rfm
Revista de la Facultad de Medicina

ORIGINAL RESEARCH

Comparison of different definitions of metabolic syndrome and their relationship with cardiovascular risk estimation

Comparación de diferentes definiciones de síndrome metabólico y su relación con la estimación del riesgo cardiovascular

Jorge David Roca-Sanchez-Moreno[1,2] Alonso Soto[2,3] Alison Liz Núñez-Muñoz[1,2]
Jhony Alberto De La Cruz-Vargas[2] Dante Manuel Quiñones-Laveriano[2]

[1] Universidad Ricardo Palma - Faculty of Human Medicine - Lima - Peru.
[2] Universidad Ricardo Palma - Biomedical Sciences Research Institute - Lima - Peru.
[3] Hospital Nacional Hipólito Unanue - Department of Internal Medicine - Lima - Peru.

Open access

Received: 31/12/2020
Accepted: 22/03/2021

Corresponding author: Jorge David Roca-Sanchez-Moreno. Instituto de Investigación en Ciencias Biomédicas, Facultad de Medicina Humana, Universidad Ricardo Palma. Lima. Peru. Email: davidroca.sm@gmail.com.

Keywords: Metabolic Syndrome; Insulin Resistance; Abdominal Obesity (MeSH).

Palabras clave: Síndrome metabólico; Resistencia a la insulina; Obesidad abdominal (DeCS).

How to cite: Roca-Sanchez-Moreno JD, Soto A, Núñez-Muñoz AL, De La Cruz-Vargas JA, Quiñones-Laveriano DM. Comparison of different definitions of metabolic syndrome and their relationship with cardiovascular risk estimation. Rev. Fac. Med. 2022;70(2):e92602. English. doi: https://doi.org/10.15446/revfacmed.v70n2.92602.

Cómo citar: Roca-Sanchez-Moreno JD, Soto A, Núñez-Muñoz AL, De La Cruz-Vargas JA, Quiñones-Laveriano DM. [Comparación de diferentes definiciones de síndrome metabólico y su relación con la estimación del riesgo cardiovascular]. Rev. Fac. Med. 2022;70(2):e92602. English. doi: https://doi.org/10.15446/revfacmed.v70n2.92602.

Abstract

Introduction: Multiple definitions of metabolic syndrome (MS) are used in Peru, and there is currently no consensus on which definition should be used in clinical practice.
Objectives: To compare cardiovascular disease (CVD) risk estimators, obtained using the ACC/AHA ASCVD Risk Calculator, and to assess their level of agreement with different definitions of MS in patients treated in Lima, Peru.
Materials and methods: Analytical cross-sectional study. Medical records, collected through consecutive sampling, of 233 patients treated between October and December 2019 at the Hospital Nacional Hipólito Unanue, Lima, Peru, were reviewed. CVR risk was calculated using the online ACC/AHA ASCVD Risk Calculator, and the MS definitions of the WHO, NCEP-ATP III, IDF, AHA/NHLBI, JIS and ALAD were considered to compare CVD risk according to each definition. Agreement between the different MS definitions was calculated using the kappa coefficient based on the six levels of strength of agreement described by Landis and Koch.
Results: The median CVD risk in patients with MS according to the definitions of the WHO, NCEP-ATP III, IDF, AHA/NHLBI, ALAD and JIS was 9.6 (3.9-20.35), 7.9 (3.1-18.6), 7.3 (3- 16.5), 7.8 (3-17.6), 7.1 (2.9-16.5), and 7.1 (3.1-16.5), respectively. The prevalence of MS according to JIS, IDF, ALAD, AHA/NHLBI, NCEP-ATP III and WHO definitions was 81.97%, 80.26%, 74.68%, 67.81%, 65.67%, and 51.14%, respectively. Agreement between the JIS criteria and the IDF, ALAD, NCEP-ATP III, and AHA/NHLBI criteria was 0.944, 0.787, 0.592, and 0.567, respectively, but it was 0.286 between the JIS criteria and the WHO criteria.
Conclusions: In Peru, there are differences between CVD risk estimates depending on the MS definition used and considered in the present study, which may have an impact on the intensity of the therapeutic and preventive interventions performed in these patients.

Resumen

Introducción. En Perú se usan múltiples definiciones de síndrome metabólico (SM); sin embargo, actualmente no hay un consenso sobre cuál definición usar en la práctica clínica.
Objetivos. Comparar las estimaciones de riesgo cardiovascular (RCV), obtenidas mediante la calculadora de RCV de la ACC/AHA, y evaluar su grado de concordancia con diferentes definiciones de SM en pacientes atendidos en Lima, Perú.
Materiales y métodos. Estudio transversal analítico. Se revisaron las historias clínicas, obtenidas por muestreo consecutivo, de 233 pacientes atendidos entre octubre y diciembre de 2019 en el Hospital Nacional Hipólito Unanue, Lima, Perú. El RCV se calculó mediante la calculadora virtual de RCV de la ACC/AHA y se consideraron las definiciones de SM de la OMS, NCEP-ATP III, IDF, AHA/NHLBI, JIS y ALAD para comparar el RCV según cada definición. La concordancia entre las distintas definiciones de SM se calculó mediante el coeficiente kappa con base en los seis niveles de fuerza de concordancia de Landis y Koch.
Resultados. Las medianas de RCV en pacientes con SM según las definiciones de la OMS, NCEP-ATP III, IDF, AHA/NHLBI, ALAD y JIS fueron 9.6 (3.9-20.35), 7.9 (3.1-18.6), 7.3 (3-16.5), 7.8 (3-17.6), 7.1 (2.9-16.5) y 7.1 (3.1-16.5), respectivamente. La prevalencia de SM según las definiciones JIS, IDF, ALAD, AHA/NHLBI, NCEP-ATP III y OMS fue 81.97%, 80.26%, 74.68%, 67.81%, 65.67% y 51.14%, respectivamente. La concordancia entre las definiciones JIS e IDF, ALAD, NCEP-ATP III y AHA/NHLBI fue 0.944, 0.787, 0.592 y 0.567, respectivamente, pero entre la JIS y la OMS fue 0.286.
Conclusiones. Existen diferencias entre las estimaciones de RCV según las distintas definiciones de SM usadas en Perú y consideradas en el presente estudio, lo que puede tener repercusiones en la intensidad de las intervenciones terapéuticas y preventivas realizadas en estos pacientes.

Introduction

According to the World Health Organization (WHO),[1] cardiovascular diseases (CVD) are the leading cause of death worldwide, accounting for approximately 17.9 million deaths annually. Since several CVD (e.g., ischemic heart disease, cerebrovascular disease, and peripheral artery disease) are associated with atherosclerosis, the current therapeutic approach focuses on preventing this condition.[2] However, it is essential to note that there are multiple risk factors for CVD, including obesity, high blood pressure, type 2 diabetes *mellitus*, and dyslipidemia.[3,4]

Metabolic syndrome (MS) is a condition whose prevalence is growing globally due to changes in lifestyle. In Peru, Tejada-Lopez *et al.*[5] reported a prevalence of 38.97% in a study of 4 696 patients treated in the Life Reform program at Hospital I Florencia de Mora EsSALUD (La Libertad) between January 2014 and December 2017.

MS is defined as a cluster of several metabolic abnormalities that occur at the same time and increase the risk of CVD. Such abnormalities include central obesity, dyslipidemia, insulin resistance, impaired fasting glucose, and high blood pressure.[6,7]

Multiple institutions, including the WHO,[8] the International Diabetes Federation (IDF),[9] the American Heart Association/National Heart Lung and Blood Institute (AHA/NHLBI)[10] and the National Cholesterol Education Program – Adult Treatment Panel III (NCEP-ATP III) have established diagnostic criteria for MS.[11] In response to this diversity of criteria, some institutions have joined forces to establish standard parameters. For example, in 2009, IDF and AHA/NHLBI proposed a Joint Interim Statement (JIS) to standardize the definition of this condition.[12] In turn, in 2010, the Latin American Consensus of the Asociación Latinoamericana de Diabetes (Latin American Diabetes Association - ALAD) was published, proposing criteria to establish the epidemiology, diagnosis, control, prevention and treatment of MS in adults with a different waist circumference threshold.[13]

In Peru, there is neither a consensus on which MS definition should be used nor on the clinical relevance of using one or the other of the existing definitions in clinical practice. Furthermore, although studies have evaluated the association between the different definitions of MS and the presence of CVD, there is no research in Latin America indicating which definition is most useful for estimating cardiovascular risk (CVR).[14,15]

Given this situation, the objectives of the present study were to compare CVR estimates obtained using the ACC/AHA ASCVD Risk Calculator, and to assess their level of agreement with different definitions of MS in patients treated in Lima, Peru.

Materials and methods

Analytical cross-sectional study. The study population consisted of patients treated by the internal medicine service of the Hospital Nacional Hipólito Unanue (HNHU) in Lima, Peru, where people with cardiometabolic diseases (hypertension, diabetes *mellitus*, dyslipidemia, obesity and/or MS) were evaluated. Sample size was calculated from the prevalence of high CVR obtained with the ACC/AHA ASCVD Risk Calculator and the reports of a similar study conducted in people with and without MS in Colombia, which was 60.7% and 39.3%, respectively.[16] A statistical power of 88.4% and a confidence level of 95% were used, resulting in a sample size of 232 patients.

Initially, 269 medical records were reviewed, but 36 were excluded for the following reasons: history of CVD (coronary heart disease, stroke, and peripheral artery disease), lack of laboratory test results to rule out MS based on any of the established definitions, absence of CVR assessment (total cholesterol, triglycerides, HDL-c, fasting glucose),

and insufficient information on the variables of interest. Thus, the medical records of 233 patients with cardiometabolic disease treated between October and December 2019 were reviewed; they were obtained through consecutive sampling during the same time period. The flow diagram for patient selection is shown in Figure 1.

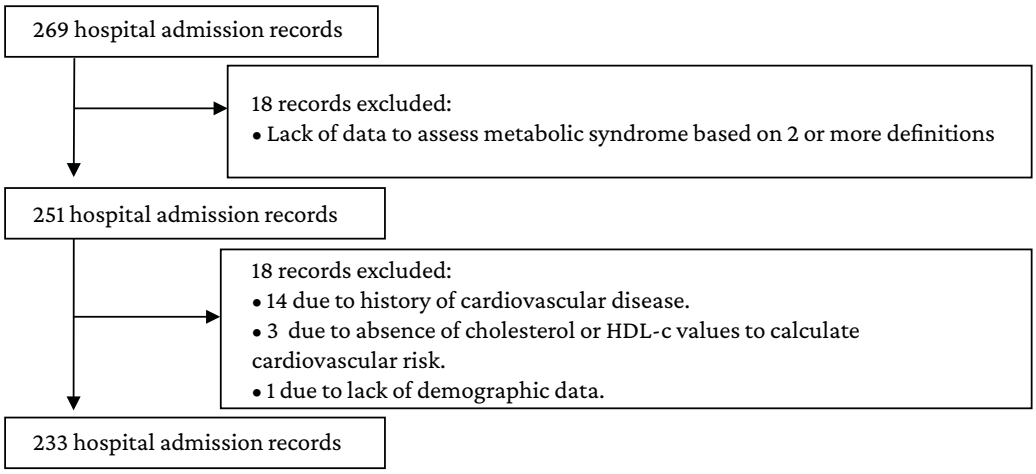

Figure 1. Flow chart for participants selection.
Source: Own elaboration.

The following information was collected from the medical records: sex, age, anthropometric measures (waist and hip circumference, body mass index), blood pressure, history of smoking, history of disease, laboratory test results (fasting glucose, total cholesterol, triglycerides, high-density lipoprotein cholesterol, microalbuminuria), and diagnoses of hypertension, diabetes *mellitus*, dyslipidemia and obesity.

For each patient, the criteria for MS were assessed according to the WHO, NCEP-ATP III, IDF, AHA/NHLBI and ALAD definitions, as well as the JIS definition (established by IDS and AHA/NHLBI). Likewise, CVR was assessed using the online ACC/AHA ASCVD Risk Calculator (available at http://www.cvriskcalculator.com/), which uses pooled cohort equations to estimate the 10-year primary risk of atherosclerotic CVD among patients without pre-existing CVD. Values are interpreted as high risk: >7.5%; intermediate risk: 5% to 7.5%; and low risk: <5%.[17]

Definitions of MS used in this study for diagnosis are as follows:

WHO: diagnosis of diabetes, fasting glucose ≥110 mg/dL, impaired glucose tolerance or insulin resistance, and at least 2 of the following criteria: waist-to-hip ratio (WHR) >0.9 in men and >0.85 in women or body mass index (BMI) >30 kg/m²; triglycerides ≥150 mg/dL and/or high-density lipoprotein cholesterol (HDL-c) <35 mg/dL in men and <39 mg/dL in women; blood pressure (BP) ≥140/90 mm Hg; or microalbuminuria (urinary albumin excretion) ≥20 ugr/min.[8]

NCEP-ATP III: presence of 3 or more of the following determinants: waist circumference >102cm in men and >88cm in women; triglycerides ≥150 mg/dL; HDL-c <40 mg/dL in men and <50 mg/dL in women; BP ≥130/85 mm Hg, or fasting glucose ≥110 mg/dL.[10]

IDF: central obesity (waist circumference ≥90cm in men and ≥80cm in women or BMI >30 kg/m²), and at least 2 of the following criteria: triglycerides ≥150 mg/dL or being under treatment for elevated triglycerides; HDL-c <40 mg/dL in men and <50 mg/dL in women or being under treatment for reduced HDL-c levels; BP ≥130/85 mm Hg or under antihypertensive treatment; fasting glucose ≥100 mg/dL or previous diagnosis of type 2 *diabetes*.[9]

AHA/NHLBI (modified ATP III): at least 3 of the following factors: central obesity (waist circumference ≥102cm in men and ≥88cm in women); triglycerides >150 mg/dL or being under treatment for elevated triglycerides; HDL-c <40 mg/dL in men and <50 mg/dL in women, or under treatment for reduced HDL-c levels; BP ≥130/85 mm Hg or under antihypertensive treatment in a patient with a history of hypertension; fasting glucose ≥100 mg/dL or under treatment for elevated glucose.[10]

AHA/JIS (modified ATP III): at least 3 of the following factors: central obesity (waist circumference ≥94cm in men and ≥80cm in women); triglycerides >150 mg/dL or being under treatment for elevated triglycerides; HDL-c <40 mg/dL in men and <50 mg/dL in women, or under treatment for reduced HDL-c levels; BP ≥130/85 mm Hg or under antihypertensive treatment in a patient with a history of hypertension; fasting glucose ≥100 mg/dL or under treatment for elevated glucose.[12]

ALAD: central obesity (waist circumference ≥94cm in men and ≥88cm in women), and at least 2 of the following criteria: triglycerides ≥150 mg/dL or under specific lipid-lowering agents treatment; HDL-c <40 mg/dL in men and <50 mg/dL in women, or under treatment for reduced HDL-c levels; BP ≥130/85 mm Hg or under antihypertensive treatment; fasting glucose 100 mg/dL or previous diagnosis of diabetes or glucose intolerance.[13]

The collected data were entered into a Microsoft Excel database. Baseline characteristics of participants were described separately for men and women, and categorical variables were presented as frequencies and percentages, while numerical variables were presented as medians and interquartile ranges or means and standard deviations, depending on their distribution. Pearson's chi-square test was used to compare qualitative variables, but Fisher's exact test was used in cases where the expected frequencies in the contingency tables were <5.

The Mann-Whitney U-test was used to determine differences in the median percentage of CVR according to the different definitions of MS. In addition, agreement between the different definitions of MS was calculated using Cohen's kappa coefficient. The interpretation of this measure was based on the 6 levels of agreement strength proposed by Landis & Koch: ≤0.00 (no agreement); 0.01-0.20 (none to slight); 0.21-0.40 (fair), 0.41-0.60 (moderate); 0.61-0.80 (substantial) and 0.81-1.00 (almost perfect).[18] All statistical analyzes were performed in the Stata 14.0 software and a $p<0.05$ was considered statistically significant.

The present study was reviewed and approved by the Research Ethics Committee of the Faculty of Human Medicine Manuel Huamán Guerrero in accordance with Minutes No. 10 of September 24, 2019, and by the Institutional Research Ethics Committee of the HNHU as per Minutes No. 213-2019-CIEI-HNHU of December 12, 2019. Similarly, the study took into account the ethical principles for medical research involving human subjects established by the Declaration of Helsinki.[19] Informed consent was not required as we did not work directly with patients. No personal information was published or utilized.

Results

The mean age of the sample was 58.56 years, with a standard deviation of 11.23 years, and the majority were women (72.10%; n=168). The clinical and epidemiological characteristics of the population are shown in Table 1.

With respect to the 6 definitions studied, MS was more frequent according to the JIS definition (81.97%, being more common in women: 84.5%), followed by the IDF (80.26%), ALAD (74.68%), AHA/NHLBI (67.81%), NCEP-ATP III (65.67%), and WHO (51.14%) definitions. The definitions of MS and their corresponding criteria in relation to sex are shown in Table 2.

Table 1. Clinical and epidemiological characteristics of the sample (n=233).

Characteristics	Men (n=65)		Women (n=168)		Total (n=233)		*p*-value
Age(mean; SD)	57.83	±11.68	58.84	±11.06	58.56	11.23	0.212
Smoker (n; %)	2	3.08	3	1.79	5	2.15	0.620
Abdominal circumference (cm) (median and IQR)	103.50	93-110	103	96-110	103	95-110	0.002
Hip circumference (cm) (median and IQR)	102.50	94-109	107	100-115	105	98-113	<0.001
Waist-to-hip ratio (mean; SD)	0.99	±0.04	0.96	±0.05	0.97	±0.05	0.143
Body mass index (median and IQR)	29.37	25.53-32.62	30.89	27.04-34.07	30.48	26.03-33.56	<0.001
Diagnosis of hypertension (n; %)	33	50.77	66	39.29	99	42.49	0.112
Systolic blood pressure (median and IQR)	120	110-135	120	110-130	120	110-130	0.003
Diastolic blood pressure (mean; SD)	77.03	±10.38	75.50	±9.28	75.93	±9.60	0.942
Diagnosis of diabetes (n; %)	34	52.31	96	57.14	130	55.79	0.505
Basal glucose (median and IQR)	106	95-137	110	95-140	108.50	95-139	<0.001
Total cholesterol (mean; SD)	185.60	±46.30	206.05	±47.84	200.34	±48.20	0.115
Triglycerides (median and IQR)	149	104-195	154	113.50-221	154	112-212	<0.001
Triglyceride treatment (n; %)	11	16.92	32	19.05	43	18.45	0.708
HDL-c (median and IQR)	40	35-46	45	39-52	43	38-50	<0.001
Microalbuminuria (median and IQR)	7.16	1.76-27.89	8	2.65 -26.97	8	2.3-27.77	<0.001

HDL-c: high-density lipoprotein cholesterol; IQR: interquartile range.
Source: Own elaboration.

Table 2. Frequency of definitions of metabolic syndrome and its criteria according to sex in the sample (n=233).

Variables		Men (n=65)		Women (n=168)		Total (n=233)		*p*-value
		n	%	n	%	n	%	
WHO:	Metabolic syndrome	27	45.76	85	53.13	112	51.14	0.334
	Glycemia	38	58.46	109	64.88	147	63.09	0.362
	BMI or WHR	65	100	166	98.81	231	99.14	>0.999
	TG and/or HDL-c	39	60	107	63.69	146	62.66	0.601
	Blood pressure	19	29.23	28	16.67	47	20.17	0.032
	Microalbuminuria	12	30	33	31.73	45	31.25	0.841
NCEP-ATP III	Metabolic syndrome	28	43.08	125	74.40	153	65.67	<0.001
	Glycemia	38	58.46	109	64.88	147	63.09	0.362
	Abdominal circumference	33	50.77	156	92.86	189	81.12	<0.001
	TG	32	49.23	90	53.57	122	52.36	0.552
	HDL-c	31	47.69	113	67.26	144	61.80	0.006
	Blood pressure	25	38.46	61	36.31	86	36.91	0.760
IDF	Metabolic syndrome	46	70.77	141	83.93	187	80.26	0.024
	Abdominal circumference	57	87.69	164	97.62	221	94.85	0.005
	Glycemia	44	67.69	124	73.81	168	72.10	0.350
	TG	35	53.85	99	58.93	134	57.51	0.482
	HDL-c	38	58.46	119	70.83	157	67.38	0.071
	Blood pressure	37	56.92	86	51.19	123	52.79	0.432
AHA/NHLBI	Metabolic syndrome	37	56.92	121	72.02	158	67.81	0.027
	Glycemia	44	67.69	124	73.81	168	72.10	0.350
	Abdominal circumference	37	56.92	159	94.64	196	84.12	<0.001
	TG	35	53.85	100	59.52	135	57.94	0.431
	HDL-c	34	52.31	101	60.12	135	57.94	0.279
	Blood pressure	37	56.92	86	51.19	123	52.7	0.432

Table 2. Frequency of definitions of metabolic syndrome and its criteria according to sex in the sample (n=233). (continued)

Variables		Men (n=65)		Women (n=168)		Total (n=233)		*p*-value
		n	%	n	%	n	%	
ALAD	Metabolic syndrome	38	58.46	136	80.95	174	74.68	<0.001
	Abdominal circumference	47	72.31	159	94.64	206	88.41	<0.001
	Glycemia	44	67.69	124	73.81	168	72.10	0.350
	TG	35	53.85	99	58.93	134	57.51	0.482
	HDL-c	38	58.46	119	70.83	157	67.38	0.071
	Blood pressure	37	56.92	86	51.19	123	52.79	0.432
JIS	Metabolic syndrome	49	75.38	142	84.52	191	81.97	0.104
	Abdominal circumference	57	87.69	164	97.62	221	94.85	0.005
	Glycemia	44	67.69	124	73.81	168	72.1	0.350
	TG	35	53.85	99	58.93	134	57.51	0.482
	HDL-c	38	58.46	119	70.83	157	67.38	0.071
	Blood pressure	37	56.92	86	51.19	123	52.79	0.432

WHO: World Health Organization; NCEP- ATP III: National Cholesterol Education Program - Adult Treatment Panel III; IDF: International Diabetes Federation; AHA/NHLBI: American Heart Association/ National Heart Lung and Blood Institute; ALAD: Asociación Latinoamericana de Diabetes; JIS: Joint Interim Statement; BMI: body mass index; WHR: waist-to-hip ratio; TG: triglycerides; HDL-c: high-density lipoprotein cholesterol.
Source: Own elaboration.

The analysis of diagnostic agreement between the definitions of MS is shown in Table 3. Agreement between the IDF and JIS definitions was 0.944, whereas the kappa coefficient between the JIS definition and the ALAD, NCEP-ATPIII, and AHA/NHLBI definitions was 0.787, 0.592, and 0.567, respectively. Agreement between the criteria of the JIS definition and those proposed by the WHO was 0.286 (Table 3).

Table 3. Agreement evaluated by kappa index between definitions of metabolic syndrome in the sample.

Metabolic syndrome	WHO	NCEP-ATP III	IDF	AHA/NHLBI	ALAD
NCEP ATP III	0.429				
IDF	0.249	0.598			
AHA/NHLBI	0.272	0.546	0.551		
ALAD	0.233	0.557	0.841	0.583	
JIS	0.286	0.592	0.944	0.567	0.787

WHO: World Health Organization; NCEP- ATP III: National Cholesterol Education Program - Adult Treatment Panel III; IDF: International Diabetes Federation; AHA/NHLBI: American Heart Association/National Heart Lung and Blood Institute; JIS: Joint Interim Statement; ALAD: Asociación Latinoamericana de Diabetes.
Source: Own elaboration.

Table 4 describes the CVR estimates (median and interquartile ranges) obtained according to each definition of MS. In this regard, it was observed that CVR was significantly higher in patients with MS regardless of the definition used, except for the definition of ALAD, where no significant differences were observed between CVR medians.

Table 4. Differences in the median percentage of cardiovascular risk according to the definitions of metabolic syndrome in the sample (n=233).

Metabolic syndrome		Estimated cardiovascular risk	
		Median (interquartile range)	*p*-value
WHO	Yes	9.6 (3.9-20.35)	<0.001
	No	4 (1.85-11.7)	
NCEP-ATP III.	Yes	7.9 (3.1-18.6)	0.008
	No	4.65 (2.35-11.63)	
IDF	Yes	7.3 (3-16.5)	0.033
	No	4.2 (1.6-11.46)	
AHA/NHLBI	Yes	7.8 (3-17.6)	0.014
	No	4.5 (2.2-11.9)	
ALAD	Yes	7.1 (2.9-16.5)	0.200
	No	5.4 (2.3-13.4)	
JIS	Yes	7.1 (3.1-16.5)	0.016
	No	3.4 (1.6-11.46)	

WHO: World Health Organization; NCEP- ATP III: National Cholesterol Education Program - Adult Treatment Panel III IDF: International Diabetes Federation; AHA/NHLBI: American Heart Association/National Heart Lung and Blood Institute; JIS: Joint Interim Statement; ALAD: Asociación Latinoamericana de Diabetes.
Source: Own elaboration.

Discussion

The results of this study demonstrate that the number of patients with MS varies depending on the definition used and that, consequently, the estimated CVR varies between definitions. For all definitions, CVR was higher in patients diagnosed with MS, which is consistent with the findings of Isomaa *et al.,*[20] who, in a study of 4 483 individuals aged 35–70 years from Finland and Sweden to estimate prevalence and CVR associated with MS using the WHO definition, found that CVR was three times higher in patients with this condition (p<0.001). It should be noted at this point that, of all the MS definitions looked at in this study, the WHO definition determined the highest CVR.

Similarly, studies such as Lovic *et al.,*[21] conducted in Serbia in 507 patients with ST-segment elevation myocardial infarction, and Li *et al.,*[22] conducted in China in 109 551 adults aged 40 years or older, also reported differences in CVR when evaluating different definitions of MS; however, the WHO definition was not used in these studies, and the cardiovascular event had already occurred in the study by Lovic *et al.*[21]

In the present study, the higher CVR in patients with MS as defined by the WHO (compared to the other definitions) could be explained by the fact that the WHO includes the results of microalbuminuria test in its criteria, and this factor has been described as a predictor of CVR.[23] Furthermore, this definition is the only one that considers central obesity (BMI or WHR). Therefore, regardless of the diagnostic criteria used, it is crucial that physicians who diagnose MS closely monitor their patients' CVR.

In the present study, MS was more frequent when applying the JIS definition (81.97%), followed by the IDF (80.26%), ALAD (74.68%), AHA/NHLBI (67.81%), NCEP-ATP III (65.66%), and WHO (51.14%) definitions. This finding similar to that reported by Saad *et al.,*[24] in a cross-sectional study of 243 patients older than 60 years from Niterói (Brazil), in which MS was also more frequent when the JIS definition was used (JIS: 69.1%, IDF: 64.1%, WHO: 51.9%, and NCEP-ATP III: 45.2%). This could be because both studies used the same abdominal circumference cut-off point since both populations were South American. It is worth mentioning that, although the prevalence of MS in both studies varied depending on the definition and was higher when the JIS definition was used, the prevalence of MS in the present study was much higher with the JIS, IDF, and NCEP-ATP III definitions.

On the other hand, Raposo *et al.*,[25] in a cross-sectional study conducted in Portugal with 4 004 participants, reported a lower prevalence of MS, finding that MS was present in 36.5%, 49.6%, and 43.1% of the sample using the NCEP-ATP III, IDF, and JIS definitions, respectively. This more marked difference could be attributed to the fact that all definitions of MS differ primarily in the criterion evaluating abdominal circumference, and in this case, the abdominal circumference cut-off point in the European population is more permissive than in the Latin American population.[11]

Regardless of the population studied, it can be seen that the JIS and IDF definitions are used more frequently to diagnose MS, and that prevalence is generally higher with the JIS definition, as was the case in the present study (81.97% vs. 80.26%). This may be related to the fact that in the IDF definition, the abdominal circumference criterion must be met in order to determine that a person has MS, whereas in the JIS, this is not required because abdominal circumference is one of the five criteria proposed for this purpose. This difference could contribute to more people being diagnosed with MS according to the JIS definition.[8,11]

The high prevalence of MS found in this study may be associated with the fact that the research was conducted in a service intended to identify patients with CVR factors or with chronic non-communicable diseases such as hypertension, diabetes, and/or dyslipidemias. This hypothesis is supported by the findings of Ghamri & Alamri,[26] who in a study conducted in 155 patients with diabetes *mellitus* found a higher prevalence of MS with the NCEP-ATP III definition (85.8%) compared to the WHO definition (80%). The high prevalence of MS according to WHO criteria can be attributed to the fact that this diagnosis is based on insulin resistance, a condition associated with type 2 diabetes *mellitus,*[7] that all participants in the Ghamri & Alamri study[26] were diabetic patients, and that patients with this condition were included in the present study. It should also be borne in mind that microalbuminuria is a criterion used only in the WHO definition and that, as an early indicator of renal dysfunction in diabetic patients, a large proportion of the diabetic population is very likely to meet this criterion.[27]

In Colombia, Agudelo-Flórez *et al.*[16] conducted a study of 250 patients aged 18 to 60 years in the CVR program of the municipality of San Carlos in which they found a prevalence of MS of 56.5% based on the ALAD criteria and 38.4% according to the NCEP-ATP III criteria. In that study, the prevalence of MS was higher than in the present study, because it included older adult patients. This difference may be attributable to the fact that the prevalence of MS tends to increase with age.[13]

As for sex, regardless of the definition used, a higher prevalence of MS was found in women, which is consistent with studies conducted in other countries.[28-30]

Few studies have been carried out in Peru that compare all of the MS definitions analyzed in this study, as these works generally only include the JIS, NCEP-ATP III, and IDF definitions.[31-33] For example, Arsentales-Montalva *et al.*,[34] in a study of 4 029 people in Peru, established that the prevalence of MS was 25.1% using the JIS definition and that it was higher in women (67.4%); however, no other definitions were used in that study, so no comparisons were made.

In the present study, agreement between the JIS and the IDF definitions of MS criteria was almost perfect, unlike agreement between the JIS and ALAD definitions, which was substantial. On the other hand, agreement between the JIS definition and the NCEP-ATP III and AHA/NHLBI definitions was moderate, while agreement with the WHO definition was fair. This finding is similar to that described by Saad *et al.*,[24] who reported almost perfect agreement between the JIS and IDF definitions (k=0.89), and moderate agreement between the WHO and NCEP-ATP III definitions (k=0.51), between IDF and NCEP-ATP III definitions (k=0.55), and between NCEP-ATP III and JIS definitions (k=0.53). Nonetheless,

it is noteworthy that Saad *et al.*[24] also reported a moderate agreement between the WHO and IDF definitions (k=0.47) and between the WHO and JIS definitions (k=0.45). On the other hand, in a study carried out in Ecuador by Vasquez *et al.*[35] in 318 patients, an almost perfect agreement (k=0.837) was found between the JIS and ALAD definitions.

In contrast, Ghamri & Alamri[26] reported substantial agreement between the NCEP-ATP III and WHO definitions (k=0.751), while Cabrera-Rode *et al.*,[36] in a study of 350 overweight non-diabetic subjects found that agreement between JIS and IDF definitions and NCEP-ATP III and AHA/NHLBI definitions was almost perfect (1.000, 0.947, and 0.885, respectively), between WHO and IDF definitions and AHA/NHLBI and JIS definitions was moderate, and between WHO and NCEP-ATP III definitions was fair. The present study confirmed the almost perfect agreement between the JIS definition and the IDF definition (k=0.944).

The difference in agreement between MS definitions in different populations may be related to ethnic characteristics and lifestyles, making it difficult to use a single definition for all populations. In this regard, if a patient is evaluated in a healthcare center with greater resource availability, for instance one that offers tests such as microalbuminuria, it may be advisable to use the WHO definition, given that such a definition allowed for the determination of a higher CVR in patients with MS in this study. Conversely, if resources are limited and tests are not available, the JIS definition could be considered, as it is the most sensitive for diagnosing SM.

The present study is one of the first in Peru to compare different definitions of MS, including the most recent ALAD definition, and its CVR estimates. However, it has some limitations, including the fact that the sample was chosen using non-probabilistic sampling; that microalbuminuria results were not available for all patients, suggesting that patients with MS according to the WHO definition may have been underreported; and that insulin resistance was not assessed. In light of this, new prospective studies should be conducted to evaluate the association between each definition and the actual probability of cardiovascular events. However, this would require the monitoring of population-based cohorts for years, if not decades.

Conclusions

The number of patients identified as MS cases varied significantly depending on the diagnostic criteria used. Similarly, CVR differs depending on the criteria used, which may have an impact on the intensity of therapeutic and preventive interventions performed in these patients. Furthermore, while the JIS, IDF, and ALAD criteria allow for a greater number of MS diagnoses, the WHO and NCEP-ATP III criteria identify those with a higher CVR.

Explanatory note

The present study, which was previously submitted to the 2nd Pan American Scientific Congress - 34th National Scientific Congress of the Peruvian Student Medical Scientific Society (held in 2020 in the city of Trujillo, Peru, and organized by the Universidad Nacional de Trujillo, the Universidad Privada Antenor Orrego, and the Universidad Cesar Vallejo de Trujillo),[37] is derived from the thesis of the corresponding author.

Conflicts of interest

None stated by the authors.

Funding

None stated by the authors.

Acknowledgments

To the Universidad Ricardo Palma, the HNHU, and everyone who contributed to this research in some way.

References

1. Organización Mundial de la Salud (OMS). Enfermedades cardiovasculares. New York: OMS; 2018 [cited 2022 Aug 23]. Available from: https://bit.ly/3PJ7BQk.
2. Turk-Adawi K, Sarrafzadegan N, Fadhil I, Taubert K, Sadeghi M, Wenger NK, *et al.* Cardiovascular disease in the Eastern Mediterranean region: epidemiology and risk factor burden. Nat Rev Cardiol. 2018;15(2):106-19. https://doi.org/gbw7s7.
3. Swarup S, Goyal A, Grigorova Y, Zeltser R. Metabolic Syndrome. Treasure Island (FL): StatPearls; 2020 [cited 2020 Sep 18]. Available from: https://bit.ly/3vDc9k0.
4. Tune JD, Goodwill AG, Sassoon DJ, Mather KJ. Cardiovascular consequences of metabolic syndrome. Transl Res. 2017;183:57-70. https://doi.org/gf9sbq.
5. Tejada-López YO, Choquehuanca-Zambrano GM, Goicochea-Ríos E del S, Vicuña-Villacorta JE, Guzmán-Aybar OY. Perfil clínico-epidemiológico del síndrome metabólico en adultos atendidos en el hospital I Florencia de Mora EsSALUD. Horiz Med. 2020;20(4):e1168. https://doi.org/h82k.
6. Garralda-Del-Villar M, Carlos-Chillerón S, Diaz-Gutierrez J, Ruiz-Canela M, Gea A, Martínez-González MA, *et al.* Healthy Lifestyle and Incidence of Metabolic Syndrome in the SUN Cohort. Nutrients. 2018;11(1):65. https://doi.org/h67w.
7. Lee AM, Gurka MJ, DeBoer MD. Trends in Metabolic Syndrome Severity and Lifestyle Factors Among Adolescents. Pediatrics. 2016;137(3):e20153177. https://doi.org/f8dnd6.
8. World Health Organization (WHO). Definition diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation. Part I: Diagnosis and classification of diabetes mellitus. Geneva: WHO; 1999.
9. International Diabetes Federation (IDF). The IDF Consensus Worldwide Definition of the Metabolic Syndrome. Brussels: IDF; 2006.
10. 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(17):2735-52. https://doi.org/bdwxvp.
11. 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 blood cholesterol in adults (Adult Treatment Panel III). JAMA. 2001;285(19):2486-97. https://doi.org/d39ksv.
12. 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(16):1640-5. https://doi.org/dkt3qk.
13. Rosas-Guzmán J, González-Chávez A, Ascner P, Bastarrachea R. Consenso Latinoamericano de la Asociación Latinoamericana de Diabetes (ALAD). Epidemiología, diagnóstico, control, prevención y tratamiento del síndrome metabólico en adultos. Rev ALAD. 2010;18(1):25-44.
14. Gao J, Wang Y, Yang YN, Wu XY, Cui Y, Zou ZH, *et al.* Impact of Metabolic Syndrome and Its Components on Clinical Severity and Long-Term Prognosis in Patients With Premature Myocardial Infarction. Front Endocrinol (Lausanne). 2022;13:920470. https://doi.org/h82m.
15. Wen J, Yang J, Shi Y, Liang Y, Wang F, Duan X, *et al.* Comparisons of Different Metabolic Syndrome Definitions and Associations with Coronary Heart Disease, Stroke, and Peripheral Arterial Disease in a Rural Chinese Population. PLoS One. 2015;10(5):e0126832. https://doi.org/gnnwpq.
16. Agudelo-Flórez LA, Manco-Patiño DR, Giraldo-González EF, Campiño-Londoño JF, Pinto-Mejía J, Calvo-Betancur VD, *et al*. Prevalencia del síndrome metabólico según criterios ALAD y ATP III en pacientes del programa de riesgo cardiovascular en San Carlos, Antioquia, Colombia. Rev ALAD. 2019;9:129-40. https://doi.org/h673.

17. Goff DC, Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB, Gibbons R, *et al*. 2013 ACC/AHA Guideline on the Assessment of Cardiovascular Risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;129(25 Suppl 2):S49-73. https://doi.org/2vr.
18. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159-74.
19. World Medical Association (WMA). WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects. Fortaleza: 64th WMA General Assembly; 2013.
20. Isomaa B, Almgren P, Tuomi T, Forsén B, Lahti K, Nissén M, *et al.* Cardiovascular Morbidity and Mortality Associated With the Metabolic Syndrome. Diabetes Care. 2001;24(4):683-9. https://doi.org/c6xdw3.
21. Lovic MB, Savic L, Matic D, Djordjevic D, Nedeljkovic I, Tasic I. Predictive value of metabolic syndrome definitions in patients with myocardial infarction with ST segment elevation - are they all the same? Acta Cardiol. 2018;73(6):574-82. https://doi.org/h675.
22. Li W, Song F, Wang X, Wang D, Chen D, Yue W, *et al*. Relationship between metabolic syndrome and its components and cardiovascular disease in middle-aged and elderly Chinese population: a national cross-sectional survey. BMJ Open. 2019;9(8):e027545. https://doi.org/gkmwkv.
23. García M, Medina C. Microalbuminuria y proteína C reactiva como índices de riesgo cardiovascular en pacientes con síndrome metabólico. Boletín Médico de Postgrado. 2019;35(2):30-4.
24. Saad MAN, Cardoso GP, Martins Wde A, Velarde LGC, Filho RAdaC. Prevalence of Metabolic Syndrome in Elderly and Agreement among Four Diagnostic Criteria. Arq Bras Cardiol. 2014;102(3):263-9. https://doi.org/gcbqgr.
25. Raposo L, Severo M, Barros H, Santos AC. The prevalence of the metabolic syndrome in Portugal: the PORMETS study. BMC Public Health. 2017;17(1):555. https://doi.org/gbps2d.
26. Ghamri RA, Alamri SH. Metabolic syndrome among adults with type 2 diabetes in a Saudi teaching hospital: A comparative prevalence study using WHO and ATP III definitions. Pak J Med Sci. 2019;35(4):1087-92. https://doi.org/h676.
27. Besse-Díaz R, Martínez-Cantillo L, Ríos-Vega L. Aspectos clínicos y epidemiológicos relacionados con la microalbuminuria en pacientes con diabetes *mellitus* de tipo 2. MEDISAN. 2018;22(1):11-8.
28. Moore JX, Chaudhary N, Akinyemiju T. Metabolic Syndrome Prevalence by Race/Ethnicity and Sex in the United States, National Health and Nutrition Examination Survey, 1988-2012. Prev Chronic Dis. 2017;14:E24. https://doi.org/gbjfbs.
29. do Vale Moreira NC, Hussain A, Bhowmik B, Mdala I, Siddiquee T, Fernandes VO, *et al.* Prevalence of Metabolic Syndrome by different definitions, and its association with type 2 diabetes, pre-diabetes, and cardiovascular disease risk in Brazil. Diabetes Metab Syndr. 2020;14(5):1217-24. https://doi.org/h677.
30. Adejumo E, Ogundahunsi O, Adejumo O, Sotunsa J, Jagun O. Prevalence of Metabolic Syndrome in a Rural and Urban Community in South-West Nigeria Using Three Different Definitions. Int J Trop Dis Health. 2017;24(2):1-9. https://doi.org/gjrr87.
31. Adams KJ, Chirinos JL. Prevalencia de factores de riesgo para síndrome metabólico y sus componentes en usuarios de comedores populares en un distrito de Lima, Perú. Rev Peru Med Exp Salud Pública. 2018;35(1):39-45. https://doi.org/h678.
32. Villar-López M, Ballinas-Sueldo Y, Gutiérrez C, Angulo-Bazán Y. Evaluation of a 'life reform' program for the metabolic syndrome in Lima, Peru. Adv Integr Med. 2020;7(3):152-7. https://doi.org/h68b.
33. Ninatanta-Ortiz JA, Núñez-Zambrano LA, García-Flores SA, Romaní FR. Frecuencia de síndrome metabólico en residentes de una región andina del Perú. Rev Peru Med Exp Salud Pública. 2016;33(4):640-50. https://doi.org/h68c.
34. Arsentales-Montalva V, Tenorio-Guadalupe M, Bernabé-Ortiz A. Asociación entre actividad física ocupacional y síndrome metabólico: un estudio poblacional en Perú. Rev Chil Nutr. 2019;46(4):392-9. https://doi.org/h68d.
35. Vásquez MA, Altamirano-Cordero LC, Álvarez R, Valdiviezo A, Cordero G, Añez R, *et al*. Prevalencia y nivel de concordancia entre tres definiciones de síndrome metabólico en la ciudad de Cuenca-Ecuador. Avan Biomed. 2017;5(3):117-28.
36. Cabrera-Rode E, Stusser B, Calix W, Orlandi N, Rodríguez J, Cubas-Dueñas I, *et al.* Concordancia diagnóstica entre siete definiciones de síndrome metabólico en adultos con sobrepeso y obesidad. Rev Peru Med Exp Salud Publica. 2017;34(1):19-27. https://doi.org/h68f.
37. Roca-Sánchez-Moreno J, Núñez-Muñoz AL, Quiñones-Laveriano DM, De La Cruz-Vargas JA, Soto A. Comparación de diferentes definiciones de síndrome metabólico y su relación con el riesgo cardiovascular en pacientes del consultorio cardio metabólico del Hospital Nacional Hipólito Unanue. In: Libro de resúmenes del II Congreso Científico Panamericano - XXXIV Congreso Científico Nacional de la Sociedad Científica Médico Estudiantil. Trujillo; 2020 [cited 2022 Aug 4]. Available from: https://bit.ly/3vFuOLY.