

Association between different cardiometabolic risk scales and metabolic syndrome scales in 418.343 Spanish workers

Asociación entre diferentes escalas de riesgo cardiometabólico y escalas de síndrome metabólico en 418.343 trabajadores españoles

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Abstract

Introduction: Cardiometabolic diseases are currently a public health problem in all countries of the world due to their high prevalence and high morbidity and mortality.

Material and methods: Descriptive, cross-sectional study to assess the association between various cardiometabolic risk scales and metabolic syndrome assessed with three different criteria.

Results: Both the mean values and the prevalence of elevated values of the different cardiometabolic risk scales analyzed (atherogenic indices, vascular age, REGICOR and SCORE scales, atherogenic dyslipidemia, lipid triad, and diabetes) were higher in persons with metabolic syndrome with any of the criteria. The scales that most increase the risk of presenting metabolic syndrome are the atherogenic indices, AD, LT and diabetes.

Conclusions: There is a good relationship between the cardiometabolic risk scales analyzed and metabolic syndrome with any of the three criteria. The variables most associated with an increased risk of developing metabolic syndrome are atherogenic indices, atherogenic dyslipidemia, lipid triad and diabetes.

Keywords: Metabolic syndrome, atherogenic indices, diabetes, atherogenic dyslipidemia, cardiometabolic risk.

Resumen

Introducción: Las enfermedades cardiometabólicas son en la actualidad un problema de salud pública en todos los países del mundo tanto por su elevada prevalencia como por su alta morbimortalidad.

Material y métodos: Estudio descriptivo y transversal para valorar la asociación entre diversas escalas de riesgo cardiometabólico y el síndrome metabólico valorado con tres criterios diferentes.

Resultados: Tanto los valores medios como la prevalencia de valores elevados de las diferentes escalas de riesgo cardiometabólico analizadas (índices aterogénicos, edad vascular, escalas REGICOR y SCORE, dislipemia aterogénica, triada lipídica y Diabetes) presentan cifras superiores en las personas con síndrome metabólico con cualquiera de los criterios. Las escalas que más incrementan el riesgo de presentar síndrome metabólico son los índices aterogénicos, DA, LT y Diabetes.

Conclusiones: Existe buena relación entre las escalas de riesgo cardiometabólico analizadas y el síndrome metabólico con cualquiera de los tres criterios. Las variables que más se relacionan con un aumento del riesgo de presentar síndrome metabólico son los índices aterogénicos, dislipemia aterogénica, triada lipídica y Diabetes.

Palabras clave: Síndrome metabólico, actividad física, adherencia a la dieta mediterránea.

Introduction

Cardiometabolic diseases, due to their high prevalence¹ and the high morbimortality they cause², are considered one of the main public health problems in most countries, and not only in developed countries³.

Metabolic syndrome (MS) is a pathological entity that has been known for more than a century and encompasses different alterations such as obesity (mainly abdominal), elevated lipid profile, insulin resistance that results in elevated blood glucose levels and elevated blood pressure⁴.

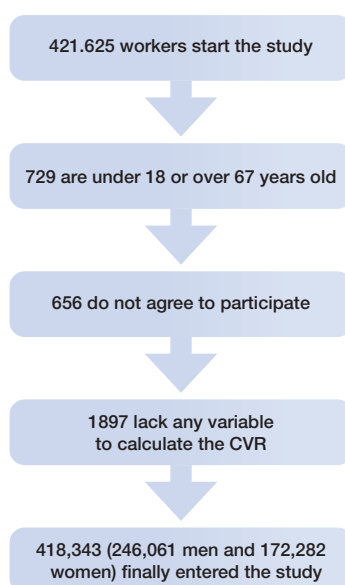
The similar pathophysiology of both pathological conditions suggests that there should be a close relationship between them, so the aim of this study is to assess the association between the values of different cardiometabolic risk scales and MS determined with different criteria in the Spanish working population.

Material and methods

A descriptive, cross-sectional study was carried out in 418,343 Spanish workers from different regions and work sectors and selected from occupational medical examinations between the months of January 2017 and December 2019. The following inclusion criteria were established: age between 18 and 69 years, working in one of the companies included in a study, not being in a situation of temporary disability, signing the informed consent to participate in the study and to use their data for epidemiological purposes.

Figure 1 shows the flow diagram of the study participants.

Figure 1: Flow chart.



Measurements and data collection

Anthropometric (height, weight and waist circumference), clinical and analytical measurements were performed by the health professionals of the companies participating in the study, after standardization of the measurement techniques.

Weight (in kg) and height (in cm) were obtained with a SECA 700 scale-measuring device. Waist circumference (WC) was measured with a SECA measuring tape with the person standing, feet together, trunk erect and abdomen relaxed. The tape was placed parallel to the ground at the height of the last floating rib.

A calibrated OMRON M3 automatic sphygmomanometer was used to determine blood pressure while the person was seated and after a 10-minute rest. Three determinations were made one minute apart and the mean of the three was obtained. The analytical parameters were obtained after 12 h of fasting. Glycemia, total cholesterol and triglycerides were obtained by automated enzymatic methods while HDL-c was obtained by a precipitation process with dextran sulfate-MgCl₂. LDL-c was calculated indirectly using the Friedewald formula (only valid for triglycerides below 400 mg/dL). All analytical parameters were expressed in mg/dL.

Friedewald formula: $LDL = cholesterol - HDL - triglycerides/5$

Metabolic syndrome (MS) was determined using three different criteria: the National Cholesterol Education Program Adult Treatment Panel III (NCEP/ATP-III), the Joint Interim Statement (JIS), and the International Diabetes Federation (IDF) update⁵.

As cardiometabolic risk scales, the following were assessed:

- a.** Cardiovascular risk scales
 - Years of life lost due to vascular age (ALLY) SCORE and Framingham⁶.
 - REGICOR and SCORE⁷ scales.
- b.** Atherogenic indices
 - Cholesterol/HDL, triglycerides/HDL and LDL/HDL⁸.
- c.** Other
 - Diabetes⁹.
 - Atherogenic dyslipidemia (AD) and lipid triad (LT)¹⁰.

A smoker is defined as a person who has consumed at least one cigarette a day (or its equivalent in other types of consumption) in the last 30 days or has quit smoking less than 1 year ago.

Based on the profession and applying the proposal of the social determinants group of the Spanish Society of Epidemiology¹¹, the social class was obtained, establishing three categories: Class I: directors/

managers, university professionals, sportsmen and artists; Class II: intermediate occupations and skilled self-employed workers; Class III: unskilled workers.

The level of education was classified as primary or elementary, secondary and university. We considered smokers to be those who had consumed at least one cigarette daily (or its equivalent in other types of consumption) during the last month, or had quit smoking less than 12 months before.

Heart-healthy eating habits are determined with the "Mediterranean diet adherence questionnaire" used in the PREDIMED study¹². The questionnaire consists of 14 questions that are scored with 0 and 1 point. Values of 9 or more indicate good adherence and therefore that the diet is heart-healthy.

Physical activity is assessed with the International Physical Activity Questionnaire IPAQ (International Physical Activity Questionnaire), which assesses physical activity in the last week¹³.

Statistical analysis

A descriptive analysis of the categorical variables was performed, calculating the frequency and distribution of the responses for each of them. For quantitative variables, the mean and standard deviation were calculated following a normal distribution.

Bivariate association analysis was performed using the chi² test (with correction for Fisher's exact statistic when conditions required it) and Student's t test for independent samples (for comparison of means). Multivariate techniques were used to establish the variables associated with the most significant risk factors. For multivariate analysis, logistic regression was used, with calculation of the odds ratio and the Hosmer-Lemeshow goodness-of-fit test. ROC curves were performed, and the area under the curve

(The statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS) version 28.0 (IBM Company, New York, NY, USA) for Windows, with an accepted statistical significance level of 0.05.

Ethical considerations and/or aspects

The research team undertook at all times to follow the ethical principles of health sciences research established nationally and internationally (Declaration of Helsinki), paying special attention to the anonymity of the participants and the confidentiality of the data collected. Approval was requested from the Ethics and Research Committee of the Balearic Islands (CEI-IB), which was obtained with indicator IB 4383/20. Participation in the study was voluntary, so the participants gave their written and oral consent to participate in the study after receiving sufficient information about the nature of the

study. To this end, they were given an informed consent form, as well as an information sheet explaining the objective of the study.

The data collected for the study were identified by a code and only the person responsible for the study can relate these data to the participants. The identity of the participants will not be disclosed in any report of this study. The investigators will not disseminate any information that could identify them. In any case, the research team undertakes to strictly comply with the Organic Law 3/2018, of December 5, on the protection of personal data and guarantee of digital rights, guaranteeing the participant in this study that he/she may exercise his/her rights of access, rectification, cancellation and opposition of the data collected

Results

Table I shows the anthropometric and clinical characteristics of the 418,343 workers (246,061 men and 172,282 women) who were included in the study. The mean age of the sample was 40.2 ± 11.0 years, the majority being in the group between 30 and 49 years of age. All variables presented more unfavorable values in men. Three out of four workers belonged to social class III, one out of three smoked and slightly more than half did not engage in regular physical activity or have high adherence to the Mediterranean diet.

Table II shows the mean values of the different cardiometabolic risk scales analyzed according to the presence or absence of metabolic syndrome applying the different criteria in men and women. The mean values of all the cardiometabolic risk scales were much higher, in both sexes, in those who presented metabolic syndrome applying any of the three criteria. In all cases, the differences observed were statistically significant.

Table III shows that the prevalence of high values of the different cardiometabolic risk scales behaved similarly to the mean values, that is, they were higher in workers with metabolic syndrome, and the differences observed were statistically significant.

Table IV shows the results of the multinomial logistic regression, showing that the risk of presenting MS with the different criteria increases in parallel with the increase in the values of the cardiometabolic risk scales. The highest odds ratios were found for atherogenic dyslipidemia, lipid triad and diabetes.

Table I: Characteristics of the population.

	Women n=172.282 Mean ± SD	Men n=246.061 Mean ± SD	Total n=418.343 Mean ± SD	p-value
Age	39.6 (10.8)	40.6 (11.1)	40.2 (11.0)	<0.0001
Height	161.8 (6.5)	174.6 (7.0)	169.4 (9.3)	<0.0001
Weight	66.2 (14.0)	81.4 (14.7)	75.1 (16.2)	<0.0001
BMI	25.3 (5.2)	26.7 (4.5)	26.1 (4.8)	<0.0001
Waist	74.8 (10.6)	86.2 (11.1)	81.5 (12.2)	<0.0001
SBP	117.4 (15.7)	128.2 (15.5)	123.7 (16.5)	<0.0001
DBP	72.6 (10.4)	77.8 (11.0)	75.6 (11.0)	<0.0001
Cholesterol	190.6 (35.8)	192.6 (38.9)	191.8 (37.7)	<0.0001
HDL-c	56.8 (8.7)	50.3 (8.5)	53.0 (9.1)	<0.0001
LDL-c	116.1 (34.8)	118.0 (36.7)	117.2 (35.9)	<0.0001
Triglycerides	89.1 (46.2)	123.7 (86.4)	109.5 (74.6)	<0.0001
Glycaemia	87.8 (15.1)	93.3 (21.3)	91.0 (19.2)	<0.0001
	%	%	%	p-value
18-29 years	20.7	18.8	19.6	<0.0001
30-39 years	3.0	27.6	17.4	
40-49 years	29.6	30.0	29.9	
50-59 years	16.8	19.7	18.5	
60-69 years	3.2	3.9	3.6	
Primary school	51.8	61.2	57.3	<0.0001
Secondary school	40.7	34.0	36.8	
University	7.5	4.8	5.9	
Social class I	6.9	4.9	5.7	<0.0001
Social class II	23.4	14.9	18.4	
Social class III	69.7	80.3	75.9	
No physical activity	47.8	54.5	51.7	<0.0001
Yes physical activity	52.2	45.5	48.3	
No mediterranean diet	48.6	59.0	54.7	<0.0001
Yes mediterranean diet	51.4	41.0	45.3	
Non-smokers	67.2	66.6	66.8	<0.0001
Smokers	32.8	33.4	33.2	

SBP systolic blood pressure. DBP diastolic blood pressure.

Table II: Mean values of different cardiometabolic risk scales according to the presence or absence of metabolic syndrome with the different criteria by sex.

	No MS ATPIII	Yes MS ATPIII		No MS IDF	Yes MS IDF		No MS JIS	Yes MS JIS	
Men	n=98425	n=33115	p-value	n=107921	n=23619	p-value	n=80890	n=50650	p-value
ALLY VA SCORE	6.7 (6.6)	10.7 (7.1)	<0,001	7.2 (6.8)	9.9 (7.0)	<0,001	6.1 (6.4)	10.1 (7.1)	<0,001
SCORE	1.5 (2.0)	2.6 (2.8)	<0,001	1.7 (2.2)	2.2 (2.5)	<0,001	1.3 (1.8)	2.5 (2.7)	<0,001
ALLY VA Framingham	4.3 (8.9)	16.4 (10.7)	<0,001	5.3 (9.8)	14.6 (10.7)	<0,001	3.1 (8.2)	14.5 (10.7)	<0,001
REGICOR	3.2 (2.2)	3.9 (2.6)	<0,001	3.2 (2.2)	3.7 (2.5)	<0,001	3.1 (2.1)	3.7 (2.5)	<0,001
Cholesterol/HDL	3.7 (1.0)	5.1 (1.3)	<0,001	3.8 (1.0)	5.0 (1.3)	<0,001	3.6 (0.9)	4.8 (1.2)	<0,001
Triglycerides/HDL	2.1 (1.4)	4.9 (3.2)	<0,001	2.3 (1.8)	4.5 (3.0)	<0,001	2.0 (1.2)	4.3 (2.9)	<0,001
LDL/HDL	2.3 (0.9)	3.1 (1.1)	<0,001	2.3 (0.9)	3.1 (1.1)	<0,001	2.2 (0.8)	3.0 (1.1)	<0,001
Women	n=72329	n=12967	p-value	n=73270	n=12026	p-value	n=70168	n=15128	p-value
ALLY VA SCORE	3.7 (5.0)	7.1 (5.4)	<0,001	3.8 (5.0)	6.5 (5.4)	<0,001	3.6 (4.9)	7.0 (5.4)	<0,001
SCORE	0.4 (0.8)	1.0 (1.4)	<0,001	0.4 (0.9)	0.9 (1.3)	<0,001	0.4 (0.8)	1.0 (1.4)	<0,001
ALLY VA Framingham	-1.2 (10.1)	16.5 (13.1)	<0,001	-0.8 (10.6)	14.5 (13.1)	<0,001	-1.4 (9.9)	15.8 (13.1)	<0,001
REGICOR	2.8 (2.2)	3.5 (2.3)	<0,001	2.8 (2.2)	3.4 (2.3)	<0,001	2.8 (2.2)	3.5 (2.3)	<0,001
Cholesterol/HDL	3.3 (0.8)	4.3 (0.9)	<0,001	3.4 (0.8)	4.3 (0.9)	<0,001	3.3 (0.8)	4.3 (0.9)	<0,001
Triglycerides/HDL	1.5 (0.7)	3.0 (1.7)	<0,001	1.5 (0.8)	2.8 (1.5)	<0,001	1.5 (0.7)	2.9 (1.7)	<0,001
LDL/HDL	2.1 (0.8)	2.8 (0.8)	<0,001	2.1 (0.8)	2.7 (0.8)	<0,001	2.0 (0.7)	2.7 (0.8)	<0,001

ALLY VA Years of life lost of vascular age. SCORE REGICOR Gironi heart registry. HDL High-density lipoproteins. LDL Low-density lipoproteins. MS ATPIII Metabolic syndrome Adult Treatment Panel III. MS IDF Metabolic syndrome International Diabetes Federation. MS JIS Metabolic Syndrome Joint Interim Statement.

Table III: Prevalence of high values of different cardiometabolic risk scales according to the presence or absence of metabolic syndrome with the different criteria by sex.

	No MS ATPIII	Yes MS ATPIII		No MS IDF	Yes MS IDF		No MS JIS	Yes MS JIS	
Men	n=98425	n=33115	p-value	n=107921	n=23619	p-value	n=80890	n=50650	p-value
SCORE high	8.1	20.8	<0.001	10.2	16.0	<0.001	6.7	18.7	<0,001
REGICOR high-very high	1.7	3.5	<0.001	1.9	2.9	<0.001	1.6	3.0	<0,001
CT/HDL moderate-high	10.1	49.5	<0.001	12.2	46.6	<0.001	7.7	40.4	<0,001
TG/HDL high	16.4	77.5	<0.001	20.2	69.2	<0.001	12.2	64.6	<0,001
LDL/HDL high	20.1	54.6	<0.001	21.7	53.4	<0.001	17.0	49.3	<0,001
Diabetes	0.6	16.9	<0.001	1.1	17.6	<0.001	0.2	11.6	<0,001
Atherogenic dyslipidemia	1.3	39.7	<0.001	3.8	33.4	<0.001	1.0	25.3	<0,001
Lipid triad	0.3	11.4	<0.001	1.1	9.2	<0.001	0.3	7.2	<0,001
Women	n=72329	n=12967	p-value	n=73270	n=12026	p-value	n=70168	n=15128	p-value
SCORE high	0.8	3.4	<0.001	1.0	2.5	<0.001	0.8	3.1	<0,001
REGICOR high-very high	1.5	2.3	<0.001	1.5	2.2	<0.001	1.5	2.3	<0,001
CT/HDL moderate-high	8.5	39.4	<0.001	9.0	35.8	<0.001	8.2	38.0	<0,001
TG/HDL high	3.4	41.6	<0.001	4.3	33.6	<0.001	3.2	38.2	<0,001
LDL/HDL high	10.5	35.9	<0.001	10.8	33.8	<0.001	10.2	35.2	<0,001
Diabetes	0.2	14.8	<0.001	0.2	15.3	<0.001	0.2	13.6	<0,001
Atherogenic dyslipidemia	1.0	31.8	<0.001	1.8	24.9	<0.001	1.0	27.9	<0,001
Lipid triad	0.3	7.9	<0.001	0.5	5.7	<0.001	0.2	7.0	<0,001

SCORE Systematic Coronary Risk Estimation REGICOR Gironi Heart Registry. CT Total cholesterol. TG Triglycerides. HDL. High-density lipoproteins. LDL. Low-density lipoproteins. TG Triglycerides. MS ATPIII Metabolic syndrome Adult Treatment Panel III. MS IDF Metabolic syndrome International Diabetes Federation. MS JIS Metabolic syndrome Joint Interim Statement.

Table IV: Multinomial logistic regression.

	MS ATPIII OR (95% CI)	MS IDF OR (95% CI)	MS IDF OR (95% CI)
SCORE low	1	1	1
SCORE moderate	1.50 (1.44-1.56)	1.16 (1.11-1.22)	1.59 (1.53-1.66)
SCORE high	4.14 (4.00-4.28)	2.00 (1.93-2.08)	5.08 (4.91-5.26)
REGICOR low	1	1	1
REGICOR moderate	1.41 (1.20-1.66)	1.38 (1.15-1.65)	1.44 (1.24-1.68)
REGICOR high	1.76 (1.51-2.06)	1.51 (1.27-1.79)	1.69 (1.46-1.95)
REGICOR very high	3.01 (2.58-3.50)	2.18 (1.89-2.59)	2.80 (2.42-3.24)
CT/HDL low	1	1	1
CT/HDL moderate	2.41 (2.05-2.84)	1.60 (1.37-1.87)	1.86 (1.57-2.20)
CT/HDL high	20.11 (17.09-23.65)	9.88 (8.46-11.54)	14.26 (12.03-16.90)
TG/HDL normal	1	1	1
TG/HDL high	17.04 (16.70-17.39)	8.63 (8.45-8.80)	16.28 (15.99-16.58)
LDL/HDL normal	1	1	1
LDL/HDL high	5.12 (5.03-5.22)	4.28 (4.20-4.37)	5.34 (5.25-5.43)
No Atherogenic dyslipidemia	1	1	1
Yes Atherogenic dyslipidemia	50.86 (49.12-52.66)	14.37 (13.99-14.77)	34.31 (33.05-35.61)
No Lipid triad	1	1	1
Yes Lipid triad	39.66 (37.13-42.37)	9.97 (9.50-10.45)	29.73 (27.67-31.94)
No Diabetes	1	1	1
Yes Diabetes	45.42 (43.00-47.98)	26.34 (25.21-27.52)	83.36 (76.43-90.91)

SCORE Systematic Coronary Risk Estimation REGICOR Gironi Heart Registry. CT Total cholesterol. HDL. High-density lipoproteins. LDL. Low-density lipoproteins. TG Triglycerides. MS ATPIII Metabolic syndrome Adult Treatment Panel III. MS IDF Metabolic syndrome International Diabetes Federation. MS JIS Metabolic syndrome Joint Interim Statement.

Discussion

The mean values and prevalence of elevated values of the different cardiometabolic risk scales analyzed (atherogenic indices, vascular age, REGICOR and SCORE scales, atherogenic dyslipidemia, lipid triad, and diabetes) show higher figures in persons with metabolic syndrome with any of the criteria.

The scales that most increase the risk of presenting metabolic syndrome are atherogenic indices, AD, LT and diabetes.

We have not found articles that relate the metabolic syndrome with most of the cardiometabolic scales analyzed in this study, so we will focus on those that relate the MS with cardiovascular risk scales.

A cohort of persons aged between 20 and 75 years (mean age 59 years) with metabolic syndrome presented a prevalence of high-risk values with the SCORE scale of 50% in men and 29.6% in women, higher figures than those found in our study, perhaps due to the higher mean

age of the sample¹⁴. A review of the literature¹⁵ concluded that, based on prospective studies, the cardiovascular risk in women with MS is equal to or somewhat higher than that of men with MS; these data differ from those found in our study. Another review conducted in Italy showed that the metabolic syndrome seems to modestly increase cardiovascular risk¹⁶.

Strengths and limitations

The greatest strengths of the study are the large sample size (more than 400 000 workers) and the large number of cardiometabolic risk and metabolic syndrome scales used. As limitations, we would highlight the fact that it was carried out in the working population, which excludes people under 18 and over 69 years of age, so we do not know whether we can extrapolate our results to the general population.

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Conclusions

The high values of all the cardiometabolic risk scales analyzed have a very good relationship with the presence of MS with the three criteria. The variables that most increase the risk of presenting MS with any of the three criteria are high atherogenic cholesterol/HDL and triglycerides/HDL indices, atherogenic dyslipidemia, lipid triad, and diabetes.

Conflict of Interest

The authors declare that no competing interests exist.

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