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Relationship between blood glucose levels and cardiovascular risk in the Spanish Mediterranean population

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Background/aim: Diabetes is associated with an increased prevalence of cardiovascular disease. Impaired fasting glucose (IFG) is an intermediate clinical situation between normal glucose levels and type 2 diabetes. The aim of this study is to determine how fasting glucose concentrations affect different cardiovascular risk scales.

Materials and methods: A descriptive study was conducted with 59,041 Mediterranean Spanish workers. IFG was determined using the American Diabetes Association (ADA) and the World Health Organization (WHO) criteria. Different indicators of cardiovascular risk were analyzed: body mass index, waist circumference, waist-to-height ratio, blood pressure, lipid parameters, atherogenic indices, metabolic syndrome, and various scales of cardiovascular risk such as REGICOR, DORICA, SCORE, Heart Age, and Vascular Age.

Results: All cardiovascular scales showed statistically significant differences between the IFG group and the normal glucose group. In all cases, values were worse in the IFG group; furthermore, men exhibited more unfavorable levels of cardiovascular risk factors than women. Higher odds ratio values were present in employees with metabolic syndrome according to ATP III criteria (9.42, 95% CI: 8.56–10.37 using WHO criteria and 9.25, 95% CI: 8.67–9.87 using ADA criteria).

Conclusions: IFG increases cardiovascular risk whether using classical scales (REGICOR, SCORE, and metabolic syndrome) or other less studied scales (atherogenic indices, Heart Age, and Vascular Age).

Key words: Impaired fasting glucose, prediabetes, cardiovascular risk

1. Introduction

Type 2 diabetes mellitus, formerly called noninsulin-dependent diabetes mellitus, is a serious, costly disease affecting approximately 250 million people in the world. The incidence of type 2 diabetes mellitus is increasing worldwide and it is estimated that nearly 400 million will be affected by the disease within 10 years.

Prediabetes is a clinical condition that includes the presence of impaired fasting glucose (IFG), impaired glucose tolerance (IGT), or both simultaneously. It is associated with an increased risk of developing type 2 diabetes and the presence of cardiovascular complications (1,2). The cutoff values to define IFG vary between organizations: for the World Health Organization (WHO) they are 110–125 mg/dL while for the American Diabetes Association (ADA) the limits are 100–125 mg/dL (1). In Spain the classification of the WHO is mainly used. Prediabetes can also be diagnosed in anyone with glycated hemoglobin between 5.7% and 6.4% by the ADA guidelines, but for the National Institute for Health and Care Excellence the limits for A1c are 6.0% and 6.4% (3).

People with prediabetes have an increased risk of developing type 2 diabetes; this risk increases between 5% and 10% every year in prediabetic patients compared with 0.7% for individuals with normal glycemia. People with both IFG and IDT have twice the risk of developing type 2 diabetes compared to those who only have one of the two conditions (3). Evidence shows that that 25% of prediabetics will become diabetic, another 25% will return to a normal situation, and the rest (50%) will remain in a state of prediabetes (4).

There is a close relationship between diabetes and cardiovascular risk. It is not so clear, however, how cardiovascular risk behaves in situations of normal glycemia and IFG. Therefore, the aim of this paper is to determine if levels of cardiovascular risk in our population

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are related to blood glucose values using the WHO and ADA criteria.

2. Materials and methods

2.1. Subjects and study protocol

A cross-sectional study with Caucasian adult workers between 20 and 69 years of age was performed. All subjects were from Mallorca (Balearic Islands, Spain), recruited from different productive sectors. All participants were selected during their occupational health examination between January and December 2011. Half of the employees were randomly selected. Thus, from a total population of 130,487 workers, 65,200 were invited to join the study: 4421 (6.8%) of them refused and 1757 (2.7%) were eliminated for being diabetic. The final number of participants was 59,041, including 25,510 women (43.2%) and 33,531 men (56.8%).

The mean of age of participants was 39.98 years (SD: ±10.36). All subjects were informed of the purpose of the study before they provided written informed consent. Following the current legislation, members of the Health and Safety Committees were informed as well. The study protocol was in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the Mallorca Health Management Company (GESMA). After their acceptance, a complete medical history, including family and personal background, was recorded. The following inclusion criteria were considered: age between 18 and 70 (working age population), no diabetics, agreement to participate, and condition of being gainfully employed.

2.2. Measurements and calculations

All anthropometric measurements were made at the same time (0900 hours) in the morning, after an overnight fast and according to the recommendations of the International Standards for Anthropometric Assessment (5). Furthermore, all measurements were performed by well-trained technicians to minimize variation. Each measurement was made three times and the average value was calculated. Weight and height were determined according to recommended techniques mentioned above. Body weight was measured to the nearest 0.1 kg using an electronic scale (Seca 700 scale, Seca GmbH, Hamburg, Germany). Height was measured to the nearest 0.5 cm using a stadiometer (Seca 220 Telescopic Height Rod for Column Scales, Seca GmbH). Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2). The criteria used to define overweight were the ones of the WHO (6), which considers obesity as BMI of $\geq 30\ kg/m^2$. Abdominal waist was measured using a flexible steel tape (Lufkin Executive Thinline W 606). The plane of the tape was perpendicular to the long axis of the body and parallel to the floor. Waist circumference was measured at the level of the umbilicus and the superior iliac crest. The measurement was made at the end of a normal expiration while the subject stood upright, with feet together and arms hanging freely at the sides. Waist circumference (WC) was measured using a tapeline at the level midway between the lateral lower rib margin and iliac crest as well as at the levels of trochanters. Waist-to-height ratio (WtHR) was calculated by dividing WC by height in centimeters. The cutoff was established to consider WtHR high at >0.5.

Venous blood samples were taken from the antecubital vein with suitable vacutainers without anticoagulant to obtain serum. Blood samples were taken following a 12-h overnight fast. Participants were seated at rest for at least 15 min before blood samples were taken. Serum was obtained after centrifugation (15 min, 1000 × *g*, 4 °C) of blood samples. Serum was stored at –20 °C and analyses were performed within 3 days. Concentrations of glucose, cholesterol, and triglycerides were measured in serum by standard procedures used in clinical biochemistry laboratories using a clinical system, the Beckman Coulter SYNCHRON CX®9 PRO (Beckman Coulter, Brea, CA, USA). High cholesterol values were considered as those from 240 mg/dL, LDL-C from 160 mg/dL, and triglycerides from 150 mg/dL. IFG values were considered between 110 and 125 mg/dL (WHO criteria) or 100 and 125 mg/mL (ADA criteria).

Blood pressure was determined after a resting period of 10 min in the supine position using an automatic and calibrated sphygmomanometer, the OMRON M3 (OMRON Healthcare Europe, Spain). As indicated for the anthropometrical measures, blood pressure was measured three times with a 1-min gap between each measurement and an average value was calculated. Hypertension was considered when values were ≥140/90 mmHg.

According to the NCEP ATP III (National Cholesterol Educational Program Adult Treatment Panel III) definition, metabolic syndrome (MS) was considered present if three or more of the following five criteria were met: waist circumference over 102 cm (men) or 88 cm (women), blood pressure over 130/85 mmHg, fasting triglyceride (TG) level over 150 mg/dL, fasting high-density lipoprotein (HDL) cholesterol level less than 40 mg/dL (men) or 50 mg/dL (women), and fasting blood sugar over 100 mg/dL.

The International Diabetes Federation (IDF) criteria, in an attempt to define MS more precisely, introduce abdominal obesity as a prerequisite of the diagnosis of MS, defined by a WC of >80 cm in women and >94 cm in men, and at least two of the following factors: triglycerides ≥150 mg/dL, blood pressure ≥130/85 mmHg, fasting glucose ≥100 mg/dL, and HDL cholesterol <40 mg/dL in men and <50 mg/dL in women.

REGICOR is the Framingham model calibrated for the Spanish population (7–9). To calculate this scale of

cardiovascular risk data on age, sex, tobacco consumption, systolic and diastolic blood pressure, cholesterol, HDL cholesterol, and diabetes are needed. This model can be calculated in people between 35 and 74 years. REGICOR risk is considered to be low when the value is less than 5%, moderate if the value is between 5% and 9.9%, high if it is between 10% and 14.9%, and very high if exceeds 15%.

The DORICA model (10) was constructed using data from populations from different Spanish regions and includes population between 25 and 64 years. The parameters used are those of REGICOR. The result provided by the DORICA model is considered to be low when the value is less than 5%, slightly higher if it is between 5% and 9%, moderate if between 10% and 19%, high when between 20% and 39%, and very high if it exceeds 40%.

The SCORE model predicts cardiovascular mortality in 10 years and provides specific tables for the Spanish population aged 40 to 65 years (11). Low risk was defined as scores of less than 3%, moderate risk was taken to be 3% to 4.9%, and patients were considered to have high cardiovascular risk if they had a risk of 5% or more according to the SCORE charts. The required variables are age, sex, systolic blood pressure (SBP), total cholesterol, high-density lipoprotein cholesterol (HDL-C), and smoking habit.

Heart Age is a risk assessment calculator based on the Framingham Heart Study (12) to predict a person's chance of having a heart attack in the next 10 years. This tool is designed for adults aged 20 to 80. Information required includes age, sex, BMI, waist circumference, family history of cardiovascular disease, diabetes, tobacco consumption, total cholesterol, HDL cholesterol, and SBP. The tool calculates heart age between 20 years younger and 20 years older than chronological age. In our study the data provided are considered to be altered when the heart age exceeds the chronological age by 1 year or more. This tool is very useful to motivate efforts to change unhealthy habits in the general population (13).

Vascular Age is a tool based on the SCORE scale. D'Agostino et al. (12) introduced this tool and defined vascular age as the age of the vascular system of a patient with different cardiovascular risk factors. This age is calculated as the age a person would be with the same calculated cardiovascular risk but whose risk factors are all within normal ranges. In 2010 (14) tables to calculate vascular age were published.

In our study three atherogenic indices have been estimated: total cholesterol/HDL cholesterol, LDL cholesterol/HDL cholesterol, and triglycerides/HDL cholesterol. For each index different cutoffs were established (15): total cholesterol/HDL cholesterol is considered low if <4.5% in women and <5% in men, moderate if 4.5%–7% in women and 5%–9% in men, and high if exceeding 7% in women and 9% in men. The LDL cholesterol/HDL cholesterol levels are considered high exceeding 3% and triglycerides/HDL cholesterol is high above 3%.

2.3. Statistical analyses

All data were tested for their normal distribution (Kolmogorov–Smirnov test). Results are expressed as means and standard deviations (SD) and, when required, in percentages. The Student t-test for unpaired data was used to evaluate differences in anthropometric and biochemical characteristics between sexes. The chi-square test was used for the difference of proportions. For multivariate analysis the multivariate logistic regression model was used. The correlation between variables was determined by Pearson correlation coefficient. Statistical analysis was carried out using IBM SPSS Statistics 20.0 software (IBM Corp., Armonk, NY, USA). Significance was accepted at $P < 0.05$.

3. Results

Age and anthropometrical and clinical characteristics of the participants in the study, categorized by sex, are shown in Table 1. Significant differences between men and women were found in all parameters: age, anthropometric characteristics (BMI, WC, and WtHR), systolic and diastolic blood pressure, total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides were significantly increased in men.

Mean values of different parameters associated with cardiovascular risk according to glucose levels with the WHO criteria are shown in Table 2, categorized by sex. Significant differences between men and women were detected: values of BMI, WC, WtHR, systolic and diastolic blood pressure, cholesterol, HDL-cholesterol, LDL-cholesterol, triglycerides, total cholesterol/HDL-cholesterol, LDL-cholesterol/HDL-cholesterol, triglycerides/HDL-cholesterol, REGICOR scale, DORICA scale, SCORE scale, Heart Age, and Vascular Age were higher in men. In both men and women all parameters examined increased in line with blood glucose values.

Mean values of different parameters associated with cardiovascular risk according to glucose levels (ADA criteria) are shown in Table 2, categorized by sex. Significant differences between men and women were found in all parameters analyzed. In this sense, higher values of BMI, WC, WtHR, systolic and diastolic blood pressure, total cholesterol, HDL-cholesterol, LDL-cholesterol, triglycerides, total cholesterol/HDL-cholesterol, LDL-cholesterol/HDL-cholesterol, triglycerides/HDL-cholesterol, REGICOR scale, DORICA scale, SCORE scale, Heart Age, and Vascular Age were identified in men. In addition, all parameters examined, in both men and women, climbed in line with blood glucose values.

Table 3 offers the prevalence of abnormal values of different parameters related to cardiovascular risk

Table 1. Anthropometric, clinical, and analytical characteristics of participants in the study.

	Women (n = 25,510)	Men (n = 33,531)	P-value
Age (years)	39.3 ± 10.1	40.0 ± 10.3	<0.0001
BMI (kg/m^2)	24.9 ± 4.8	26.8 ± 4.2	<0.0001
Waist circumference (cm)	75.2 ± 9.7	88.4 ± 9.5	<0.0001
WtHR	0.47 ± 0.06	0.51 ± 0.06	<0.0001
Systolic BP (mmHg)	114.4 ± 14.9	124.9 ± 15.4	<0.0001
Diastolic BP (mmHg)	70.3 ± 10.3	75.8 ± 10.7	<0.0001
Cholesterol (mg/dL)	192.8 ± 36.4	196.7 ± 38.6	<0.0001
HDL-C (mg/dL)	55.0 ± 9.2	50.7 ± 7.5	<0.0001
LDL-C (mg/dL)	120.4 ± 36.9	121.8 ± 37.2	<0.0001
Triglycerides (mg/dL)	87.0 ± 43.8	123.2 ± 85.8	<0.0001

BMI, Body mass index. WtHR, Waist-to-height-ratio. BP, Blood pressure. HDL-C, high-density lipoprotein cholesterol. LDL-C, low-density lipoprotein cholesterol.
Data are expressed as means ± standard deviations.
Statistical significance was estimated by independent t-test.

according to glucose levels (WHO criteria), disaggregated by sex. In both sexes all parameters analyzed grew in parallel with blood glucose levels. It is also noteworthy that the prevalence of abnormal values of all parameters related to cardiovascular risk was significantly higher in men.

Table 3 shows the prevalence of abnormal levels of different parameters related to cardiovascular risk according to glucose levels (ADA criteria) distributed by sex. It is significant that in both sexes all parameters grew in tandem with blood glucose levels. Moreover, the prevalence of abnormal values of all parameters related to cardiovascular risk was higher in men.

Table 4 shows the results of the multivariate logistic regression model in order to establish the influence of blood glucose levels (WHO and ADA criteria) in the appearance of abnormal values of different parameters related to cardiovascular risk. The category of reference was IFG. Highest odds ratio (OR) values were found for metabolic syndrome according to ATP III criteria (9.42, 95% CI: 8.56–10.37 using WHO criteria and 9.25, 95% CI: 8.67–9.87 using ADA criteria). Odds ratios were higher if the WHO criteria were applied.

Studying a young population (average age of 40 years), it was also interesting to analyze the influence of age on the different variables related to cardiovascular risk by ex. To this end, two groups of individuals were established: up to 50 years and above 50 years of age. It was also interesting to know how tobacco consumption affected the different scales of cardiovascular risk. Complete data are presented in Table 5.

In closing, Table 6 presents the level of correlations between different scales of cardiovascular risk.

4. Discussion

Values of all parameters related to cardiovascular risk analyzed are more unfavorable in the IFG group using the two models. In all cases the values are worse in men.

Anthropometric variables, BMI, waist circumference, and WtHR have significantly higher values in the IFG group. These results agree with those found in other studies conducted in Spain. In the investigation carried out by the Universidad Complutense de Madrid (16), higher prevalences of obesity and abdominal obesity were observed in people with IFG. Similar results were obtained in a Korean population study (17).

Systolic and diastolic blood pressures as well as the prevalence of excessive blood pressure are also higher in workers with IFG. These data are consistent with those found in studies conducted in Korea and Spain as mentioned above and another one with a Chinese population (18).

Lipid parameters showed higher values in the IFG group: total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides. These data are consistent with those found in the population of Peru (19), for which the criteria used were the ADA ones, or the populations of Korea (17) and Spain (18), where the WHO criteria were used, although in the study of Spain no differences in cholesterol were observed.

Atherogenic indices showed higher values in the IFG group, values being higher in males. We found no studies in the literature to which we could compare our results, although other studies showed that atherogenic indices values are also higher in males (20,21). Some studies have linked an increase of values of total cholesterol/HDL

Table 2. Values of different parameters according to glucose levels (WHO and ADA criteria).

	WHO criteria					ADA criteria				
	Women		Men		P-value	Women		Men		P-value
Characteristics	<110 mg/dL	110–125 mg/dL	<110 mg/dL	110–125 mg/dL		<100 mg/dL	100–125 mg/dL	<100 mg/dL	100–125 mg/dL	
BMI	24.9 ± 4.8	28.8 ± 6.0	26.7 ± 4.1	29.2 ± 4.8	<0.0001	24.7 ± 4.7	27.7 ± 5.5	26.5 ± 4.0	28.3 ± 4.5	<0.0001
Waist circumference	75.2 ± 9.6	79.3 ± 11.1	88.2 ± 9.5	91.7 ± 10.5	<0.0001	75.0 ± 9.6	78.2 ± 10.5	87.9 ± 9.3	90.8 ± 10.4	<0.0001
WtHR	0.47 ± 0.06	0.50 ± 0.07	0.51 ± 0.05	0.53 ± 0.06	<0.0001	0.47 ± 0.06	0.49 ± 0.07	0.51 ± 0.05	0.53 ± 0.06	<0.0001
Systolic BP	114.2 ± 14.8	124.0 ± 18.4	124.5 ± 15.1	133.2 ± 18.6	<0.0001	113.9 ± 14.6	120.6 ± 17.4	124.0 ± 14.7	130.1 ± 17.6	<0.0001
Diastolic BP	70.2 ± 10.3	76.2 ± 10.7	75.5 ± 10.6	80.8 ± 11.8	<0.0001	70.0 ± 10.2	74.4 ± 11.3	75.1 ± 10.5	79.3 ± 11.5	<0.0001
Cholesterol	192.4 ± 36.2	213.6 ± 39.7	196.1 ± 38.4	210.4 ± 41.1	<0.0001	191.7 ± 35.8	207.5 ± 40.2	195.1 ± 38.1	205.9 ± 40.3	<0.0001
HDL-C	55.1 ± 9.2	52.4 ± 8.6	50.8 ± 7.5	47.6 ± 7.3	<0.0001	55.2 ± 9.2	52.8 ± 8.8	51.0 ± 7.5	48.9 ± 7.6	<0.0001
LDL-C	120.1 ± 36.8	136.6 ± 39.6	121.4 ± 36.9	130.7 ± 41.1	<0.0001	119.4 ± 36.5	133.3 ± 39.8	120.6 ± 36.7	128.5 ± 38.9	<0.0001
Triglycerides	86.3 ± 43.0	123.2 ± 66.0	121.2 ± 82.8	166.0 ± 126.4	<0.0001	85.4 ± 42.2	107.4 ± 57.6	118.9 ± 78.9	147.1 ± 113.5	<0.0001
Cholesterol/HDL-C	3.6 ± 1.0	4.2 ± 1.1	4.0 ± 1.2	4.6 ± 1.4	<0.0001	3.6 ± 1.0	4.1 ± 1.2	3.9 ± 1.1	4.4 ± 1.3	<0.0001
LDL-C/HDL-C	2.3 ± 1.0	2.7 ± 1.0	2.5 ± 1.0	2.9 ± 1.2	<0.0001	2.3 ± 0.9	2.6 ± 1.1	2.5 ± 1.0	2.7 ± 1.1	<0.0001
Triglycerides/HDL-C	1.6 ± 1.0	2.5 ± 1.5	2.5 ± 2.1	3.7 ± 3.3	<0.0001	1.6 ± 0.9	2.1 ± 1.4	2.5 ± 2.0	3.2 ± 3.0	<0.0001
REGICOR	2.1 ± 1.5	3.7 ± 2.6	3.2 ± 2.0	4.8 ± 3.0	<0.0001	2.0 ± 1.5	3.0 ± 2.1	3.1 ± 1.9	4.0 ± 2.6	<0.0001
DORICA	2.0 ± 2.4	5.1 ± 4.4	5.1 ± 4.3	9.4 ± 6.6	<0.0001	1.9 ± 2.4	3.8 ± 3.6	4.9 ± 4.2	9.1 ± 6.1	<0.0001
SCORE	0.3 ± 0.7	0.6 ± 1.3	1.3 ± 1.5	1.9 ± 1.8	<0.0001	0.3 ± 0.7	0.5 ± 1.0	1.2 ± 1.4	1.7 ± 1.8	<0.0001
Years lost, heart age	0.6 ± 9.1	8.0 ± 10.6	5.7 ± 7.7	11.8 ± 7.9	<0.0001	0.4 ± 9.0	5.2 ± 10.4	5.4 ± 7.6	9.1 ± 8.1	<0.0001
Years lost, vascular age	2.1 ± 4.2	3.6 ± 4.6	4.0 ± 5.9	6.4 ± 6.3	<0.0001	2.0 ± 4.2	3.1 ± 4.5	3.8 ± 5.8	5.4 ± 6.3	<0.0001

WtHR, Waist-to-height-ratio. HDL-C, High-density lipoprotein cholesterol. LDL-C, Low-density lipoprotein cholesterol.
Data are expressed as means ± standard deviations.
Statistical significance was estimated by independent t-test.

Table 3. Prevalence of high values of different parameters and relationship with cardiovascular risk according to glucose levels (WHO and ADA criteria).

	WHO criteria					ADA criteria				
	Women		Men		P-value	Women		Men		P-value
	<110 mg/dL	110–125 mg/dL	<110 mg/dL	110–125 mg/dL		<100 mg/dL	100–125 mg/dL	<100 mg/dL	100–125 mg/dL	
Obesity	13.5	38.7	18.2	39.2	<0.0001	12.7	29.4	17.0	31.0	<0.0001
WtHR > 0.5	22.9	41.6	52.0	71.1	<0.0001	22.2	36.8	50.6	65.2	<0.0001
Hypertension	11.3	33.6	24.3	50.5	<0.0001	10.6	25.9	22.7	40.5	<0.0001
Cholesterol ≥ 240 mg/dL	9.8	23.8	12.3	22.9	<0.0001	9.4	19.3	11.7	19.0	<0.0001
LDL-C ≥ 160 mg/dL	13.7	26.7	14.1	22.1	<0.0001	13.2	23.9	13.6	19.5	<0.0001
Triglycerides ≥ 150 mg/dL	6.6	25.3	22.6	41.7	<0.0001	6.3	16.1	21.6	33.4	<0.0001
Cholesterol/HDL-C moderate-high	20.0	36.5	15.02	29.1	<0.0001	17.4	31.7	14.4	23.5	<0.0001
LDL-C/HDL-C high	22.3	37.6	13.2	23.5	<0.0001	21.6	34.8	12.6	19.5	<0.0001
Triglycerides/ HDL-C > 3	6.8	26.0	23.5	44.1	<0.0001	6.4	17.5	22.5	35.1	<0.0001
MS ATP III criteria	4.0	40.7	9.0	40.9	<0.0001	2.7	30.1	6.5	32.2	<0.0001
MS IDF criteria	5.1	32.7	9.8	34.0	<0.0001	4.0	26.0	7.5	29.6	<0.0001
REGICOR low-moderate-high	7.8	29.4	18.0	42.9	<0.0001	7.3	19.1	16.7	30.8	<0.0001
DORICA low-moderate-high-very high	15.1	47.8	40.8	74.5	<0.0001	14.2	35.3	38.7	61.6	<0.0001
SCORE medium-high	0.5	1.9	5.9	13.4	<0.0001	0.4	1.3	5.4	10.2	<0.0001
Years lost, heart age > 0	44.7	74.7	72.0	89.7	<0.0001	43.8	64.6	70.7	83.7	<0.0001
Years lost, vascular age > 0	62.6	75.7	69.2	81.6	<0.0001	61.9	72.3	68.3	76.2	<0.0001

WtHR, Waist-to-height-ratio. MS ATP III criteria. Metabolic syndrome NCEP ATP III criteria. MS IDF criteria. Metabolic syndrome IDF criteria. HDL-C, High-density lipoprotein cholesterol. LDL-C, Low-density lipoprotein cholesterol.
Data are expressed as percentages.
Statistical significance was estimated by independent t-test.

Table 4. Multivariate logistic regression model.

	WHO criteria			ADA criteria		
Parameters	OR	95% CI	P-value	OR	95% CI	P-value
Obesity (kg/m^2)	3.34	3.04–3.67	<0.0001	2.49	2.36–2.64	<0.0001
WtHR > 0.5	2.79	2.54–3.06	<0.0001	2.28	2.16–2.40	<0.0001
Hypertension (mmHg)	3.34	3.04–3.67	<0.0001	2.59	2.44–2.74	<0.0001
Cholesterol ≥ 240 mg/dL	2.38	2.13–2.65	<0.0001	1.98	1.86–2.12	<0.0001
LDL-C ≥ 160 mg/dL	1.86	1.67–2.07	<0.0001	1.68	1.58–1.79	<0.0001
Triglycerides ≥ 150 mg/dL	3.32	3.02–3.65	<0.0001	2.38	2.25–2.52	<0.0001
Cholesterol/HDL-C moderate-high	2.26	2.05–2.50	<0.0001	1.84	1.73–1.95	<0.0001
LDL-C/HDL-C high	1.76	1.59–1.95	<0.0001	1.52	1.43–1.62	<0.0001
Triglycerides/HDL-C > 3	3.44	3.13–3.78	<0.0001	2.46	2.33–2.61	<0.0001
MS ATP III criteria	9.42	8.56–10.37	<0.0001	9.25	8.67–9.87	<0.0001
MS IDF criteria	6.04	5.47–6.67	<0.0001	6.41	6.01–6.82	<0.0001
REGICOR low-moderate-high	4.22	3.82–4.68	<0.0001	2.70	2.53–2.89	<0.0001
DORICA low-moderate-high-very high	5.16	4.68–5.69	<0.0001	3.19	3.02–3.36	<0.0001
SCORE medium-high	3.18	2.67–3.79	<0.0001	2.58	2.27–2.93	<0.0001
Years lost, heart age > 0	4.18	3.67–4.76	<0.0001	2.64	2.49–2.80	<0.0001
Years lost, vascular age > 0	2.05	1.81–2.33	<0.0001	1.60	1.49–1.72	<0.0001

MS ATP III criteria. Metabolic syndrome NCEP ATP III criteria. MS IDF criteria. Metabolic syndrome IDF criteria. HDL-C, High-density lipoprotein cholesterol. LDL-C, Low-density lipoprotein cholesterol.
Data are expressed as OR (odds ratio).
Statistical significance was estimated by independent t-test.

cholesterol in comparing normoglycemic and diabetic populations (22).

All scales studied (REGICOR, DORICA, SCORE, Heart Age, and Vascular Age) showed, as the other parameters analyzed so far, a poorer performance in the group of people with IFG, mainly in men. We have not found studies that have specifically analyzed these scales, although there are other studies that evaluated the cardiovascular risk and its relationship with fasting glucose levels. A metaanalysis (23) of 2010 that reviewed 18 studies that used the WHO criteria and 8 others using the ADA criteria showed that most of them agree with our results. Another study (24) of 2014 indicated a reduction in cardiovascular risk when patients moved from a situation of IFG to a normal fasting glucose.

Classic cardiovascular risk scales (REGICOR, SCORE, or metabolic syndrome) or lipid parameters (total cholesterol, HDL cholesterol, LDL cholesterol, or triglycerides) present worse results in people with IFG or diabetes, as is well known and expected. Therefore, a relevant contribution of this paper is to examine how other scales less studied perform in the evaluation of cardiovascular risk (atherogenic indices, Heart Age, and Vascular Age).

Table 5. Influence of age and tobacco consumption on the different variables related to cardiovascular risk by sex.

	Women		Men		P-value	Women		Men		P-value
	<50 years	≥50 years	<50 years	≥50 years		Nonsmoker	Smoker	Nonsmoker	Smoker	
BMI	24.6 ± 4.8	26.7 ± 4.6	26.5 ± 4.2	28.2 ± 4.0	<0.0001	25.2 ± 4.9	24.4 ± 4.6	27.1 ± 4.1	26.2 ± 4.2	<0.0001
Waist circumference	74.8 ± 9.6	77.5 ± 9.8	88.0 ± 9.4	90.0 ± 9.7	<0.0001	75.5 ± 9.6	74.7 ± 9.7	88.8 ± 9.4	87.7 ± 9.8	<0.0001
WtHR	0.46 ± 0.06	0.49 ± 0.06	0.50 ± 0.05	0.53 ± 0.06	<0.0001	0.47 ± 0.06	0.46 ± 0.06	0.51 ± 0.06	0.50 ± 0.06	<0.0001
Systolic BP	112.4 ± 13.7	123.7 ± 16.9	122.9 ± 14.0	132.7 ± 17.8	<0.0001	114.8 ± 15.1	113.53 ± 14.6	125.3 ± 15.4	124.2 ± 15.3	<0.0001
Diastolic BP	69.2 ± 9.9	75.4 ± 10.7	74.6 ± 10.4	80.3 ± 10.7	<0.0001	70.6 ± 10.4	69.7 ± 10.2	76.2 ± 10.6	75.0 ± 10.9	<0.0001
Cholesterol	187.4 ± 34.3	218.2 ± 35.1	193.4 ± 36.4	210.1 ± 36.8	<0.0001	193.3 ± 36.1	191.6 ± 37.0	197.0 ± 37.5	196.3 ± 40.4	<0.0001
HDL-C	55.6 ± 9.0	52.6 ± 9.6	51.6 ± 7.3	47.1 ± 7.5	<0.0001	55.4 ± 9.5	54.4 ± 8.3	51.2 ± 7.2	49.8 ± 8.0	<0.0001
LDL-C	115.1 ± 35.1	145.2 ± 35.1	118.3 ± 36.7	135.6 ± 36.0	<0.0001	120.9 ± 37.1	119.3 ± 36.6	122.6 ± 36.2	120.4 ± 38.7	<0.0001
Triglycerides	83.8 ± 41.3	101.8 ± 51.4	119.3 ± 84.7	138.7 ± 88.2	<0.0001	85.6 ± 43.0	89.8 ± 45.2	117.4 ± 76.9	133.28 ± 98.4	<0.0001
Cholesterol/HDL-C	3.5 ± 1.0	4.3 ± 1.1	3.9 ± 1.1	4.6 ± 1.2	<0.0001	3.6 ± 1.1	3.6 ± 1.0	4.0 ± 1.1	4.1 ± 1.3	<0.0001
LDL-C/HDL-C	2.2 ± 0.9	2.9 ± 1.0	2.4 ± 1.0	3.0 ± 1.0	<0.0001	2.3 ± 1.0	2.3 ± 0.9	2.5 ± 0.9	2.5 ± 1.1	<0.0001
Triglycerides/HDL-C	1.6 ± 0.9	2.0 ± 1.2	2.4 ± 2.1	3.1 ± 2.3	<0.0001	1.6 ± 1.0	1.7 ± 1.0	2.4 ± 1.8	2.9 ± 2.7	<0.0001
REGICOR	1.6 ± 1.0	3.6 ± 1.8	2.6 ± 1.4	4.8 ± 2.6	<0.0001	2.0 ± 1.5	2.4 ± 1.7	2.8 ± 1.7	4.1 ± 2.5	<0.0001
DORICA	1.5 ± 1.5	5.5 ± 2.9	4.0 ± 3.3	10.0 ± 5.3	<0.0001	2.1 ± 2.3	2.4 ± 2.7	4.4 ± 3.6	6.9 ± 5.4	<0.0001
SCORE	0.1 ± 0.3	0.7 ± 1.0	0.6 ± 0.6	2.4 ± 1.8	<0.0001	0.2 ± 0.5	0.6 ± 1.0	0.9 ± 1.2	2.0 ± 1.9	<0.0001
Years lost, heart age	-0.7 ± 8.2	7.1 ± 10.6	4.7 ± 7.3	11.0 ± 7.9	<0.0001	-1.7 ± 8.4	5.7 ± 8.7	3.0 ± 6.7	11.0 ± 7.1	<0.0001
Years lost, vascular age	0.8 ± 4.0	4.4 ± 3.7	2.3 ± 5.1	6.9 ± 6.0	<0.0001	0.8 ± 3.6	5.0 ± 4.3	1.8 ± 4.5	8.7 ± 5.7	<0.0001

HDL-C, High-density lipoprotein cholesterol. LDL-C, Low-density lipoprotein cholesterol.
Data are expressed as means ± standard deviations.
Statistical significance was estimated by independent t-test.

Table 6. Correlation between different variables and scales related to cardiovascular risk.

	BMI	WC	WtHR	Cholesterol/ HDL-C	LDL-C/ HDL-C	Triglyc/ HDL-C	REGICOR	DORICA	SCORE	Years lost, HA	Years lost, VA
BMI		0.64	0.69	0.26	0.20	0.28	0.23	0.28	0.14	0.31	0.10
WC			0.92	0.26	0.16	0.40	0.26	0.35	0.25	0.33	0.16
WtHR				0.28	0.19	0.39	0.27	0.34	0.22	0.32	0.16
Cholesterol/HDL-C					0.96	0.55	0.57	0.58	0.28	0.60	0.36
LDL-C/HDL-C						0.31	0.52	0.52	0.24	0.56	0.32
Triglyc/HDL-C							0.39	0.43	0.23	0.40	0.25
REGICOR								0.95	0.72	0.66	0.68
DORICA									0.74	0.68	0.71
SCORE										0.48	0.68
Years lost, HA											0.61
Years lost, VA											

BMI, Body mass index. WC, Waist circumference. WtHR, Waist-to-height-ratio. HDL-C, high-density lipoprotein cholesterol. LDL-C, low-density lipoprotein cholesterol.

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