43.6	34.7	21.7
*SES**								
Low	53.6	31.0	15.4	54.1	45.9	39.0	30.8	30.2
Medium	30.7	41.8	27.5	38.8	61.2	31.8	35.3	32.9
High	26.6	41.3	32.1	34.8	65.2	36.7	35.3	28.0
Region								
North	30.2	39.5	30.3	36.9	63.1	36.5	34.0	29.5
Central	33.5	39.0	27.5	39.8	60.2	34.4	34.3	31.3
Mexico City	27.5	43.1	29.5	32.9	67.1	32.2	37.6	30.2
South	43.8	36.0	20.2	49.2	50.8	37.5	33.8	28.7
Area								
Rural	42.8	35.4	21.8	47.7	52.3	36.2	34.1	29.7
Urban	28.8	41.5	29.7	35.6	64.4	34.8	34.7	30.5
Smoking								
Never	34.0	38.4	27.6	33.4	66.6	31.8	31.6	36.6
Previously	35.7	39.5	24.8	50.2	49.8	38.5	40.7	20.8
Currently	41.6	37.8	20.6	61.5	38.5	46.5	36.2	17.3
Alcohol Consumption								
Never	35.3	36.9	27.8	28.0	72.0	28.4	30.5	41.1
Previously	35.5	42.7	21.8	51.7	48.3	38.5	38.5	23.0
Currently	35.7	36.7	27.6	51.8	48.2	43.8	36.2	20.0
Diabetes								
Yes	28.1	41.5	30.4	32.9	67.1	29.3	35.6	35.1
No	39.4	37.0	23.6	45.9	54.1	38.8	33.8	27.4
Hypertension								
Yes	29.9	40.1	30.0	35.1	64.9	31.8	35.1	33.1
No	44.0	36.2	19.8	51.7	48.3	41.5	34.7	23.8

n= 6 994; N= 6 225 214; * SES: Socioeconomic status

than those with normal BMI. Elderly individuals with high WC were more likely to have HTN (OR=1.62, 95%CI=1.25-2.10, P<0.001) than comparable individuals with normal WC. And individuals in the upper CI tertile were more likely to have HTN than comparable individuals in the lower CI tertile (OR=1.53, 95%CI= 1.16-2.03, P<0.01).

Discussion

This study, using nationally representative cross-sectional data, showed the association between anthropometric measures such as BMI, WC and CI with two chronic diseases for the first time in the Mexican geriatric population. The CI is an anthropometric index that correlated well with other anthropometric measures such as the waist to hip ratio in the Caucasian European population and Caucasian and American-Indian in the United States (15). However, this index has not been studied as an independent variable associated to T2DM and HTN in the Mexican population. Our study shows that a significant association exists with the prevalence of T2DM and HTN among the older Mexican population. It must be acknowledged that CI shows a high correlation with the WC and a low correlation with BMI, which suggests that it can be a useful indicator of risk for chronic disease that is mostly associated with abdominal fat.

Diabetes Mellitus and heart disease are among the leading causes of death among older Mexican adults (6). This study corroborates the high prevalence of diabetes and hypertension in older Mexican adults (6) and the positive and significant association of these diseases with BMI, WC, and CI. After adjusting for important covariates, the anthropometric measures remained positively and independently associated with T2DM and HTN. The association between T2DM and the indicators of abdominal obesity (WC and CI) was significant and the ORs higher than with the overweight (which was not significant) and obesity categories (Table 5). On the other hand, the association between HTN and BMI was stronger than with WC or CI. Although this study cannot be directly compared to previous studies due to differences in the methodology and study population, the results are in general agreement with previous reports by identifying BMI and abdominal obesity associated with T2DM and HTN.

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Table 5
Multivariate association of BMI, WC, and CI with diabetes mellitus and hypertension

Independent Variables	Diabetes Mellitus Model 1 BMI OR (CI 95%)	Model 2 WC OR (CI 95%)	Model 3 CI OR (CI 95%)	Hypertension Model 4 BMI OR (CI 95%)	Model 5 WC OR (CI 95%)	Model 6 CI OR (CI 95%)
BMI						
Normal+	1.00			1.00		
Overweight	1.26 (1.01-1.58)*			1.42 (1.13-1.77) †		
Obesity	1.38 (1.08-1.79)†			1.98 (1.48-2.65) ‡		
WC						
Low Risk+		1.00			1.00	
High Risk		1.59 (1.26-2.01) ‡			1.62 (1.25-2.10) ‡	
CI						
Tertile 1+			1.00			1.00
Tertile 2			1.49 (1.20-1.88)†			1.23 (0.99-1.55)
Tertile 3			1.60 (1.22-2.08)‡			1.53 (1.16-2.03)†
Family History						
None+	1.00	1.00	1.00	1.00	1.00	1.00
Father or mother	1.60 (1.24-2.07)*	1.68 (1.30-2.19) ‡	1.72 (1.33-2.22)‡	1.64 (1.23-2.21)†	1.61 (1.19-2.17) †	1.67 (1.24-2.24)†
Both	2.30 (1.07-4.93)*	2.35 (1.10-5.02) *	2.28 (1.07-4.87)*	0.92 (0.49-1.74)	0.86 (0.45-1.65)	0.93 (0.49-1.77)
Region						
South +	1.00	1.00	1.00	1.00	1.00	1.00
Mexico City	0.94 (0.64-1.40)	0.88 (0.59-1.31)	0.89 (0.60-1.32)	0.90 (0.58-1.40)	0.93 (0.60-1.44)	0.93 (0.60-1.45)
Central	0.73 (0.58-0.92) †	0.75 (0.59-0.94)*	0.75 (0.60-0.95)*	1.16 (0.90-1.51)	1.19 (0.91-1.54)	1.21 (0.93-1.58)
North	0.81 (0.65-1.01)	0.83 (0.66-1.05)	0.83 (0.66-1.04)	1.48 (1.14-1.90) †	1.61 (1.24-2.10) ‡	1.62 (1.25-2.11)‡
SES						
High +	1.00	1.00	1.00	1.00	1.00	1.00
Medium	1.06 (0.85-1.32)	1.02 (0.82-1.28)	1.01 (0.81-1.27)	1.15 (0.89-1.49)	1.19 (0.92-1.55)	1.15 (0.88-1.49)
Low	0.81 (0.63-1-04)	0.80 (0.63-1.03)	0.77 (0.60-0.98)*	0.93 (0.71-1.23)	0.93 (0.70-1.22)	0.86 (0.65-1.13)
Expanded N	4 362 305	4 283 147	4 209 658	4 640 778	4 566 298	4 487 810
Goodness of fit test	0.2773	0.2494	0.1322	0.5533	0.7926	0.3744

+ Reference category. * p<0.05, †p<0.01, ‡p<0.001; All models were adjusted for age decade, sex, smoking= number of cigarettes smoked/day, alcohol consumption= never, previously, currently, and cholesterol self report; Models 1, 2 and 3 adjusted for hypertension. Models 4, 5 and 6 ajusted for diabetes. Models 2 and 5 also adjusted for height (in meters)

Our results are consistent with a prospective study in older women (29), where BMI and waist to hip ratio (WHR) were closely associated with T2DM and with data from another study (6) in which T2DM was associated with WHR but not with BMI. Hypertension has been significantly and positively associated with BMI in men and women over 60 years in agreement with our findings (30). A study in German adults 40-65 years of age found a similar relation (31) and Must et al, reported an increase in the prevalence of hypertension as BMI increased in adults 25 years of age and older (32). Data from the Iowa Women's Health Study (33) have shown that between WC and BMI, WC has the strongest association with T2DM and BMI has the strongest association with hypertension. This is consistent with results from a cohort study in Dutch elderly population which found an association of WC to T2DM independent of BMI. This study also found a protective effect of hip circumference on the risk of diabetes (34). However we were not able to evaluate this anthropometric parameter since it was not collected

When socioeconomic level was included in the models, T2DM and hypertension were more closely associated with obesity in the high socioeconomic level. This finding differs from other studies where the association was stronger among those in the low socioeconomic level (35). The difference might be due to stage of the epidemiologic transition that each population is undergoing. In less developed populations obesity is often associated with affluence while the opposite occurs in more developed populations (36).

The prevalence of T2DM was highest in the Mexico city; the prevalence of hypertension was highest in the North and Urban regions of Mexico. Other studies that have looked at older adults in Mexico found a prevalence of T2DM that is lower than the one reported in this study. For example, the 1993 Mexican Chronic Disease Survey (MCDS) reported a 21.0% prevalence and a 1998 study (6) found a prevalence of 26.8%. However, it should be noted that the MCDS data included only the population between the ages of 60 and 69 and this study includes population older than 70 years of age. The prevalence of hypertension found in this study (73.6%) is higher than the one reported by the MCDS in 1993 (38%) and the one found by Brown in the 60-79 age group (56.3%) and those ≥ 80 years (70%). Both T2DM and hypertension were more prevalent in women than in men, consistent with data from some studies in elderly population from other countries such as United States and Spain (30, 37). However, other studies among the elderly have found a higher prevalence of diabetes in men than in women (38, 6). The prevalence of T2DM and HTN diminishes in the older age groups, similarly to previous reports in Mexico (6) and Spain (37). This diminished prevalence is usually attributed to a survivor effect, by which those more sensitive to the effects of obesity and its consequences die at younger ages (33). Diverse studies in Europe and America have shown a differential association between overall and abdominal obesity and chronic conditions like diabetes and hypertension (13, 33, 39, 40). Associations are usually stronger for abdominal adiposity. Abdominal fat depots are characterized by enhanced

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lipolytic activity, decreasing insulin sensitivity and glucose metabolism (41). Likewise, the rise in fat mass leads to higher blood pressure as a physiological response to the increased demand of blood flow necessary to satisfy the needs of a larger body weight (13). Studies that look at groups of older adults should pay attention to the survivor effect which is likely to affect the results.

A potential limitation of this study is the cross-sectional design. Because this type of study only looks at subjects at one time and place there is a lack of prospective information and cause-effect relationships cannot be established. Another limitation was the diagnosis of T2DM using capillary blood, since this method could systematically obtain values ~15mg/dl below intravenous glucose measures. Consequently, the prevalence of T2DM in this study might have been underestimated. Finally, this survey did not collected physical activity or dietary information which is necessary to better understand how lifestyles are linked to diverse diseases.

Our study showed that total body mass as measured by BMI and abdominal obesity measured by WC and CI were significantly and independently associated with an increase in the prevalence of T2DM and hypertension in older Mexican adults. The association between obesity and chronic diseases in this population suggests the need to prevent and control overweight and obesity in order to reduce the risk of T2DM, hypertension and its complications as well as to improve the quality of life of this fast growing population.

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