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ORIGINAL

Relationship between different scales of overweight and obesity and heart age values in 139634 spanish workers

Relación entre diferentes escalas de sobrepeso y obesidad y valores de edad cardiaca en 139634 trabajadores españoles

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Abstract

Introduction: Both obesity and cardiovascular disease are highly prevalent worldwide and are responsible for high morbidity and mortality. The aim of this study is to assess the relationship between different scales that assess obesity and a scale that assesses cardiovascular risk such as heart age.
Methods: Descriptive and cross-sectional study carried out in 139634 Spanish workers in which excess weight was determined by applying different scales, both anthropometric and based on the estimation of body and visceral fat, and cardiovascular risk was also assessed by applying the heart age scale.
Results: The values of heart age are higher in those persons who present obesity applying any of the scales analyzed. The value of the obesity scales for predicting high values of heart age is scarce.
Conclusions: There is a good relationship between the scales that assess excess weight and heart age values, but the value of these scales for predicting high values of heart age is not high.

Key words: Heart age, obesity, CUN BAE.

Resumen

Introducción: Tanto la obesidad como las enfermedades cardiovasculares son altamente prevalentes en todo el mundo y son responsables de una elevada morbimortalidad. El objetivo de este studio es valorar la relación que existe entre diferentes escalas que valoran la obesidad y una Escala que valora el riesgo cardiovascular como es la edad del corazón.
Material y metodos: Estudio descriptivo y transversal realizado en 139634 trabajadores españoles en los que se determina el exceso de peso aplicando diferentes escalas, tanto antropométricas como basadas en la estimación de la grasa corporal y visceral, además se valora el riesgo cardiovascular aplicando la escala edad del corazón.
Resultados: Los valores de edad del corazón son más elevados en aquellas personas que presentan obesidad aplicando cualquiera de las escalas analizadas. El valor de las escalas de obesidad para predecir valores elevados de edad del corazón es escaso.
Conclusiones: Existe buena relación entre las escalas que valoran el exceso de peso y los valores de edad del corazón, sin embargo el valor de estas escalas para predecir valores elevados de edad cardiaca no es alto.

Palabras clave: Edad del corazón, obesidad, CUN BAE.

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Introduction

When we talk about excess weight, whether overweight or obesity, there are divergences about which is the most appropriate method to assess it, some are based exclusively on the total weight while others are more inclined to an excess of body fat. Currently, it seems that the most accepted definition is that of an abnormal or excessive accumulation of fat that can be harmful to health[1].

The WHO warns about the high prevalence of excess weight indicating that in the last 40 years the global prevalence of obesity has tripled. In 2016, 1.9 billion people were overweight and 650 million of them obese. Thirty-nine percent of adults worldwide were overweight and 13% obese (11% in men and 15% in women)[2,3].

The repercussions of obesity on health are very varied, as it is considered a risk factor for heart disease and stroke[4,5], diabetes[6], musculoskeletal disorders, especially osteoarthritis[7], and certain types of cancer (endometrial[8], breast[9], ovarian[10], prostate[11], liver[12], gallbladder[13], kidney[14] and colon[15]).

Cardiovascular diseases are currently the leading cause of death worldwide, both in the more developed and less developed countries[16]. Many scales have been developed to assess the level of cardiovascular risk, from the classic Framingham scales to the current scales adapted to each country, all of which are based on the probability of presenting a cerebrovascular event, fatal or non-fatal, in a given period of time, generally 10 years. These scales present a problem, which is none other than the feeling that the risk is never very high. A person with a large number of risk factors: male sex, high age, hypertension, diabetes, hypercholesterolemia and tobacco use will present a risk level of between 20 and 30%, depending on the scales, of presenting a cardiovascular event in the next decade, or in other words a 70-80% risk of not presenting one. For this reason, in recent years other instruments have been developed that do not assess probability but rather estimate the aging of the heart or blood vessels, which is what we know as the age of the heart[17] or vascular age[18].

Based on the above, the aim of this study is to assess the relationship between the age of the heart and different scales that assess overweight and obesity in a group of Spanish workers.

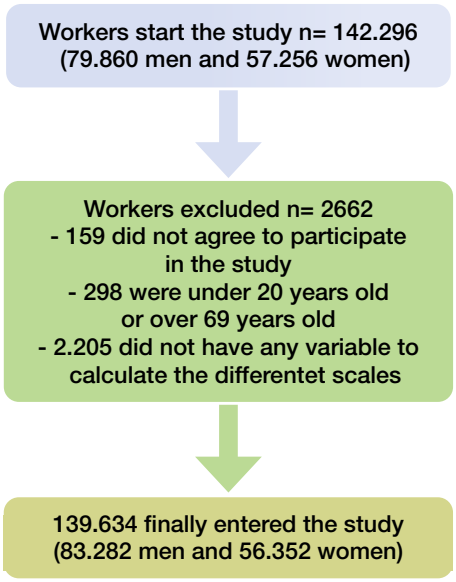
Methods

A cross-sectional descriptive study was carried out with data from occupational medical examinations of 139634 Spanish workers from different productive sectors. The study was conducted between January 2019 and June 2020.

Inclusion criteria were established as follows: being between 18 and 69 years old. - Working in the companies included in the study. - Agreeing to participate in the study and providing the data to carry it out.

The flow chart is presented in **figure 1**:

Figure 1: Flow chart of the participants.



Determination of variables

The health personnel of the participating companies were responsible for determining all the variables, both clinical and analytical and anthropometric, necessary to calculate the age of the heart. All measurements were standardized to reduce interobserver bias.

Waist circumference was obtained by placing a tape measure parallel to the floor and at the level of the last rib while the person was standing and with the abdomen relaxed.

Blood pressure was measured with an OMRON M3 sphygmomanometer, after 10 minutes of rest and with the person seated. Three determinations were made and the mean of the three was considered.

Blood analysis was obtained after a fasting period of no less than 12 hours and using enzymatic techniques (glycemia, cholesterol and triglycerides) and precipitation (HDL-cholesterol). LDL-cholesterol was determined indirectly by applying the Friedewald formula. The results of all variables were expressed in mg/dL.

Cardiac age is a tool calculated from the Framingham cardiovascular risk scale. These classic risk scales assess the probability of suffering a cerebrovascular

event, fatal or otherwise, in the next ten years. To calculate cardiac age, the following are taken into account: age, sex, height (in cm), weight (in kg), waist circumference (in cm), family history of cardiovascular disease in the parents and the age at which they first suffered it, diabetes, smoking (if not currently smoking, we ask whether the patient has stopped smoking in the last year), total cholesterol and HDL cholesterol, systolic blood pressure and whether the patient is currently on antihypertensive treatment[17].

Heart age values are obtained using the "Heart Age Calculator" tool available on the web page: http://www.heartage.me. The scale can be applied between 18 and 80 years of age. The range of years that can be gained or persisted is 20, with a minimum age of 18 years and a maximum of 80 years.

A concept we should be aware of is ALLY[19] (avoidable years of life lost), which we could define as the difference between chronological age and cardiac age. A study conducted by our group established 11 years as the cut-off point for moderate ALLY and 17 years for high ALLY[20].

Blood glucose values were classified according to the criteria of the American Diabetes Association[21], which considered diabetes if the values exceeded 125 mg/dL in two different determinations, if the HbA1c ≥ 6.5% or if the patient was under hypoglycemic treatment.

Different scales of overweight and obesity were determined:

- *Waist to height ratio* (WtHR). Obtained by dividing the perimeter of the waist by height, both in cm. The cut-off point was 0.50.
- *Body mass index*. It is obtained by dividing the weight (in kg) by the altura^2 (in m). It is considered low weight < 18.5, normal weight between 18.5 and 24.9, overweight between 25 and 29.9 and obesity above 30 kg/m^2.
- *Clínica Universitaria de Navarra-body adiposity estimator* (CUN BAE)[22].
-44,988 + (0,503 x age) + (10,689 x sex) + (3,172 x age) - (0,026 x IMC2) + (0,181 x IMC x sex) - (0,02 x IMC x age) - (0,005 x IMC2 x sex) + (0,00021 x IMC2 x age). Male = 0 female = 1. Cut-off points are: normal weight (< 30 in women and < 20 in men), overweight (30-35 in women and 20-25 in men) and obesity (> 35 in women and > 25 in men).
- *Equation Cordoba estimator-body fat* (ECORE-BF)[23]
– 97.102 + 0.123 (age) + 11.9 (gender) + 35.959 (LnBMI) where male = 0 and female = 1.
The authors propose the same cutoff points as CUN-BAE.
- *Relative fat mass* (RFM)[24] women 76(– ×20 (height/waist)) men it is 64(– ×20 (height/waist)). obesity cutoff points are 40% in women and 30% in men
- *Deuremberg fat mass index*[25]. 1.2 x (BMI) + 0.23 x (Age in years) - 10.8 x (sex) - 5.4 Where female = 0 and male = 1. Obesity is considered as from 25% in men and 32% in women.
- *Metabolic score for visceral fat* (METS-VF)[26]
4,466 + 0,011*(Ln(METS-IR))3 + 3,239*(Ln(cintura/altura))3 + 0,319*(Sexo) + 0,594*(Ln(edad)). Men = 1 women = 0 cutoff 7.2
- *Conicity index*[27].

$$\frac{\text{waist circumference (in metres)}}{0{,}109} \times 1\sqrt{\frac{\text{Weight (in kilogram)}}{\text{Height (in metres)}}}$$

A smoker is a person who has consumed at least one cigarette every day during the last month (or its equivalent in other forms of consumption) or who has stopped smoking less than one year ago.

Applying the questionnaire on adherence to the Mediterranean diet[28], which consists of 14 questions scored with 0 and 1 point, high adherence is determined when the values are equal to or greater than 9.

The level of physical activity was quantified with the IPAQ[29] (International Physical Activity Questionnaire). Alcohol consumption is assessed using alcohol units (AU). In Spain, one AU is equivalent to 10 grams of pure ethanol. Consumption is considered high from 14 AU in women and 21 in men per week.

Social class is determined from the 2011 National Classification of Occupations (CNO-11)[30] and following the criteria established by the Spanish Society of Epidemiology. According to the CNO-11, workers were classified into three social classes: I. Managers, university professionals, athletes and artists. II. Intermediate occupations and skilled self-employed workers. III. Unskilled workers.

Ethical considerations and aspects

The ethical standards of the institutional research committee and the 2013 Declaration of Helsinki were respected at all times. Anonymity and confidentiality were guaranteed. The study The study was approved by the Research Ethics Committee of the Balearic Islands (CEI-IB): IB 4383/20. The data of each worker included in the study were coded and only the person responsible for the study knew the identity of each person. The researchers undertook to strictly comply with the Organic Law 3/2018, of December 5, on the protection of personal data and guarantee of digital rights, guaranteeing participants the right of access, rectification, cancellation and opposition of the data collected.

Statistical analysis

For quantitative variables, Student's t-test was used to calculate the mean and standard deviation. For qualitative

variables, the chi-square test was used to calculate prevalence. For ROC curves. The area under the curve (AUC), the cut-off points with their sensitivity, specificity and Youden index were calculated. Multivariate analysis was performed by multinomial logistic regression. SPSS 28.0 was used for statistical analysis. The accepted level of statistical significance was $p<0.05$.

Results

Table I shows the values of the anthropometric and clinical variables of the 139634 (83282 men 59.6% and 56352 women 40.4%) workers included in the study. The mean age of the sample was slightly over 40 years, the majority group being between 30 and 49 years of age. All the variables showed more unfavorable values in men. Most of the women belonged to social class III and had primary education. In men, most were sedentary and had a low adherence to the Mediterranean diet (in women the situation was somewhat better). One third of the people smoked.

Table II shows the mean values of ALLY cardiac age according to the values of the different overweight and obesity scales. These mean values increase as the different overweight-obesity scales increase. The differences observed are statistically significant in all cases.

Table III shows the prevalence of ALLY values according to the values of the overweight-obesity scales. The trend observed is similar to that seen for the mean values, i.e. an increase in the prevalence of high ALLY values as the values of the overweight-obesity scales increase. In this case all the differences observed are also statistically significant.

Table IV shows the results of the multinomial logistic regression. The risk of presenting either moderate or high values of ALLY heart age increases as the values of the overweight-obesity scales increase. The highest OR values were found for the body fat estimators CUN BAE and ECORE-BF.

Figure 2 and **table V** show the results of the ROC curves. The areas under the curve of all the overweight-obesity scales for predicting the occurrence of moderate or high heart-age ALLY values is very low, with the exception of the METS-VF visceral fat estimator for predicting high ALLY (AUC 0.727).

Table I: Characteristics of the population.

	Men n=83,282 Mean (SD)	Women n=56,352 Mean (SD)	p-value
Age (years)	41.4 (10.7)	40.1 (10.4)	<0.0001
Height (cm)	173.8 (7.1)	161.2 (6.5)	<0.0001
Weight (kg)	83.2 (14.6)	66.3 (13.9)	<0.0001
Body mass index (kg/m²)	27.5 (4.5)	25.5 (5.3)	<0.0001
Waist circumference (cm)	90.2 (10.3)	76.3 (10.5)	<0.0001
Waist to height ratio	0.52 (0.06)	0.47 (0.07)	<0.0001
Systolic blood pressure (mmHg)	126.2 (15.9)	115.6 (15.7)	<0.0001
Diastolic blood pressure (mmHg)	76.6 (10.9)	71.1 (10.7)	<0.0001
Total cholesterol (mg/dl)	199.6 (38.6)	194.6 (36.9)	<0.0001
HDL-cholesterol (mg/dl)	50.0 (7.7)	54.7 (9.2)	<0.0001
LDL-cholesterol (mg/dl)	122.6 (37.4)	121.5 (37.1)	<0.0001
Triglycerides (mg/dl)	133.8 (95.6)	90.8 (49.7)	<0.0001
Glycaemia (mg/dl)	93.0 (25.4)	86.8 (18.1)	<0.0001
	n (%)	**n (%)**	**p-value**
18-29 years	12558 (15.1)	10110 (18.0)	<0.0001
30-39 years	24648 (29.6)	17460 (31.0)	
40-49 years	25178 (30.2)	17094 (30.3)	
50-59 years	17370 (20.9)	9984 (17.7)	
60-70 years	3528 (4.2)	1704 (3.0)	
Social class I	6234 (7.5)	7632 (13.6)	<0.0001
Social class II	19856 (23.8)	18112 (32.1)	
Social class III	57192 (68.7)	30608 (54.3)	
Primary school	55306 (66.4)	27086 (48.1)	
Secondary school	22408 (26.9)	22574 (40.0)	
University	5568 (6.7)	6692 (11.9)	
Non-smokers	55618 (66.8)	38252 (67.9)	<0.0001
Smokers	27664 (33.2)	18100 (32.1)	
Non physical activity	51984 (62.4)	28962 (51.4)	<0.0001
Yes physical activity	31298 (37.6)	27390 (48.6)	
Non healthy food	54792 (65.8)	29764 (52.8)	<0.0001
Yes healthy food	28490 (34.2)	26588 (47.2)	
Non alcohol consumption	56022 (67.3)	47536 (84.4)	<0.0001
Yes alcohol consumption	27260 (32.7)	8816 (15.6)	

Table II: Mean values of ALLY heart age according different scales of overweight and obesity by sex.

ALLY heart age	Men			Women		
	n	Mean (SD)	p-value	n	Mean (SD)	p-value
Underweight BMI	440	2.8 (6.8)	<0.0001	1518	-3.3 (6.9)	<0.0001
Normalweight BMI	24986	4.2 (7.7)		29432	-0.8 (8.6)	
Overweight BMI	36204	6.9 (7.9)		15208	3.3 (9.9)	
Obesity BMI	21652	9.5 (7.9)		10194	7.2 (9.6)	
WtHR <0.50	33346	4.8 (7.7)	<0.0001	40924	0.3 (9.1)	<0.0001
WtHR ≥0.50	49936	8.1 (8.1)		15428	5.3 (10.1)	
Normalweight RFM	25792	4.5 (7.6)	<0.0001	32324	-0.3 (8.9)	<0.0001
Obesity RFM	57490	7.8 (8.1)		24028	4.3 (10.0)	
Normalweight Deuremberg	36450	3.7 (7.1)	<0.0001	17164	-3.0 (6.5)	<0.0001
Obesity Deuremberg	46832	9.2 (8.0)		39188	3.7 (10.1)	
Normalweight ECORE-BF	11246	2.5 (6.9)	<0.0001	13942	-2.8 (7.0)	<0.0001
Overweight ECORE-BF	21748	4.7 (7.6)		15376	-0.2 (8.8)	
Obesity ECORE-BF	50288	8.6 (8.0)		27034	5.1 (10.1)	
Normalweight CUN BAE	12084	2.3 (6.5)	<0.0001	13618	-3.0 (6.6)	<0.0001
Overweight CUN BAE	20852	4.9 (7.6)		15198	-0.2 (8.9)	
Obesity CUN BAE	50346	8.6 (8.0)		27536	5.0 (10.1)	
METS-VF normal	70928	5.8 (7.8)	<0.0001	55236	1.4 (9.6)	<0.0001
METS-VF high	12354	12.3 (7.5)		1116	12.7 (8.5)	
Normal conicity index	59884	6.3 (8.0)	<0.0001	51084	1.4 (9.6)	<0.0001
High conicity index	23398	7.9 (8.2)		5268	4.1 (10.4)	

ALLY Avoidable lost life years. BMI Body mass index. WtHR Waist to heigh ratio. RFM Relative Fat Mass ECORE-BF Equation Cordoba for Estimation of Body fat CUN BAE Clínica Universitaria de Navarra Body Adiposity Estimator. METS-VF Metabolic Score for Visceral Fat

Table III: Prevalence of values of ALLY heart age according different scales of overweight and obesity by sex.

ALLY heart age	Men					Women				
	n	Normal %	Moderate %	High %	p-value	n	Normal %	Moderate %	High %	p-value
Underweight BMI	440	88,2	4,5	7,3	<0.0001	1518	96,6	1,7	1,7	<0.0001
Normalweight BMI	24986	81,3	8,9	9,8		29432	89,4	4,3	6,2	
Overweight BMI	36204	71,2	11,3	17,5		15208	76,1	8,4	15,6	
Obesity BMI	21652	58,3	13,9	27,9		10194	62,9	11,2	25,8	
Normalweight RFM	25792	80,7	9,0	10,3	<0.0001	32324	87,8	4,9	7,3	<0.0001
Obesity RFM	57490	66,6	12,2	21,2		24028	72,4	8,8	18,7	
Normalweight Deuremberg	36450	85,2	7,8	6,9	<0.0001	17164	97,0	1,9	1,1	<0.0001
Obesity Deuremberg	46832	59,9	13,8	26,3		39188	74,3	8,6	17,0	
Normalweight ECORE-BF	11246	88,8	6,3	4,9	<0.0001	13942	95,8	2,2	2,0	<0.0001
Overweight ECORE-BF	21748	80,6	9,3	10,1		15376	88,1	5,0	6,9	
Obesity ECORE-BF	50288	62,8	13,2	24,0		27034	69,8	9,8	20,5	
Normalweight CUN BAE	12084	89,9	6,0	4,1	<0.0001	13618	96,7	1,9	1,4	<0.0001
Overweight CUN BAE	20852	79,7	9,5	10,8		15198	88,0	5,1	6,9	
Obesity CUN BAE	50346	62,8	13,1	24,0		27536	69,8	9,7	20,4	
METS-VF normal	70928	76,0	10,2	13,8	<0.0001	55236	82,1	6,4	11,5	<0.0001
METS-VF high	12354	42,2	16,8	41,0		1116	37,3	14,7	48,0	

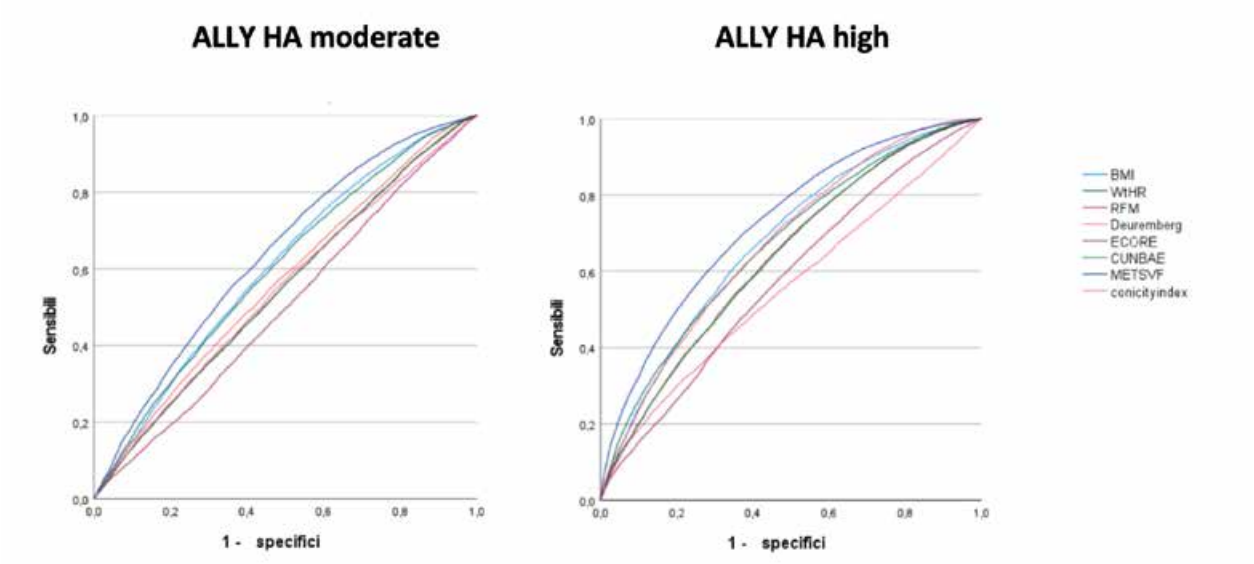
ALLY Avoidable lost life years. BMI Body mass index. WtHR Waist to heigh ratio. RFM Relative Fat Mass ECORE-BF Equation Cordoba for Estimation of Body fat CUN BAE Clínica Universitaria de Navarra Body Adiposity Estimator. METS-VF Metabolic Score for Visceral Fat

Table IV: Multinomial logistic regression.

	ALLY HA moderate		ALLY HA high	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Underweight BMI	1		1	
Normalweight BMI	1.12 (1.03-1.21)	<0.0001	1.08 (1.04-1.12)	<0.0001
Overweight BMI	1.89 (1.82-1.97)	<0.0001	1.50 (1.46-1.55)	<0.0001
Obesity BMI	2.18 (2.08-2.28)	<0.0001	1.68 (1.61-1.75)	<0.0001
Normalweight RFM	1		1	
Obesity RFM	1.17 (1.13-1.21)	<0.0001	1.17 (1.12-1.22)	<0.0001
Normalweight Deuremberg	1		1	
Obesity Deuremberg	1.60 (1.53-1.67)	<0.0001	2.01 (1.89-2.13)	<0.0001
Normalweight ECORE-BF	1		1	
Overweight ECORE-BF	1.55 (1.31-1.84)	<0.0001	1.55 (1.26-1.89)	<0.0001
Obesity ECORE-BF	5.44 (4.47-6.40)	<0.0001	7.82 (6.03-9.89)	<0.0001
Normalweight CUN BAE	1		1	
Overweight CUN BAE	1.31 (1.11-1.54)	<0.0001	1.39 (1.14-1.70)	<0.0001
Obesity CUN BAE	5.36 (4.29-6.68)	<0.0001	7.86 (5.98-10.33)	<0.0001
METS-VF normal	1		1	
METS-VF high	3.06 (2.94-3.19)	<0.0001	2.85 (2.73-2.97)	<0.0001

ALLY Avoidable lost life years. BMI Body mass index. WtHR Waist to heigh ratio. RFM Relative Fat Mass ECORE-BF Equation Cordoba for Estimation of Body fat CUN BAE Clínica Universitaria de Navarra Body Adiposity Estimator. METS-VF Metabolic Score for Visceral Fat

Figure 2: ROC curve.



ALLY Avoidable lost life years. BMI Body mass index. WtHR Waist to heigh ratio. RFM Relative Fat Mass ECORE-BF Equation Cordoba for Estimation of Body fat CUN BAE Clínica Universitaria de Navarra Body Adiposity Estimator. METS-VF Metabolic Score for Visceral Fat

Table V: Area under the curve (ROC curve).

	ALLY HA moderate AUC (95% CI)	ALLY HA high AUC (95% CI)
BMI	0.604 (0.599-0.609)	0.677 (0.674-0.681)
WtHR	0.598 (0.593-0.603)	0.669 (0.665-0.673)
RFM	0.501 (0.496-0.507)	0.578 (0.573-0.582)
Deuremberg	0.564 (0.559-0.570)	0.673 (0.669-0.677)
ECORE-BF	0.545 (0.540-0.550)	0.637 (0.633-0.641)
CUN BAE	0.546 (0.541-0.551)	0.636 (0.632-0.640)
METS-VF	0.638 (0.633-0.643)	0.727 (0.723-0.730)

ALLY Avoidable lost life years. BMI Body mass index. WtHR Waist to heigh ratio.
RFM Relative Fat Mass ECORE-BF Equation Cordoba for Estimation of Body fat
CUN BAE Clínica Universitaria de Navarra Body Adiposity Estimator.
METS-VF Metabolic Score for Visceral Fat

Discussion

The mean value and the prevalence of high ALLY values for cardiac age increase as the values of the different overweight-obesity scales analyzed increase. Multivariate analysis shows that the scales with the highest ORs are those that estimate body fat (CUN BAE and ECORE-BF).

A pooled analysis of 41 World Health Organization STEPS surveys[31] conducted in 41 countries in six world regions between 2013 and 2019 involving 94 655 individuals aged 30 to 74 years assessed the relationship of weight to vascular age values with the Framingham model and concluded that overweight individuals had higher vascular age ALLY values than normal-weight individuals.

A study conducted on 429 047 Chinese residents aged 35-64 years who completed the Heart Age Assessment of the official WeChat account "Heart Strengthening Action" via the Internet between the months of January 2018 and April 2021 assessed the effect of different variables such as age, sex, body mass index, blood pressure, smoking and total cholesterol on heart age. This study concluded that the two main risk factors for excess cardiac age were overweight or obesity and smoking[32].

A study conducted in 6117 New Yorkers aged 30-74 years using data from the New York State Behavioral Risk Factor Surveillance System from 2011, 2013 and 2015 also assessed the effect of different variables, including BMI, on heart age values and observed that ALLY heart age increased from 1.1 years among adults with normal weight to 11.8 years among adults with obesity[33].

A study conducted in women using data from the Pregnancy Risk Assessment Monitoring System assessed heart age and also concluded that ALLY heart age values were also higher in those with obesity[34].

A study that included 501 individuals without cardiovascular disease and with a mean age of 55.9 years, estimated heart age with the VaSera VS-1500 device, observing that people with obesity showed higher heart ages[35].

An investigation of 1330 patients undergoing bariatric surgery showed a marked decrease in heart age values after surgery[36].

A study of 29,996 participants from the United Kingdom Biobank without cardiovascular disease estimated heart age by magnetic resonance imaging and also observed higher aging patterns in obese versus normal-weight individuals[37].

Strengths and limitations

As strong points we can highlight the enormous size of the sample (more than 139,000 people) and the large number of overweight-obesity scales used.

The main limitation is that both diet and physical activity were determined using questionnaires or surveys and not using objective methods.

Conclusions

The mean values and the prevalence of high values of ALLY heart age increase in parallel with the increase in the values of the different overweight-obesity scales analyzed in this study. The value of the overweight-obesity scales to predict the appearance of moderate or high values of ALLY heart age is generally low.

Conflict of Interest

The authors declare that there is no conflict of interest.

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