ISSN (electrónico): 1699-5198 - ISSN (papel): 0212-1611 - CODEN NUHOEQ S.V.R. 318

ARÁN

Nutrición Hospitalaria

Trabajo Original

Nutrición en el anciano

Prevalence of metabolic syndrome and its determinants in older Mexican non-diabetic adults

Prevalencia de síndrome metabólico y sus determinantes en adultos mayores mexicanos sin diabetes

Heliodoro Alemán-Mateo[1], Miriam T. López Teros[2], Rene Urquidez-Romero[3] and Luis Huesca[4]

[1]Department of Nutrition and Metabolism. Coordination of Nutrition. Centro de Investigación en Alimentación y Desarrollo (CIAD), A. C. Hermosillo, Sonora. México. [2]Health Department. Universidad Iberoamericana, Ciudad de México. Ciudad de México, México. [3]Department of Health Science. Biomedical Science Institute. Universidad Autónoma de Ciudad Juárez. Ciudad Juárez, Chihuahua. México. [4]Department of Economics. Coordination of Regional Development. Centro de Investigación en Alimentación y Desarrollo (CIAD), A. C. Hermosillo, Sonora. México

Abstract

Introduction: the prevalence of metabolic syndrome (MetS) is high in older people, and several factors have been explored as main determinants. However, few data exist for older people from low- and middle-income countries. Therefore, our objective was to estimate the prevalence of MetS. Secondly, to explore which of the cardio-metabolic, body composition, inflammatory and demographic risk factors were associated with the prevalence of MetS in a population of older Mexican adults.

Methods: data for this analysis were collected in subjects over 60 years of age from northwest Mexico. Fasting and two-hour glucose, fasting insulin, homeostasis model assessment of insulin resistance, lipid profiles, markers of adiposity and inflammation, and blood pressure were assessed. In addition, anthropometry and body composition data, levels of physical activity and demographic variables were also considered. MetS was diagnosed by three different criteria.

Results: total sample size was 369 subjects. The prevalence of MetS varied widely, from 36% to 52% depending on the criteria applied, but regardless of the criteria, all subjects with MetS were heavier and more overweight, and had higher triglyceride values and lower values of total HDL-cholesterol compared to those without MetS ($p < 0.0001$). Final models adjusted for age showed that, regardless of the diagnostic criteria applied, fat mass, the homeostasis model assessment and some demographic variables were main determinants of MetS in this sample of older people without diabetes.

Conclusions: the prevalence of MetS is relatively high in non-diabetic older adults and it was associated with some biological and demographic factors as the main determinats.

Key words:

Demographic status. Inflammation markers. Insulin resistance. Metabolic syndrome. Older people. Risk factors.

Resumen

Introducción: la prevalencia de síndrome metabólico (SMet) es alta en los adultos mayores y se han explorado diversos factores como los principales determinantes. Sin embargo, existen pocos datos para los adultos mayores de países de ingresos bajos y medios. Por lo tanto, nuestro objetivo fue estimar la prevalencia de SMet. Segundo, se exploraron cuáles de los factores cardiometabólicos, de composición corporal, inflamatorios y demográficos fueron los principales determinantes del SMet.

Métodos: se incluyeron 369 sujetos mayores de 60 años de edad del noroeste de México. Se determinaron la glucosa en ayuno y de dos horas y la insulina en ayuno, y se realizó la evaluación del modelo homeostático de resistencia a la insulina, perfil de lípidos, de los marcadores de adiposidad e inflamación y la presión sanguínea. También se consideraron los datos de antropometría y composición corporal, la actividad física y las variables demográficas. El SMet se diagnosticó por tres diferentes criterios.

Resultados: la prevalencia de SMet varió ampliamente de 36 a 52% y fue dependiente del criterio aplicado. Independientemente del criterio, todos los sujetos con SM presentaron sobrepeso y tenían valores más altos de triglicéridos y valores más bajos de colesterol HDL comparados con aquellos sin SMet ($p < 0,0001$). La masa grasa, el modelo de determinación de la homeostasis y algunas variables demográficas fueron los principales determinantes del SMet en esta muestra de adultos mayores sin diabetes.

Conclusiones: la prevalencia de SMet es relativamente alta en adultos mayores no diabéticos y se asoció con algunos factores biológicos y demográficos como los principales determinantes.

Palabras clave:

Factores demográficos. Marcadores de inflamación. Resistencia a la insulina. Síndrome metabólico. Adultos mayores. Factores de riesgo.

Received: 24/08/2017 • Accepted: 18/09/2017

Alemán-Mateo H, López Teros MT, Urquidez-Romero R, Huesca L. Prevalence of metabolic syndrome and its determinants in older Mexican non-diabetic adults. Nutr Hosp 2018;35:294-304

DOI: http://dx.doi.org/10.20960/nh.1518

Correspondence:

Heliodoro Alemán Mateo. Department of Nutrition and Metabolism. Centro de Investigación en Alimentación y Desarrollo (CIAD), A. C. Carretera a La Victoria, km 0,6. 83304. Hermosillo, Sonora. México. Apartado postal 1735. C. P. 83304
e-mail: helio@ciad.mx

INTRODUCTION

Metabolic syndrome (MetS) is characterized by a cluster of cardio-metabolic risk factors that includes abdominal obesity, high blood pressure, increased glucose concentrations, and dyslipidemia (1,2). MetS is highly-prevalent in geriatric populations, where it varies from 11-43%, 23-55%, and 37-41.9%, according to the World Health Organization, the National Cholesterol Education Program-Third Adult Treatment Panel (ATP III), and the International Diabetes Federation (IDF), respectively (3-7). The clinical impact of MetS in older adult populations consists in its association with cardiovascular morbidity (4,7-10) and mortality (11-13).

The underlying causes of MetS are still being studied. Though insulin resistance and central obesity are currently considered as the most significant factors (1), other important contributing factors include inflammation, endothelial, renal and hepatic dysfunction, and oxidative stress (14). Also, recent studies had reported an association of MetS with such gender-specific risk factors as demographic variables (socioeconomic status, educational level and marital status, among others) in adult (15,16) and older adult subjects (17-21). To our knowledge, there are few specific studies of the association between socioeconomic status and MetS in older people, and even fewer of older people in developing countries. It is well-known that the prevalence of MetS increases with age, especially in individuals with high body-mass index (BMI) and low levels of physical activity (22).

In Mexico, the over-60 population has grown considerably. At the same time, obesity, central obesity, type 2 diabetes and hypertension, among other ailments, have become significant public health issues (23,24). In addition, an important segment of older Mexican people have low educational levels, a large proportion has neither formal jobs nor pensions, and others have extremely low incomes. Many are single; indeed, living alone is quite common in this age group (25). Unfortunately, few data exist on the prevalence and determinants of MetS in relation to cardio-metabolic, body composition and inflammatory profiles, or to associated demographic factors in older people from low- and middle-income countries. Therefore, the objective of the present study was to estimate the prevalence of MetS and, secondly, to explore which of the cardio-metabolic, body composition, inflammatory and demographic risk factors were associated with the prevalence of MetS in a population of older Mexican adults.

METHODS

A non-probabilistic, cross-sectional study was conducted with older people from the city of Hermosillo and some rural areas of Municipality of Hermosillo, Sonora, Mexico. During visits to homes and clubs, short interviews were conducted to invite older people to participate, in order to gather information on their health and nutritional status. All potential participants then underwent a comprehensive medical examination, an oral glucose tolerance test (OGTT) and other biochemical determinations. Anthropometric measurements were taken and body composition was assessed. A series of demographic variables was also evaluated as part of the study protocols. The research protocol was carried out in the Laboratory of Body Composition and Functionality, Coordination of Nutrition, Research Center for Food and Development, and was approved by the Ethics Committee of CIAD, A.C. All volunteers were fully informed and signed the consent form before commencing the protocol.

STUDY POPULATION

The total sample comprised 369 participants, and included 195 women and 174 men over 60 years old (range: 60-83 years) who were physically independent according to the Katz scale (26) and in free-living conditions. Participants underwent a general medical examination and urine analyses and an oral glucose tolerance tests (OGTT). Subjects were free of type 2 diabetes as determined by the OGTT and the 1997 ADA criteria (27) and were also free of other major chronic diseases, according to their clinical histories. Controlled hypertensive subjects and those with controlled endocrine disorders such as hypothyroidism were included.

MEASURES

Anthropometry and body composition assessment

Body weight and standing height were recorded, and BMI (kg/m^2) was determined and used as indirect marker of adiposity (overweight and obesity) (28). Waist circumference (WC) was measured to the nearest 0.1 cm at the umbilicus level using a fiberglass measuring tape. Body composition including fat-free mass (FFM), total appendicular skeletal muscle mass (TASM) and fat mass (FM) was measured by DXA using DPX-MD+™ (GE Lunar Madison, WI, USA), as previously published (29). Fat mass index (FMI), kg/m^2 was obtained and considering the FMI values and the classification proposed by Kelly et al. (2009), three categories were formed (30). Both, FM and FMI were used as direct marker of adiposity.

Cardio-metabolic and inflammatory biochemical determinations

After an 8-12 h overnight fast, whole blood samples (20 ml) were collected. Glucose levels were measured using the glucose oxidase method, while serum insulin was analyzed by radioimmunoassay (Iso Data, IL, USA) following the Coat-A-Count® procedure (Coat-A-Count, DPC) and by enzyme-linked immunosorbent assay (DRG Instruments GmbH, Marburg, Germany), using ALPCO™ (cat. EIA2935 DRG). The homeostasis model assessment (HOMA) of insulin resistance (HOMA-IR) was calculated using the Matthews' equation (31) and insulin resistance was defined based on percentile distribution using the 75th per-

centile (HOMA-IR = 2.43). Lipid profile was calculated by the enzymatic-colorimetric method and, more recently, by RX monza (Randox Laboratories Ltd; Crumlin, UK). Serum interleukin 6 (IL-6) and C-reactive protein (CRP) concentrations were measured by ELISA High Sensitivity HS600 Quantikine® kit (R&D Systems Inc., Minneapolis, MN, USA).

Blood pressure measurements

Blood pressure (BP) was measured with a mercury column sphygmomanometer (Graham-Field™ Inc., NY, USA). The values reported are the mean of two measurements. In relation to the application of the MetS criteria, subjects with a systolic BP > 130 or diastolic BP > 85 mmHg, or who were taking medications for previously-diagnosed hypertension were registered as hypertensive (ATP III and AHA/NHLBI), while for the 2009 IDF standards, systolic BP ≥ 130 or diastolic BP ≥ 85 mmHg, or treatment of previously-diagnosed hypertension were the parameters used.

Assessment of demographic variables

In the study protocol, age and gender were recorded. Family income was ascertained from the amount estimated by subjects considering all household members who contributed to total monthly family income. Classification of socioeconomic status followed the procedure in Esteban et al. (2007) obtaining three socioeconomic (SES) groups (Low SES group: 38.7%; medium: 46.7%; high: 14.6%) (32). The estimates in this study for the low SES group (the poor) comprised 52%, in line with those shown in official poverty figures from CONEVAL (2015) (33). In addition, educational level was classified in accordance with Mexico's educational system. Technical careers were also considered when classifying educational levels. Marital status, toxicities (smoking and alcoholism) and employment status were identified.

Physical activity level

Physical activity levels (PAL) were estimated by predictive equations that estimate total energy expenditure and resting metabolic rate in older people (34). PAL was classified as sedentary, moderately active, vigorously active, and extremely active (28).

Diagnoses of MetS

We applied three sets of criteria to diagnose Mets: ATP III (35), ATP III modified by the AHA/NHLBI in 2005 (AHA/NHLBI) (1), and the 2009 IDF classification (36). For the 2009 IDF criteria (36), the cut-off points for WC recommended for Asian populations were used.

Statistical analysis

Student's t-tests or Chi-squared tests were used to compare several characteristic of the subjects with and without MetS. The main associated factors of the MetS were explored by multiple logistic regression, both univariate analysis and multivariate stepwise regression methods. It is important to specify that models were constructed separately for MetS as diagnosed by the ATP III, AHA/AHLBI, and 2009 IDF criteria. Models were evaluated for logistic regression assumptions (*i.e.*, lack of strongly-influential outliers) and interactions of all variables in the model with gender were tested at $p \leq 0.1$. All analyses were performed using STATA (version 11.0; Stata Corp, College Station, TX, USA).

RESULTS

The mean age of the total sample was 68.9 ± 6.5 years, and they had a mean BMI of 27.3 ± 3.9 kg/m^2. Women represented 53% of the total sample. Overall prevalence of MetS was 36% and 45% according to ATP III and AHA/NHLBI, respectively, increasing to 52% with the 2009 IDF criteria.

Table I shows the behavior of several cardio-metabolic, marker of adiposity, inflammatory and demographic variables according to the different criteria used. Subjects with MetS were heavier and had greater BMI, FM, FMI, and WC. Overweight and obesity were more prevalent in subjects with MetS, regardless of the criteria applied ($p < 0.0001$). Additionally, they had higher values of triglycerides and lower values of total HDL-cholesterol compared to those without MetS ($p < 0.0001$). Fasting glucose, insulin and HOMA were significantly higher in the MetS group diagnosed by AHA/NHLBI and 2009 IDF criteria. Also, an effect of gender and hypothyroidism was found. MetS was also more prevalent in older subjects with educational levels of high school or less, single or widowler or divorce, low socioeconomic status, and those who were sedentary or had low physical activity levels, regardless of the criteria applied.

Table II shows the potential predictors of MetS. Waist circumference, BMI, FM, FMI, fasting glucose and insulin, HDL-cholesterol, triglycerides, gender, educational level, alcohol consumption, PAL, BMI, owerweight and obesity by BMI classification and hypertension, all proved to be predictors of MetS defined by all three sets of criteria ($p \leq 0.2$). Other variables were selected as predictors of MetS, but for only one or two criteria, such as residence (rural and urban), marital status, socioeconomic status, obesity by FMI classification and HOMA and insulin resistance.

Tables III, IV and V show the final separate models, and in which the components of each of the three criteria used for MetS were not included. These models were adjusted for age, and shows that both, biological and demographic variables such as fat mass and HOMA, and schooling, socioeconomic status, and physical activity level, respectively were the best predictors of MetS defined by the ATP III, AHA/NHLBI and IDF criteria. The OR for each predictor of the different criteria is depicted in the tables III, IV and V.

[Nutr Hosp 2018;35(2):294-304]

Table I. Behavior of several cardio-metabolic, body composition compartments, inflammatory and demographic variables according to MetS status as defined by three different sets of criteria

Variables	MetS								
	2001 NECP ATP III			2005 AHA/NHLBI			2009 IDF		
	Without	With	p-value	Without	With	p-value	Without	With	p-value
Age, years	69.2 ± 6.6	68.4 ± 6.3	0.2440	69.2 ± 6.7	68.5 ± 6.4	0.3297	69.1 ± 6.3	68.8 ± 6.7	0.5174
Body weight, kg	69.6 ± 11.6	74.3 ± 12.3	0.0003	67.9 ± 10.8	75.5 ± 12.1	0.0000	67.5 ± 10.6	75.0 ± 12.2	0.0000
Height, m	1.67 ± 0.09	1.60 ± 0.09	0.0103	1.62 ± 0.09	1.60 ± 0.08	0.1742	1.62 ± 0.08	1.61 ± 0.09	0.2196
BMI, kg/m^2	26.34 ± 3.7	28.9 ± 3.7	0.0000	25.8 ± 3.7	29.1 ± 3.5	0.0000	25.7 ± 3.8	28.7 ± 3.5	0.0000
Waist circumference, cm	94.5 ± 10.8	103.1 ± 9.9	0.0000	92.3 ± 10.0	103.6 ± 9.7	0.0000	92.7 ± 10.3	102.4 ± 10.1	0.0000
Fat-free mass, kg	44.3 ± 9.0	43.2 ± 9.4	0.2563	43.8 ± 8.9	43.9 ± 9.6	0.9097	43.5 ± 8.6	44.2 ± 9.7	0.4759
TASM, kg	18.5 ± 4.2	17.9 ± 4.4	0.2494	41.4 ± 8.5	41.5 ± 9.2	0.9136	41.1 ± 8.2	41.7 ± 9.3	0.4654
Fat mass, kg	24.1±8.7	29.5±7.7	0.0000	22.9±8.5	29.8±7.4	0.0000	22.9±8.8	29.1±7.5	0.0000
Fat mass index, kg/m^2	9.3 ± 2.6	10.6 ± 2.5	0.0000	9.0 ± 2.6	10.7 ± 2.3	0.0000	9.0 ± 2.7	10.5 ± 2.3	0.0000
Fasting glucose (mg/dl)	94.7 ± 8.5	96.4 ± 10.5	0.0941	93.2 ± 8.1	97.9 ± 9.9	0.0000	93.2 ± 8.0	97.4 ± 9.9	0.0000
Fasting insulin, UI/ml	9.2 ± 4.4	9.9 ± 7.1	0.4213	8.9 ± 4.0	10.0 ± 6.9	0.0524	8.6 ± 3.2	10.2 ± 7.0	0.0057
HOMA	2.19 ± 1.08	2.33 ± 1.76	0.3220	2.07 ± 0.94	2.45 ± 1.73	0.0072	1.99 ± 0.79	2.47 ± 1.70	0.0006
Insulin resistance, %									
Yes	65.9	34.0	0.5957	56.3	43.7	0.3726	51.2	48.8	0.2000
No	62.9	37.0		51.0	49.0		43.6	56.4	
Total cholesterol, mg/dl	207.4 ± 38.2	205.9 ± 41.2	0.7457	207.7 ± 3.2	205. ± 41.2	0.6387	208.0 ± 36.6	205.7 ± 41.7	0.5806
HDL-cholesterol, mg/dl	54.1 ± 15.1	39.0 ± 9.1	0.0000	54.6 ± 15.8	41.3 ± 10.4	0.0000	55.6 ± 15.8	41.8 ± 10.8	0.0000
Triglycerides, mg/dl	126.2 ± 66.8	177.5 ± 63.6	0.0000	124.3 ± 65.9	169.9 ± 66.9	0.0000	120.6 ± 65.5	168.4 ± 66.3	0.0000
LDL-cholesterol, mg/dl	128.3 ± 33.1	131.9 ± 35.1	0.3211	128.5 ± 32.2	131.9 ± 35.8	0.4495	128.4 ± 31.5	130.9 ± 36.0	0.4751
CRP, log natural (mg/l)	0.87 ± 0.83	1.0 ± 0.63	0.3257	0.77 ± 0.81	1.0 ± 0.67	0.0298	0.82 ± 0.75	1.0 ± 0.76	0.1689
IL-6 log natural (pg/ml)	0.67 ± 0.95	0.81 ± 0.65	0.3076	0.58 ± 0.98	0.86 ± 0.67	0.0579	0.57 ± 1.0	0.84 ± 0.66	0.0651
Gender, % women	54.9	45.1	0.0002	47.7	52.3	0.0028	43.6	56.4	0.0197
Residence, %									
Rural	52.0	48.0		41.6	58.4		41.7	58.3	
Urban	65.4	34.6	0.0731	57.0	43.0	0.0463	50.5	49.5	0.2553
Schooling, %									
High school,	80.2	19.8		71.4	28.6		62.6	37.4	
High school or less	58.4	41.6	0.0002	49.6	50.4	0.0003	45.2	54.8	0.0041
Marital status, %									
Married or common-law	65.1	34.9		60.9	39.1		50.7	49.3	
Single or widow/er or divorced	58.8	41.2	0.2514	44.6	55.4	0.0026	44.7	55.3	0.3026

(Continue in the next page)

Table I (Cont.). Table I. Behavior of several cardio-metabolic, body composition compartments, inflammatory and demographic variables according to MetS status as defined by three different sets of criteria

Variables	MetS								
	2001 NECP ATP III			2005 AHA/NHLBI			2009 IDF		
	Without	With	p-value	Without	With	p-value	Without	With	p-value
Employment status, %									
Manual and non-manual	67.6	32.4		57.6	42.4		54.0	56.0	
None	62.3	37.7	0.3433	54.8	45.4	0.6179	47.7	52.3	0.2685
Smoking, %									
No	63.2	36.8		53.9	46.1		48.8	51.2	
At least 100 cigarettes	66.6	33.4	0.6909	63.6	36.4	0.2833	51.5	48.5	0.7622
Alcohol consumption, %									
No	59.3	40.7		51.2	48.8		45.3	54.7	
Yes	74.3	25.7	0.0148	60.9	39.1	0.1289	54.9	45.1	0.1363
Chronic disease, %									
No	64.6	35.4		55.5	44.5		49.4	50.6	
Yes	58.6	41.6	0.5175	51.7	48.3	0.6961	48.3	51.7	0.9084
Hypertension, %									
No	63.8	36.2		55.2	44.8		49.3	50.6	
Yes	64.8	35.2	0.8879	53.7	46.3	0.8319	48.1	51.9	0.8715
Body mass index, %									
Normal	81.8	18.2		80.9	19.1		76.4	23.6	
Overweight	60.3	39.7		51.1	48.9		43.1	56.9	
Obese	47.0	53.0	0.0000	29.4	70.6	0.0000	27.0	73.0	0.0000
SES, %									
High	13.5	6.1		13.5	7.4		13.8	8.0	
Medium	53.9	43.1		53.7	44.4		50.9	48.1	
Low	33.6	50.4	0.0030	32.8	48.2	0.0080	35.3	43.9	0.1070
PAL, %									
Active or moderately active	96.1	3.9		96.1	3.9		92.3	7.7	
Sedentary or light	61.2	38.8	0.0004	51.9	48.1	0.0000	46.0	54.0	0.0000
Heart disease, %									
No	63.7	36.3		55.1	44.9		49.1	50.9	
Yes	71.4	28.6	0.6740	42.8	58	0.5178	42.8	57.2	0.7419
Hypothyroidism, %									
No	62.8	37.2		53.4	46.6		47.2	52.8	
Yes	93.3	6.7	0.0157	93.3	6.7	0.0023	93.3	6.7	0.0005

BMI: body mass index; HOMA: homeostasis model assessment; TASM: total appendicular skeletal muscle; HDL: high-density lipoprotein; LDL: low-density lipoprotein; CRP: C-reactive protein; IL-6: interleukin 6; SES: socioeconomic status; PAL: physical activity level. A Student's t-test was used for continuous variables and Chi-squared test for categorical variables.

[Nutr Hosp 2018;35(2):294-304]

Table II. Univariate associations of potential predictors of MetS as defined by three different sets of criteria

Variables	MetS								
	2001 NECP ATP III			2005 AHA/NHLBI			2009 IDF		
	OR	SE	p	OR	SE	p	OR	SE	p
Age, years	0.98	0.02	0.244†	0.98	0.02	0.329†	0.99	0.02	0.362†
Waist circumference, cm	1.08	0.01	0.000	1.12	0.02	0.000	1.09	0.01	0.000
BMI, kg/m^2	1.20	0.04	0.000	1.29	0.05	0.000	1.26	0.04	0.000
TASM, kg	0.97	0.03	0.247†	1.00	0.02	0.941†	1.03	0.03	0.304†
Fat mass, kg	1.08	0.02	0.000	1.11	0.02	0.000	1.09	0.02	0.000
Fat mass index, kg/m^2	1.22	0.06	0.000	1.34	0.07	0.000	1.30	0.06	0.000
Fasting glucose, mg/dl	1.02	0.01	0.095	1.06	0.01	0.000	1.06	0.01	0.000
HOMA	1.08	0.09	0.339†	1.34	0.15	0.009	1.60	0.21	0.000
Fasting insulin, UI/ml	1.02	0.02	0.432	1.05	0.03	0.007	1.09	0.03	0.004
Total cholesterol, mg/dl	1.00	0.00	0.745†	1.00	0.00	0.638†	1.00	0.00	0.394†
HDL-cholesterol, mg/dl	0.89	0.01	0.000	0.92	0.01	0.000	0.91	0.01	0.000
Triglycerides, mg/dl	1.01	0.00	0.000	1.01	0.00	0.000	1.01	0.00	0.000
LDL-cholesterol, mg/dl	1.00	0.00	0.320†	1.00	0.00	0.448†	1.00	0.00	0.610†
C-reactive protein, mg/l*	1.26	0.29	0.324†	1.67	0.40	0.033†	1.22	0.29	0.382†
Interleukin 6, pg/ml*	1.25	0.27	0.306†	1.51	0.33	0.061†	1.39	0.30	0.132†
Gender, % women	2.29	0.51	0.000	1.89	0.40	0.003	1.42	0.30	0.095
Residence, %									
Rural	Ref.			Ref.			Ref.		
Urban	0.57	0.18	0.076	0.54	0.17	0.049	0.76	0.24	0.371†
Schooling, %									
High school	Ref.			Ref.			Ref.		
High school or less	2.56	0.80	0.003	2.18	0.61	0.006	1.61	0.43	0.072
Marital status, %									
Married or common-law	Ref.			Ref.			Ref.		
Single or widow/er or divorced	1.40	0.33	0.156	1.33	0.31	0.217†	1.24	0.29	0.350†
Employment status, %									
Manual and non-manual	Ref.			Ref.			Ref.		
None	1.26	0.31	0.344†	1.12	0.26	0.618†	1.15	0.27	0.532†
Smoking, %									
No	Ref.			Ref.			Ref.		
At least 100 cigarettes	1.17	0.38	0.624†	0.85	0.27	0.616†	0.89	0.28	0.724†

(Continue in the next page)

Table II (Cont.). Univariate associations of potential predictors of MetS as defined by three different sets of criteria

Variables	MetS								
	2001 NECP ATP III			2005 AHA/NHLBI			2009 IDF		
	OR	SE	p	OR	SE	p	OR	SE	p
Alcohol consumption, %									
No	Ref.			Ref.			Ref.		
Yes	0.54	0.15	0.027	0.72	0.19	0.204	0.80	0.20	0.374†
SES, %									
High	Ref.			Ref.			Ref.		
Medium	1.81	0.77	0.166	1.51	0.58	0.276†	1.62	0.59	0.184
Low	3.30	1.43	0.006	2.68	1.04	0.011	2.13	0.80	0.043
PAL, %									
Active or moderately-active	Ref.			Ref.			Ref.		
Sedentary or light	15.83	16.24	0.007	23.17	23.76	0.002	15.08	11.22	0.000
Heart disease, %									
No	Ref.			Ref.					
Yes	0.70	0.59	0.676†	1.64	1.26	0.522†	1.20	0.93	0.811†
BMI classification, %									
Normal	Ref.			Ref.			Ref.		
Overweight	2.96	0.86	0.000	4.05	1.16	0.000	3.69	0.97	0.000
Obesity	5.06	1.67	0.000	10.17	3.46	0.000	7.19	2.33	0.000
FMI classification, %									
Normal	Ref.			Ref.			Ref.		
Excess fat	1.07	0.31	0.821†	1.38	0.40	0.269†	1.47	0.41	0.167
Obesity	1.49	0.45	0.188	2.57	0.77	0.002	2.96	0.88	0.000
Hypertension, %									
No	Ref.			Ref.			Ref.		
Yes	3.38	0.76	0.000	3.44	0.76	0.000	4.05	0.91	0.000
Insulin resistance, %									
No	Ref.			Ref.			Ref.		
Yes	0.88	0.22	0.596†	1.23	0.30	0.373†	1.48	0.36	0.103
Chronic diseases, %									
No	Ref.			Ref.			Ref.		
Yes	1.29	0.51	0.518†	1.63	1.26	0.522†	1.20	0.93	0.811†

BMI: body mass index; HOMA: homeostasis model assessment; TASM: total appendicular skeletal muscle; HDL: high-density lipoprotein; LDL: Low-density lipoprotein; SES: socioeconomic status; PAL: physical activity level; FMI: fat mass index; Ref: reference. †Variables not selected for the multivariate analysis according to the criteria p≤0.2 and/or a reduced number of observations or categories. OR: odds ratio; SE: standard error.

Table III. Association between MetS defined by the 2001 NECP ATP III criteria as dependent variable and fat mass and demographic variables as risk factors

Independent variables	OR	SE	CI 95%	p-value
Fat mass, kg	1.08	0.02	1.05-1.12	0.000
Schooling, %				
High school	Ref			
High school or less	2.07	0.70	1.07-4.02	0.032
SES, %				
High	Ref			
Medium	1.72	0.79	0.70-4.22	0.235
Low	3.29	1.56	1.29-8.33	0.012

Stepwise backward using logistic regression analysis using MetS as the dependent variable. The model was age-adjusted. SES: socioeconomic status; OR: odds ratio; *SE: standard error; CI: confidence intervals.*

Table IV. Association between MetS defined by 2005 AHA/NHLBI criteria as dependent variable and fat mass and demographic variables as risk factors

Independent variables	OR	SE	CI 95%	p-value
Fat mass, kg	1.11	0.02	1.07-1.14	0.000
Schooling, %				
High school	Ref			
High school or less	1.87	0.61	0.99-3.54	0.054
PAL, %				
Active or moderately-active	Ref			
Sedentary or light	9.40	10.02	1.16-76.10	0.036
SES, %				
High	Ref			
Medium	1.51	0.64	0.66-3.46	0.325
Low	3.38	1.53	1.39-8.22	0.007

Stepwise backward by logistic regression analysis using MetS as the dependent variable. The model was age-adjusted. PAL: physical activity level; SES: socioeconomic status; OR: odds ratio; *SE: standard error; CI: confidence intervals.*

Table V. Association between MetS defined by 2009 IDF criteria as dependent variable and fat mass, HOMA and demographic variables as risk factors

Independent variables	OR	SE	CI 95%	p-value
Fat mass, kg	1.07	0.02	1.03-1.10	0.000
HOMA	1.60	0.25	1.18-2.18	0.002
PAL, %				
Active or moderately-active	Ref			
Sedentary or light	14.12	14.95	1.77-112.42	0.012
SES, %				
High	Ref			
Medium	2.65	1.11	1.16-6.00	0.021
Low	4.78	2.12	2.01-11.39	0.000

Stepwise backward by logistic regression analysis using MetS as the dependent variable. The model was age-adjusted. HOMA: homeostasis model assessment; PAL: physical activity level; SES: socio-economic status. OR: odds ratio; SE: standard error; CI: confidence intervals.

DISCUSSION

The prevalence of MetS in this Mexican aged group is high, and varies widely according to the diagnostic criteria used (p = 0.0001), with the 2009 IDF standards generating the highest prevalence. Similar findings have been reported by studies carried out in some Latin American countries with older people (5,6,21). This could be explained largely by the high proportion of obesity, especially central obesity, in this age group. In fact, recent evidence underscores that older obese people with MetS have more abdominal visceral fat, but less subcutaneous thigh fat than older obese people without this condition (37). To our knowledge, few studies have explored cardio-metabolic, body composition, inflammatory and demographic variables as the main the determinants of MetS in older people in a developing country. Our results show that this high prevalence is strongly and consistently associated with fat mass as direct marker of adiposity in this age group. It is important to note that, aside from fat mass and HOMA, only some sociodemographic variables assessed in this study were found to be mainly determinants of the high prevalence of MetS. Therefore, our findings are important and may help define specific lifestyle and demographic strategies for preventing MetS in this vulnerable age group as evidence of the association between MetS and cardiovascular mortality in older adult population continues to accumulate (11-13).

At the national level, the prevalence of MetS in older people is relatively high in Mexico. The 2012 National Health and Nutrition Survey (2012 ENSANUT for its initials in Spanish) reported a prevalence of MetS of 56.3% using the ATP III criteria, 60.8% according to the AHA/NHLBI's definition, and 67.9% by the IDF criteria (24). The prevalence found in this non-representative sample is lower (36%, 45% and 52% according to the ATP III, AHA/NHLBI, and 2009 IDF criteria, respectively), perhaps because our study excluded subjects diagnosed with type 2 diabetes by the 1977 ADA criteria (28), while the ENSANUT report included them. However, independently of the inclusion of diabetics, prevalence in this non-representative sample is high, indicating that greater attention must be paid to preventing this condition. Overall, prevalence of MetS in this age group is within the range reported for other, non-Latin American populations (3,4,7). Thus, it seems that the presence of MetS in older adult populations is relatively high regardless of genetic background, environmental exposures and the diagnostic criteria used.

Central obesity, hypertension and low-HDL-cholesterol were the most frequent criteria components found in subjects with MetS, and similar results have been reported by other studies in adults and older people (12,38). Central obesity was consistently the most prevalent factor identified by each set of criteria (87%, 87% and 99% by the ATP III, AHA/NHLBI, and 2009 IDF, respectively), followed, in second place, by hypertension (84%, 81% and 79% by the ATP III, AHA/NHLBI and 2009 IDF criteria, respectively), and then low HDL-cholesterol (87%, 75% and 72%, respectively). It is interesting to note that low HDL-cholesterol was the most prevalent component of abnormality found in a study of young and middle-aged Korean men and women (39). In our sample, the prevalence of central obesity, hypertension and low HDL-cholesterol were related to the increasing prevalence of MetS, which has been found to be relatively high among older age groups (40).

The regression analysis showed that most of the variables were determined to be significant predictors of MetS, but that some cardio-metabolic, body composition, inflammatory and demographic variables (including age, TASM, total cholesterol, LDL-cholesterol, CRP, interleukin-6, marital status, employment status, smoking, alcohol consumption, insulin resistance and chronic diseases) were not selected as predictors of MetS (Table II). It is important to note that several studies have shown a strong association between demographic variables and MetS in adult and fewer in older adult subjects (15-21). In fact, in this study we found a significant association between schooling or education level, socioeconomic status based on family income, and physical activity level with MetS, together with several biological factors as shown in table I and II. In addition, multiple logistic regression results presented in tables III, IV and V show that high school or less; low SES and sedentary or light activities, together with fat mass and HOMA as independent variables were main determinants, regardless of the criteria used. Therefore, our results do support that fat mass as direct marker of adiposity and HOMA, and some demographic variables as the main determinants of the high prevalence of MetS. Other studies have reported a significant association between such variables as gender, socioeconomic status, educational level and marital status, among others, with MetS in adults (15-16) and older adult subjects (17-21).

Importantly, there are few studies in older people and the results are controversial about the association between SES, schooling and MetS, and fewer on the association between PAL and MetS (17-21,41,42). These three factors are important indicators of social status. The role of education level in the development of MetS is unclear nowadays. However, it has been reported that SES or income and education level can influence health behaviors, psychological distress, neighborhood characteristics, and access to health care (42). Regarding to the association between fat mass and MetS, some studies have shown a significant association; however, this component no added value over other markers of adiposity such as WC and BMI (43,44). In the elderly, adiposity particularly peripheral subcutaneous fat and trunk subcutaneous fat are associated with insulin resistance and this last one is one of the markers of MetS (45).

In accordance with the results of our multiple logistic regression analysis, it is clear that in addition to fat mass and HOMA, some demographic variables were main determinants of MetS in older subjects who may, therefore, be at high risk of cardiovascular morbidity and mortality. Of the total mortality recorded in Mexico in 2014 (633,000 deaths), 63.9% corresponded to people aged ≥ 60. Heart diseases (16.9%), cerebrovascular diseases (6.8%) and hypertension (4.7%) were the main contributing factors to all deaths that occurred in this population group (INEGI, 2014) (46). Therefore, we must give high priority to defining and implementing strategies to prevent MetS in this growing, older Mexican adult population.

The present study had some limitations. Firstly, all subjects included were free of type 2 diabetes, using the former criteria of

2 hour glucose value OGTT (fasting glucose ≥ 126 or ≥ 200 mg/dL at 2 h). Therefore, prevalence of MetS found is only valid for this particular sample. Second, HOMA to define insulin resistance and its associations could not be determined using the hyperinsulinemic-euglycemic clamp. However, it is well known that the method used in the present study correlated well with the hyperinsulinemic-euglycemic clamp. Additionally, the methods used for insulin determination in the three different mentioned studies varied in sensitivity. Third, this is a cross-sectional study, therefore only an association, not a causal relationship, is shown. Further studies in different settings are required to explore the effect of demographic variables as determinant of MetS in older people.

In conclusion, metabolic syndrome is highly prevalent in non-diabetic older adults and non-representative sample. In this study, the main determinants were fat mass and HOMA, and some demographic variables, mainly schooling, physical activity and SES. It is well-known that all these risk factors are potentially modifiable at general population. However, more research in other population on the interrelation between MetS and socioeconomic status and other demographic variables would provide additional evidence and allow us to identify other significant factors and to strength our results. At present, however, our findings support the importance of strengthening specific lifestyle strategies to prevent MetS in this vulnerable age group.

ACKNOWLEDGMENTS

The authors wish to thank CONACYT for funding some projects (J37891-M, CB-2013-01/000000000221664, S0008-2010-1-140157). Also, we thank the funds of the International Atomic Energy Agency (IAEA, research contract No. 12694/R0), the Research Center for Food and Development, and the Kellogg Institute of Nutrition and Health. From these funds this work was derived.

REFERENCES

1. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735-52.
2. Alberti KG, Zimmet P, Shaw J. Metabolic syndrome - A new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med 2006;23:469-80.
3. Denys K, Cankurtaran M, Janssens W, Petrovic M. Metabolic syndrome in the elderly: an overview of the evidence. Acta Clin Belg 2009;64:23-34.
4. Hadaegh F, Zabetian A, Tohidi M, Ghasemi A, Sheikholeslami F, Azizi F. Prevalence of metabolic syndrome by the Adult Treatment Panel III, International Diabetes Federation, and World Health Organization definitions and their association with coronary heart disease in an elderly Iranian population. Ann Acad Med Singapore 2009;38:142-9.
5. Sempértegui F, Estrella B, Tucker KL, Hamer DH, Narvaez X, Sempértegui M, et al. Metabolic syndrome in the elderly living in marginal peri-urban communities in Quito, Ecuador. Public Health Nutr 2011;14:758-67.
6. Rigo JC, Vieira JL, Dalacorte RR, Reichert CL. Prevalence of metabolic syndrome in an elderly community: comparison between three diagnostic methods. Arq Bras Cardiol 2009;93:85-91.
7. Maggi S, Noale M, Gallina P, Bianchi D, Marzari C, Limongi F, et al. Metabolic syndrome, diabetes, and cardiovascular disease in an elderly Caucasian cohort: the Italian Longitudinal Study on Aging. J Gerontol A Biol Sci Med Sci 2006;61:505-10.
8. He Y, Jiang B, Wang J, Feng K, Chang Q, Fan L, et al. Prevalence of the metabolic syndrome and its relation to cardiovascular disease in an elderly Chinese population. J Am Coll Cardiol 2006;47:1588-94.
9. McNeill AM, Katz R, Girman CJ, Rosamond WD, Wagenknecht LE, Barzilay JI, et al. Metabolic syndrome and cardiovascular disease in older people: the cardiovascular health study. J Am Geriatr Soc 2006;54:1317-24.
10. Pradeepa R, Surendar J, Indulekha K, Chella S, Anjana RM, Mohan V. Prevalence of metabolic syndrome and its association with coronary artery disease among an urban elderly south Indian population (CURES-145). J Assoc Physicians India 2016;64:20-5.
11. Wang J, Ruotsalainen S, Moilanen L, Lepistö P, Laakso M, Kuusisto J. The metabolic syndrome predicts cardiovascular mortality: a 13-year follow-up study in elderly non-diabetic Finns. Eur Heart J 2007;28:857-64.
12. Mozaffarian D, Kamineni A, Prineas RJ, Siscovick DS. Metabolic syndrome and mortality in older adults: the Cardiovascular Health Study. Arch Intern Med 2008;168:969-78.
13. Butnoriene J, Bunevicius A, Saudargiene A, Nemeroff CB, Norkus A, Ciceniene V, et al. Metabolic syndrome, major depression, generalized anxiety disorder, and ten-year all-cause and cardiovascular mortality in middle aged and elderly patients. Int J Cardiol 2015;190:360-6.
14. Robberecht H, Hermans N. Biomarkers of metabolic syndrome: biochemical background and clinical significance. Metab Syndr Relat Disord 2016;14:47-93.
15. Park SJ, Kang HT, Nam CM, Park BJ, Linton JA, Lee YJ. Sex differences in the relationship between socioeconomic status and metabolic syndrome: the Korean National Health and Nutrition Examination Survey. Diabetes Res Clin Pract 2012;96:400-6.
16. Malayala SV, Raza A. Health behavior and perceptions among African American women with metabolic syndrome. J Community Hosp Intern Med Perspect 2016;6:30559.
17. Cho KI, Kim BH, Je HG, Jang JS, Park YH. Gender-specific associations between socioeconomic status and psychological factors and metabolic syndrome in the Korean population: findings from the 2013 Korean National Health and Nutrition Examination Survey. Biomed Res Int 2016;2016:3973197.
18. Ebrahimi H, Emamian MH, Shariati M, Hashemi H, Fotouhi A. Metabolic syndrome and its risk factors among middle aged population of Iran, a population based study. Diabetes Metab Syndr 2016;10:19-22.
19. Santos AC, Ebrahim S, Barros H. Gender, socio-economic status and metabolic syndrome in middle-aged and old adults. BMC Public Health 2008;8:62.
20. Romaguera J, Ortiz AP, Roca FJ, Colón G, Suárez E. Factors associated with metabolic syndrome in a sample of women in Puerto Rico. Menopause 2010;17:388-92.
21. Marquezine GF, Oliveira CM, Pereira AC, Krieger JE, Mill JG. Metabolic syndrome determinants in an urban population from Brazil: social class and gender-specific interaction. Int J Cardiol 2008;129:259-65.
22. Roos V, Elmståhl S, Ingelsson E, Sundström J, Ärnlöv J, Lind L. Metabolic syndrome development during aging with special reference to obesity without the metabolic syndrome. Metab Syndr Relat Disord 2017;15:36-43.
23. Shamah-Levy T, Cuevas-Nasu L, Mundo-Rosas V, Morales-Ruán C, Cervantes-Turrubiates L, Villalpando-Hernández S. Estado de salud y nutrición de los adultos mayores en México: resultados de una encuesta probabilística nacional. Salud Pública Méx 2008;50:383-9.
24. ENSANUT. Encuesta Nacional de Salud y Nutrición 2012. Accessed on August 29, 2013. Available from: http://ensanut.insp.mx/
25. Wong R, Espinoza M, Palloni A. Mexican older adults with a wide socioeconomic perspective: health and aging. Salud Pública Méx 2007;49:S436-47.
26. Katz S, Downs TD, Cash HR, Grotz RC. Progress in development of the index of ADL. Gerontologist 1970;10:20-30.
27. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diabetes Care 1997;20(7):1183-97.
28. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Geneva: World Health Organization 1997.
29. Alemán-Mateo H, Macías L, Esparza-Romero J, Astiazaran-García H, Blancas AL. Physiological effects beyond the significant gain in muscle mass in sarcopenic elderly men: evidence from a randomized clinical trial using a protein-rich food. Clin Interv Aging 2012;7:225-34.

30. Kelly TL, Wilson KE, Heymsfield SB. Dual energy X-Ray absorptiometry body composition reference values from NHANES. PLoS One 2009;4(9): e7038.
31. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 1985;28:412-9.
32. Esteban J, Gradín C, Ray D. Extensions of a measure of polarization, with an application to the income distribution of five OECD countries. J Econ Inequal 2007;5:1-19.
33. CONEVAL. Medición de la pobreza en México y en las entidades federativas 2014;2015:1:225
34. Alemán-Mateo H, Salazar G, Hernández-Triana M, Valencia ME. Total energy expenditure, resting metabolic rate and physical activity level in free-living rural elderly men and women from Cuba, Chile and México. Eur J Clin Nutr 2006;60:1258-65.
35. Expert panel on detection, evaluation and treatment of high blood cholesterol in adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert panel on detection, evaluation and treatment of high cholesterol. JAMA 2001;285:2486-97.
36. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120:1640-5.
37. Koster A, Stenholm S, Alley DE, Kim LJ, Simonsick EM, Kanaya AM, et al. Body fat distribution and inflammation among obese older adults with and without metabolic syndrome. Obesity (Silver Spring) 2010;18:2354-61.
38. Moreira GC, Cipullo JP, Ciorlia LA, Cesarino CB, Vilela-Martin JF. Prevalence of metabolic syndrome: association with risk factors and cardiovascular complications in an urban population. PLoS One 2014;9(9):e105056.
39. Park E, Kim J. Gender- and age-specific prevalence of metabolic syndrome among Korean adults: analysis of the fifth Korean National Health and Nutrition Examination Survey. J Cardiovasc Nurs 2015;30:256-66.
40. Campbell KL, Kushner H, Falkner B. Obesity and high blood pressure: a clinical phenotype for the insulin resistance syndrome in African Americans. J Clin Hypertens (Greenwich) 2004;6:364-72.
41. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. Arch Intern Med 2003;163(4):427-36.
42. Ramsay SE, Whinaup PH, Morris R, Lennon L, Wannamethee SG. Is socioeconomic position related to the prevalence of metabolic syndrome? Influence of social class across the life course in a population-based study of older men. Diabetes Care 2008;31(12):2380-82.
43. Beydoun MA, Kuczmarski MT, Wang Y, Mason MA, Evans MK, Zonderman AB. Receiver-operating characteristics of adiposity for metabolic syndrome: the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. Public Health Nutr 2011;14(1):77-92.
44. Liu PJ, Ma F, Lou HP, Zhu YN. Body roundness index and body adiposity index: two new anthropometric indices to identify metabolic syndrome among Chinese postmenopausal women. Climacteric 2016;19(5):433-9.
45. Roosheroe AG, Setiati S, Istanti R. Insulin resistance as one of indicators for metabolic syndrome and its associated factors in Indonesian elderly. Acta Med Indones 2012;44(3):199-206.
46. Lista especial de tabulados (tabulación 1 para la mortalidad). CIE-10. Fuente: INEGI. Estadísticas de defunciones, 2014. Base de datos.