ARTÍCULO ORIGINAL

Risk factors associated with the metabolic syndrome in Cali, Colombia (2013): A case-control study

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Introduction: In 2016, the World Health Organization reported that more than 2 billion adults were overweight, of whom 600 million were obese, 347 million had diabetes mellitus type II, and people with hypertension had increased from 600 million in 1980 to 1 billion in 2010. Additionally, 20% of the world's adult population will develop metabolic syndrome during their lifespan with tremendous effects for their wellbeing and the health systems.
Objective: To identify social, biological, and behavioral factors associated with the metabolic syndrome in adults to help in the design of health policies in urban environments.
Materials and methods: We included 300 cases and 675 controls. For cases, the waist circumference (abdominal obesity) in men was ≥94 cm and ≥88 cm in women, and other two factors should be present including hypertension, high glycated hemoglobin, high triglycerides, and low HDL levels. Controls presented only one or none of these risk factors.
Results: The total prevalence of metabolic syndrome was 30.2%, 33.6% in females, and 25.6% in males. Therefore, females had a higher risk of developing a metabolic syndrome (OR=1.70; 95% CI 1.17-2.47). Being a *mestizo* also increased the risk of having metabolic syndrome (OR=1.55; 95% CI 1.10-2.19). In contrast, frequent fruit consumption and being a housekeeper were protective factors: OR=0.83; 95% CI 0.69-1.00, and OR=0.58; 95% CI 0.36-0.92, respectively. Logistic regression showed that obesity had the strongest association with metabolic syndrome (OR=7.52; 95% CI 4.79-11.80). Increasing age yielded a linear trend with regard to metabolic syndrome: the OR for the 40 to 49-year-old group was 4.24 (95% CI 2.20-8.16), for the 50 to 59-year-old group, 4.63 (95% CI 2.40-8.93), and for those over 80 years of age, 5.32 (95% CI 1.92-14.71).
Conclusion: Obesity was the main risk factor associated with the metabolic syndrome. Our findings can help health policy makers to design interventions for metabolic syndrome control in urban populations in Colombia.

Key words: Metabolic syndrome; risk factors; case-control studies; logistic models; regression analysis.

Factores de riesgo asociados con el síndrome metabólico en Cali, Colombia (2013): estudio de casos y controles

Introducción. En el 2016, la Organización Mundial de la Salud reportó la existencia de casi 2000 millones de adultos con sobrepeso, de los cuales más de 600 millones presentaban obesidad, 347 millones tenían diabetes mellitus de tipo 2, y las personas con hipertensión habían aumentado de 600 millones en 1980 a mil millones en el 2010. Además, 20 % de los adultos desarrollaría el síndrome metabólico con los consecuentes efectos negativos en sus vidas y en los servicios de salud.
Objetivo. Determinar los factores de riesgo en la esfera social, biológica y de comportamiento asociados con el síndrome metabólico.
Materiales y métodos. Se seleccionaron 300 casos y 675 controles. Los casos se definieron como los hombres con una circunferencia de cintura (obesidad abdominal) de ≥94 cm y las mujeres con ≥88 cm y que presentaran, además, otros dos factores entre los siguientes: hipertensión arterial sistémica, hemoglobina 'glicosilada' alta, triglicéridos altos y bajos niveles de colesterol de baja densidad. Los controles eran personas que no presentaban ninguno de los factores de riesgo o solo uno de ellos.
Resultados. La prevalencia del síndrome metabólico fue de 30,2 %: 33,6 % en mujeres y 25,6 % en hombres. Las mujeres presentaron un mayor riesgo, con una *odds ratio* (OR) de 1,70 ($IC_{95\%}$ 1,17-2,47), seguidas por los *mestizos* con una OR de 1,55 (1,10-2,19).

El consumo regular de frutas y el ser ama de casa fueron factores protectores, con una OR de 0,83 ($IC_{95\%}$ 0,69-1,00) y de 0,58 ($IC_{95\%}$ 0,36-0,92), respectivamente. La obesidad fue el factor de riesgo con la mayor asociación (OR=7,52; $IC_{95\%}$ 4,79-11,80). El síndrome metabólico aumentó con la edad, así, las personas entre 40 y 49 años presentaron una OR de 4,24 ($IC_{95\%}$ 2,20-8,16), la de 50 a 59 años, una de 4,63 ($IC_{95\%}$ 2,40-8,93) y los mayores de 80 años, una de 5,32 ($IC_{95\%}$ 1,92-14,71).
Conclusiones. Estos hallazgos pueden facilitar la implementación de medidas de intervención para el control del síndrome metabólico.

Palabras clave: síndrome metabólico; factores de riesgo; estudios de casos y controles, modelos logísticos; análisis de regresión.

Diabetes mellitus type II is frequently associated with lipid metabolic alteration, hypertension, being overweight/obese, which leads to metabolic syndrome and, later, to cardiovascular disease and mortality (1-4). There is evidence indicating that the prevalence of the metabolic syndrome increases with age, being 24% at 20 years of age, 30% or more in those over 50 years and over 40% in those 60 years or older (5). Unless urgent public health measures are taken, drastic decreases in life expectancy and increasing expenditure for health systems might generate a negative impact on developing economies, such as Colombia and other similar countries.

The Colombian *Observatorio Nacional de Salud* reported a 15% mortality due to diabetes mellitus, while hypertension accounted for 14% (5). Another two main contributors to mortality were ischemic heart disease with 53.6% followed by cerebrovascular disease with 20.6% (6). From this national health report, it is evident that non-communicable diseases, among them the metabolic syndrome, have a huge impact on the Colombian population. Such epidemiological situation prompted our question regarding the risk factors associated with the metabolic syndrome among inhabitants from Cali, Colombia. In this context, we conducted a case-control study aimed at determining the social, biological, and behavioral factors associated with the metabolic syndrome.

Materials and methods

We collected the data for 2013 using a random and representative population survey in Cali conducted by the *Centro para el desarrollo y evaluación de políticas y tecnología en salud pública* (CEDETES) at *Universidad del Valle* with the support of Cali's public health office.

Case definition

Any man with waist circumference (abdominal obesity) of ≥94 cm or any woman with ≥88 cm plus two of the factors reported in table 1.

Table 1. Parameters used to classify subjects with metabolic syndrome according to the *Asociación Latinoamericana de Diabetes*

Parameter	*Asociación Latinoamericana de Diabetes*
High triglycerides	>150 mg/dl (or in specific lipid-lowering treatment)
Cholesterol	Cholesterol >200 mg/L
HDL (C-HDL) (less)	Men <40 mg/dl Women <50 mg/dl
High blood pressure	Systolic blood pressure (SBP) ≥130 mm Hg and/or Diastolic blood pressure (DBP) ≥85 mm Hg or under anti-hypertensive treatment
Alteration in glucose regulation	Glycated HG>7.0
LDL	LDL>150

Control definition

Any man with waist circumference of <94 cm or any woman with <88 cm plus one or none of the other criteria established for MS diagnosis.

Population and sample

We calculated the sample size for an urban population of 1,476,264 people over 15 years of age in Cali according to the most recent national population census (2005). We randomly selected 4,000 households and we visited 9,000 families (7), and we included the subjects that fullfilled the case definition, as well as a random subsample of controls.

We applied a multiple logistic regression model to identify the factors associated with the metabolic syndrome. We reported the OR and its 95% confidence interval (CI) for each of the variables that significantly contributed to the metabolic syndrome.

Subjects' age was tested as a potential confounder factor or having a modification effect (interaction), and we assessed its degree of uncertainty. Given that the study subjects came from a random sample in exposed and non-exposed subpopulations, we assumed that the sampling distribution of the data resulted from two binomial distributions. Based on this assumption, the marginal total was fixed by design and the sample was divided into several strata, which were homogenous internally with respect to the confounding factors. The strata analysis demonstrated that the OR systematically increased with age. We run a homogeneity test along the strata and, based on its result, a chi-square test for the trend.

Usually, the simple dichotomization of a risk variable in a 2 by 2 table will mask the ample rank of the association between exposure risk and disease. However, more valuable information is obtained if the values from a quantitative variable like age are grouped into ordered levels to reveal a dose-response gradient that could be critical to address the therapeutical interventions among those people already affected with metabolic syndrome and, on the other hand, to promote healthy life-styles among still healthy groups. A logistic conditional regression model was applied to determine the relationship between having a metabolic syndrome (case) or not (control), and the different social, biological, and behavioral risk factors.

Table 2. Demographics, nutritional habits, and biological measures in the metabolic syndrome cases and in the controls

	Control (n=675)		Case (n=300)		
	Average	**SD**	**Average**	**SD**	**p**
Age	47.07	17.23	53.67	14.36	0.01
BMI	25.18	4.66	28.68	5.37	0.01
Fruit consumption	0.94	0.98	1.08	0.79	0.03
Vegetable consumption	0.57	0.74	1.55	0.75	0.01
Fruit and vegetable consumption	1.52	1.33	2.63	1.18	0.01
Physical activity frequency	4.23	2.43	3.48	2.60	0.01

BMI: Body Mass Index
All results were significant.

Results

Overall metabolic syndrome prevalence was 30.2%: 33.6% in women and 25.6% in men.

Table 2 shows the characteristics of cases and controls: Controls were younger than the cases with an average age of 47 (SD=17.23) and cases' average age was 53.67 (SD=14.36) the difference being significant (p<0.01). Controls also had a lower body mass index (BMI), 25.18 kg/m² (SD=4.66), while the BMI for cases was 28.68 kg/m² (SD=5.37; p<0.01). Fruit consumption per day was higher in the control group along with the combined intake of both fruits and vegetables (p<0.01). Vegetable consumption was also higher in the control group, but it was not statistically significant. Additionally, the frequency of physical activity was higher in controls: 4.23 days per week (SD=2.43) as compared to cases with 3.48 days per week (SD=2.60; p<0.01).

Table 3 shows the comparison between cases and controls. Being female and a lack of education were the main factors associated with the metabolic syndrome, while ethnicity, civil status, occupation, and type of health insurance appeared not to be related. We also present here the antecedents of behavioral risk factors with their respective percentages categorized in a dichotomous way: Does consume or does not consume, except for the variable "Oil consumption" which included the different types of oil used in the region. This analysis indicated that there was a difference in the alcohol consumption variable: Chi-squared test (1, N=975) =7.97, p<0.05. This difference also occurred in the sugar consumption variable: chi-squared test (2, N=975) =18.5, p<0.01. On the other hand, salt consumption showed a chi-square value for trend (2, N=975) =7.42, p<0.06, while the other variables did not reveal significant differences.

Table 4 shows the results of multiple logistic regression analyses. The strongest risk factor associated with the metabolic syndrome was obesity (OR=7.52; 95% CI 4.79-11.80). Age showed a linear trend with the risk of developing metabolic syndrome. The 40 to 49-year-old group yielded an OR of 4.24 (95% CI 2.20-8.16), the 50 to 59-year-old group one of 4.63 (95% CI 2.40- 8.93), and those older than 80 years, one of 5.32 (95% CI 1.92-14.71). Other important risk factors associated with the metabolic syndrome were being overweight (OR=3.52; 95% CI 2.38-5.20), being female (OR=1.70; 95% CI 1.17-2.47), and being *mestizo* (OR=1.55; 95%CI 1.10-2.19).

Discussion

Our study aimed at identifying the social, biological, and behavioral factors associated with the metabolic syndrome in Cali in 2013.

The overall metabolic syndrome prevalence was 30.2%: 33.6% in women and 25.6% in men. Other studies have reported similar findings (8). A Peruvian study conducted by Soto and Vergara reported a global prevalence of 28.3% according to the Adult Treatment Panel III criteria (ATPIII) (9). The global prevalence in our study was also similar to that reported by Aguilar and Rojas, 25% (10). For Asian populations, Mohan Deepa reported a metabolic syndrome prevalence of 13% in China and 30% in Iran (11). In a later study he informed that the prevalence of metabolic syndrome was lower among poor people and in rural areas compared to middle class and urban populations, possibly because the rural population is more engaged in physical activity and consume less processed food. Industrialized food is more related to the urban life style, it is consumed at any time of the day, and is always hypercaloric (12).

Table 3. Demographics, educational level, occupation, race, and other risk factors associated with the metabolic syndrome

Characteristic / Factor	Case	Control	Chi²	Gl	p
Gender					
Female	211 (33.6%)	417 (66.4%)	6.63	1	0.01
Male	89 (25.6%)	258 (74.4%)			
Civil status					
Married	78 (31.3%)	171 (68.7%)	5.04	4	0.28
Consensual union	57 (27.8%)	148 (72.2%)			
Divorced	47 (31.8%)	101 (68.2%)			
Widow/er	39 (40.6%)	57 (59.4%)			
Single	79 (28.8%)	195 (71.2%)			
Education level					
No education	10 (50%)	10 (50%)	20.34	10	0.02
Incomplete elementary school	50 (39.1%)	78 (60.9%)			
Complete elementary school	43 (36.1%)	76 (63.9%)			
Incomplete high school	49 (29.5%)	117 (70.5%)			
Complete high school	83 (27.4%)	220 (72.6%)			
Technician	26 (24.3%)	81 (75.7%)			
College education	33 (27.7%)	86 (72.3%)			
Grad school	5 (71.4%)	2 (28.6%)			
Ethnicity					
White	122 (41.5%)	307 (46.7%)	12.283	13	0.50
Black	40 (13.6%)	82 (12.5%)			
Mestizo	127 (43.2%)	250 (38.5%)			
Indigenous	4 (1.4%)	8 (1.2%)			
Raizal	1 (0.3%)	9 (1.4%)			
Gypsy	0	1 (0.2%)			
Ocupation					
None	28 (31.8%)	60 (68.2%)	6.912	5	0.22
Household	84 (31.2%)	185 (68.8%)			
Student	5 (17.2%)	24 (82.8%)			
Worker	2 (66.7%)	1 (33.3%)			
Employee	54 (26.6%)	149 (73.4%)			
Freelance	125 (33.0%)	254 (67.0%)			
Health system affiliation					
Affiliated	287 (30.4%)	656 (69.6%)	6.98	3	0.07
Unaffiliated	10 (34.5%)	19 (65.5%)			
Tobacco consumption					
Yes	13 (21%)	49 (79%)	2.2	2	0.32
No	284 (31.6%)	614 (68.4%)			
Alcohol consumption					
Yes	26 (25%)	77 (74.8%)	7.97	1	0.05
No	273 (32%)	586 (68.2%)			
Salt consumption					
Yes	34 (31.8%)	73 (68.2%)	7.42	2	0.06
No	265 (30.9%)	592 (69.1%)			
Sugar consumption					
Yes	20 (29.9%)	47 (70.1%)	18.05	2	0.01
No	277 (31.1%)	615 (68.9%)			
Type of Oil consumption					
Vegetable oil	280 (30.9%)	625 (69.1%)	2.48	4	0.64
Lard	1 (20%)	4 (80%)			
Margarine	1 (20%)	4 (80%)			
Other	11 (27.5%)	29 (72.5%)			
Several of the above	5 (50%)	5 (50%)			
Physical activity					
Yes	104 (32.7%)	214 (67%)	0.61	2	0.73
No	195 (30.2%)	450 (69.8%)			

Table 4. Logistic regression results on risk factors associated with the metabolic syndrome

	OR	95% CI to OR	
		Lower	Upper
Gender			
Baseline:female	1.70	1.17	2.47
Civil status			
Single	1.14	0.72	1.80
Widow/er	1.27	0.69	2.33
Consensual union	0.89	0.55	1.44
Divorced	0.96	0.57	1.63
Ethnicity			
Black	1.38	0.83	2.31
Mestizo	1.55	1.10	2.19
Education level			
Incomplete elementary school	0.95	0.48	1.86
Complete elementary school	0.86	0.45	1.66
Incomplete high school	0.70	0.37	1.32
Complete high school	0.81	0.46	1.41
Technician	0.82	0.41	1.65
Ocupation			
None	0.90	0.26	3.09
Household	0.58	0.36	0.92
Student	1.12	0.34	3.72
Freelance	0.96	0.65	1.44
Social security			
Public health insurance	1.00	1.00	1.00
No health insurance	1.22	0.77	1.94
Fruit consumption			
Fruit consumption	0.83	0.69	1.00
Vegetable consumption			
Vegetable consumption	0.99	0.79	1.22
BMI			
Subnormal	1.10	0.30	4.02
Overweight	3.52	2.38	5.20
Obesity	7.52	4.79	11.80
Age (years)			
30-39	1.56	0.74	3.27
40-49	4.24	2.20	8.16
50-59	4.63	2.40	8.93
60-69	5.57	2.76	11.27
70-79	4.86	2.09	11.28
≥80	5.32	1.92	14.71

BMI: Body Mass Index

Aging is a definitive risk factor for the metabolic syndrome (13,14). This finding may be due to the accumulative effect of the etiological factors along the course of life, the metabolic changes associated with becoming older or the sum of both. It was also relevant in our study showing a linear trend as regarded the risk of developing the metabolic syndrome with a 4.24 OR for the 40-49-year-old-group, 4.63 OR for the 50-59-year-old group, and 5.32 OR for those older than 80 years. This finding supports our hypothesis that increasing age has a modifying effect as demonstrated by the increasing magnitude of the OR through time (tables 2 and 4). The homogeneity test showed a significant result (chi^2=77.2; DF=4; p<0.001), which means that the odds ratios across the age strata were not uniform. The result of the trend gave a chi^2 of 189.7, a DF of 1, and a p-value of <0.000, which happens to be significant suggesting a modifying effect of age in relation to the metabolic syndrome.

A study carried out in Medellin, Colombia, reported sedentarism as the most prevalent risk factor (prevalence, 73.1%) (15). In addition, obesity, smoking, high blood pressure, and a history of coronary disease showed high relevance.

Having dark skin (*mestizo* or brown skin) showed an association with the metabolic syndrome (OR=1.55; 95% CI 1.10-2.19), similar to the findings reported in Hawaii for multiracial individuals. The association was higher in Hawaiian-Asian natives (OR=1.45; 95% CI 1.27-1.65) than in native populations without mixed ancestry (16). Ethnicity has been associated with cultural and lifestyle habits that predispose to alcohol abuse, smoking, bad eating habits, and less physical activity and sports (17-19).

When analyzing the social factors that may be associated with the metabolic syndrome, we found that the occupation (housekeeper) (OR=0.59; 95% CI 0.40-0.87) was a protective factor. This unexpected result is opposite to what has been reported in the literature. It is possible to infer that in Cali women who are engaged in household activities are less sedentary and, therefore, less likely to develop a metabolic syndrome.

Regarding nutrition, fruit consumption was another protective factor (OR=0.83; 95% CI 0.69-1.00) against the metabolic syndrome, which was also reported in South Korea (20) where healthy eating patterns were found to be protective both for men and women (p=0.005). In contrast, traditional bad eating patterns had a positive relationship with high blood pressure (p=0.0328), low HDL levels (p=0.0007), and higher metabolic syndrome prevalence. Nutritional education could reduce the metabolic syndrome prevalence at the population level (20).

It is worth noting the lack of significant associations with alcohol, sugar, salt intake, and tobacco consumption in our study while in other studies, alcohol intake and smoking seemed to be important risk factors for the occurrence of the metabolic syndrome (21). A study conducted in Brazil showed that taking alcohol with meals had an inverse relationship with the metabolic syndrome: ≤4 drinks a week: OR=0.85; 95% IC 0.74-0.97, and 4 to 7 drinks a week: OR=0.75; 95% IC 0.61-0.92. In contrast, alcohol consuming out of meals showed a direct relationship (7-14 drinks a week: OR=1.32; 95% IC 1.11-1.57; ≥14 drinks a week, OR=1.60; 95% IC: 1.29-1.98) (21). In our study, alcohol consumption was not a factor associated withthe metabolic syndrome.

On the other hand, obesity was associated with the metabolic syndrome (OR=7.52; 95% IC 4.79-11.80), as well as being overweight (OR=3.52; 95% IC 2.38- 5.20) (table 4). In a randomized study conducted by Martin, *et al.* (22), they reported that a high BMI correlated with a higher prevalence of abdominal obesity and with metabolic syndrome (23,24).

In conclusion, this study determined the factors positively associated with the metabolic syndrome, such as being overweight, obesity, being older than 40 years, female and *mestizo*, while fruit consumption and housekeeping were inversely related. Risk factors are considered important for the development of public health interventions to promote protective behaviors and healthy lifestyles in the population.

Acknowledgements

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