ORIGINAL

Correlation between overweight and obesity scales and blood pressure values in 418.343 Spanish workers

Correlación entre las escalas de sobrepeso y obesidad y los valores de presión arterial en 418.343 trabajadores españoles

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Abstract

Objective: One of the objectives of a health system is to be able to identify people with high blood pressure and achieve a good control of them in order to avoid future complications and reduce cardiovascular morbidity and mortality. For this reason, the aim of this study was to determine the relationship between blood pressure and different overweight and obesity scales, some of which include the estimation of body fat.

Methods: A retrospective, cross-sectional study was conducted in 421625 Spanish workers. Anthropometric, clinical, and analytical measurements were carried out after standardizing the measurement techniques. Several overweight and obesity scales were analyzed: Visceral adiposity index (VAI), dysfunctional adiposity index, a body shape index (ABSI), normalized weight-adjusted index (NWAI), conicity index, body mass index (BMI), and also other formulas to estimate the percentage of body fat. A descriptive analysis of the categorical variables was performed.

Results: The results show higher values in the indicators of overweight and obesity in the group of patients with hypertension compared to the group of non-hypertensive patients for both sexes. Values of the anthropometric measurements and clinical parameters, as well as the different scales of overweight and obesity, had more unfavorable results in the group of men, favoring the appearance of arterial hypertension, while patients with normal weight tended to have better blood pressure levels. It was also seen that the older the age, the greater the risk of presenting altered blood pressure rates in both sexes.

Conclusions: The study shows in a statistically significant way that overweight and obese patients have a greater risk of presenting arterial hypertension in both sexes, with an increased risk at an older age, so it is vitally important to influence lifestyle modifications, in order to reduce morbidity and mortality due to different pathologies deriving from overweight, obesity, and hypertension.

Key words: Obesity, Hypertensión, Body mass index.

Resumen

Objetivo: Uno de los objetivos de un sistema sanitario es poder identificar a las personas con hipertensión arterial y lograr un buen control de las mismas para evitar futuras complicaciones y reducir la morbilidad y mortalidad cardiovascular. Por ello, el objetivo de este estudio fue determinar la relación entre la presión arterial y diferentes escalas de sobrepeso y obesidad, algunas de las cuales incluyen la estimación de la grasa corporal.

Métodos: Se realizó un estudio retrospectivo y transversal en 421625 trabajadores españoles. Se realizaron mediciones antropométricas, clínicas y analíticas tras estandarizar las técnicas de medición. Se analizaron varias escalas de sobrepeso y obesidad: Índice de adiposidad visceral (VAI), índice de adiposidad disfuncional, índice de forma corporal (ABSI), índice normalizado ajustado al peso (NWAI), índice de conicidad, índice de masa corporal (IMC) y también otras fórmulas para estimar el porcentaje de grasa corporal. Se realizó un análisis descriptivo de las variables categóricas.

Resultados: Los resultados muestran valores más altos en los indicadores de sobrepeso y obesidad en el grupo de pacientes con hipertensión en comparación con el grupo de pacientes no hipertensos para ambos sexos. Los valores de las medidas antropométricas y los parámetros clínicos, así como las diferentes escalas de sobrepeso y obesidad, tuvieron resultados más desfavorables en el grupo de hombres, favoreciendo la aparición de hipertensión arterial, mientras que los pacientes con peso normal tendieron a tener mejores niveles de presión arterial. También se observó que a mayor edad, mayor es el riesgo de presentar índices de presión arterial alterados en ambos sexos.

Conclusiones: El estudio muestra de forma estadísticamente significativa que los pacientes con sobrepeso y obesidad tienen un mayor riesgo de presentar hipertensión arterial en ambos sexos, con un riesgo mayor a mayor edad, por lo que es de vital importancia incidir en las modificaciones del estilo de vida, con el fin de reducir la morbilidad y mortalidad por las diferentes patologías derivadas del sobrepeso, la obesidad y la hipertensión.

Palabras clave: Obesidad, Hipertensión arterial, índice de masa corporal.

Introduction

High blood pressure levels are associated with an increased risk of cardiovascular morbidity and mortality[1,2] so if these levels can be reduced, the mortality rate and the risk of suffering cardiovascular events can also be significantly reduced[3]. For this reason, one of the most important objectives of a health system is to be able to identify people with high blood pressure and achieve good control of them in order to avoid future complications.

In Spain, the prevalence of arterial hypertension is high, and the degree of knowledge and control is lower than in neighboring countries and in the United States[4-6], with the negative medical and economic implications that this entails.

Many risk factors have been associated with hypertension, some of which are considered to be nonmodifiable, including family history[7,8], and male sex, although the figures are very high in menopausal women[9], and black race[10]. Among the modifiable risk factors[11-13] are excessive consumption of alcohol, caffeine, sodium, potassium, sedentary lifestyle, and tobacco use. A modifiable factor closely related to hypertension is obesity, and 60-70% of hypertension in adults has been estimated to be related to this increase in weight[14]. Many mechanisms are known to be involved in the genesis of hypertension in obese individuals, including insulin resistance, sodium retention, increased activity of the sympathetic nervous system, activation of the renin-angiotensin-aldosterone axis, and altered vascular function[14]. However, the relationship between excess weight and arterial hypertension has some nuances, since excess body mass does not always really indicate obesity. For this reason, body fat distribution can be important in such a way that centripetal obesity is associated with more lipid disorders[15,16].

The aim of this study was therefore to assess the relationship between blood pressure and different overweight and obesity scales, some of which include the estimation of body fat.

Materials and methods

Study design

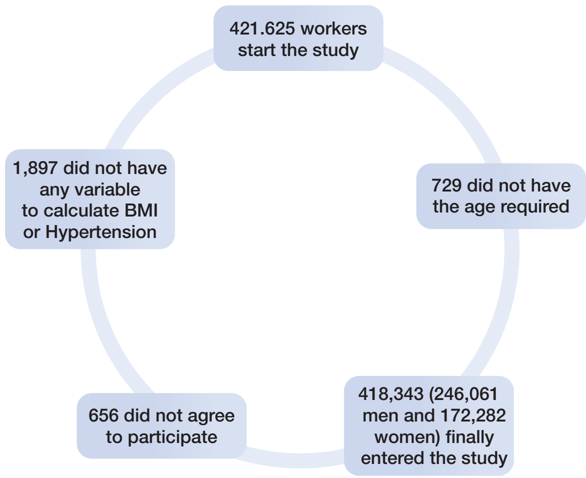
A retrospective, cross-sectional study was conducted in 421.625 Spanish workers between January 2019 and June 2020, selected based on their attendance to periodic occupational medical examinations.

Inclusion criteria:

- Belonging to one of the participating companies.
- Agreeing to participate in the study and consenting to the use of the data for epidemiological purposes.
- Not under 18 years of age and not over 69 years of age.
- Having the parameters to calculate overweight or obesity scales or the presence of hypertension.

The workers finally included in the study and reasons for exclusion are presented in the flow chart. (see **figure 1**).

Figure 1: Participant flow chart.



Anthropometric, clinical, and analytical measurements were carried out by the healthcare professionals of the different occupational health units that participated in the study, after standardizing the measurement techniques.

Glycemia, total cholesterol, and triglycerides were determined by automated enzymatic methods and HDL by precipitation with dextran sulfate Cl2Mg. LDL was calculated using the Friedewald formula (provided that triglycerides were less than 400 mg/dl). All the above values are expressed in mg/dl.

Friedewald's formula: LDL = total cholesterol – HDL – triglycerides/5

To measure weight (in kilograms) and height (in cm), a height bar scale (model: SECA 700) with an added SECA 220 telescopic height bar was used.

Abdominal waist circumference was measured in cm with a tape measure, using the SECA model 20, with an interval of 1-200 cm and millimeter division. For this, the individual was measured in a standing position, feet together and trunk erect, abdomen relaxed, and upper extremities hanging on both sides of the body. The tape measure was then placed parallel to the ground at the level of the last floating rib.

The overweight and obesity indexes analyzed include:

- Visceral adiposity index[17] (VAI)

Males:

$$VAI = \left(\frac{WC}{39{,}68 + (1{,}88 \times BMI)}\right) \times \left(\frac{TG}{1{,}03}\right) \times \left(\frac{1{,}31}{HDL}\right)$$

Females:

$$VAI = \left(\frac{WC}{36{,}58 + (1{,}89 \times BMI)}\right) \times \left(\frac{TG}{0{,}81}\right) \times \left(\frac{1{,}52}{HDL}\right)$$

- Dysfunctional adiposity index[18]
[WC/[22.79 + [2.68*BMI]]]*[triglycerides (TG, mmol/L)/1.37] * [1.19/high density lipoprotein-cholesterol (HDL-C, mmol/L)] for males, and [WC/[24.02 + [2.37*BMI]]]* [TG(mmol/L)/1.32]*[1.43/HDL-C(mmol/L)] for females.

- A body shape index (ABSI)[19].

$$ABSI = \frac{WC}{BMI^{2/3} \times height^{1/2}}$$

- Normalized weight-adjusted index (NWAI)[20]
[(weight/10) – (10 x height) + 10] with weight measured in kg and height in m.

- Conicity index[21]

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

- Body Roundness Index[22] (BRI)

$$BRI = 364{,}2 - 365{,}5 \times \sqrt{1 - \frac{WC/(2\pi)^2}{(0{,}5\ height)^2}}$$

- Body mass index (BMI) was calculated by dividing weight by height in squared meters. and was classified according to SEEDO criteria[23].

- Body mass index modified[24]
$BMI = 1.3(\text{weight in kg}) / (\text{height in m})^{2.5}$

- The waist-to-height ratio was considered risky over 0.50[25].

- The body surface index[26] (BSA) was calculated from the body surface area (BSA)

$$BSA = w^{0{,}425} \star h^{0{,}725} \star 0{,}007184$$

where w represents weight in kg and h height in cm

$$BSI = \frac{WEIGHT}{\sqrt{BSA}}$$

Formulas to estimate the percentage of body fat:

- Relative fat mass[27] 76 – (20 x (height/p waist)) Height and waist circumference are expressed in meters.

- CUN BAE[28] (University of Navarra Body Adiposity Estimator Clinic)
-44.988 + (0.503 x age) + (10.689 x sex) + (3.172 x BMI) – (0.026 x BMI²) + (0.181 x BMI x sex) - (0.02 x BMI x age) – (0.005 x BMI² x sex) + (0.00021 x BMI² x age)

- ECORE-BF (Equation COrdoba Estimator Body Fat)[29]

–97.102 + 0.123 (age) + 11.9 (gender) + 35.959 (LnBMI)
In CUN BAE and ECORE-BF, male is 0 and female 1, and cut-off points for obesity are 35% in women 25% in men.

- Palafolls formula[30].
Men = (BMI/waist] *10) + BMI. Women = (BMI/waist] *10) + BMI + 10.

- Deurenberg formula[31].
1.2 x (BMI) + 0.23 x (age) – 10.8 x (gender) – 5.4
Male = 0 Female = 1

Blood pressure was measured with a calibrated OMRON M3 automatic sphygmomanometer after 10 minutes of rest. Three measurements were taken at one-minute intervals, obtaining the mean value of the three. JNC-7 criteria were used to classify blood pressure[32].

An individual was considered a smoker if s/he had regularly consumed at least 1 cigarette/day (or the equivalent in other types of consumption) in the previous month or had quit smoking less than 12 months before.

Statistical analysis

A descriptive analysis of the categorical variables was carried out, calculating the frequency and distribution of responses for each of them. For quantitative variables, the mean and standard deviation were calculated, whereas for qualitative variables the percentage was calculated. A bivariate association analysis was performed using the I^2 test (with a correction with the Fisher's exact statistical test, when conditions required so) and a Student's t-test for independent samples. For the multivariate analysis, binary logistic regression was used with the Wald method, the calculation of the Odds-ratio, and the Hosmer-Lemeshow goodness-of-fit test. Statistical analysis was performed with the SPSS 27.0 program, and a p value of <0.05 was considered as statistically significant.

Considerations and ethical aspects

The study was approved by the Clinical Research Ethics Committee of the Health Area of the Balearic Islands (nº IB 4383/20). All procedures were performed in accordance with the ethical standards of the institutional research committee and with the 2013 Declaration of Helsinki. All patients signed written informed consent documents prior to participation in the study.

Results

The mean values of the anthropometric and clinical parameters and also the parameters from the overweight and obesity scales are higher in men, while parameters that estimate body fat are higher in women. In all cases, as shown in **table I**, the differences are statistically significant between both sexes. All data are presented in **table I**.

The mean values of all the overweight and obesity indicators are higher in the hypertensive group compared with non-hypertensive individuals. This situation is repeated in both sexes. Differences between both groups are statistically significant in all cases. The group of hypertensive patients in both sexes is also observed to have a higher mean age. Complete data are presented in **table II**.

Table III shows the degree of relationship between systolic blood pressure (SBP), diastolic blood pressure (DPB), and the different scales that assess overweight and obesity. In all cases, except with the body shape index, there is a positive correlation. The highest degree of correlation in both sexes and for both SBP and DBP is with the Deurenberg formula.

Table I: Baseline characteristics and anthropometric measurements and indices in the study population.

	Male n=246061 Mean (SD)	Female n=172282 Mean (SD)	Total n=418343 Mean (SD)	p-value
Age (years)	40.57 (11.06)	39.58 (10.78)	40.16 (10.96)	<0.0001
Systolic blood pressure (mmHg)	128.17 (15.53)	117.43 (15.66)	123.74 (16.45)	<0.0001
Diastolic blood pressure (mmHg)	77.75 (10.96)	72.59 (10.40)	75.62 (11.03)	<0.0001
Waist circumference (cm)	86.16 (11.09)	74.77 (10.55)	81.47 (12.23)	<0.0001
Body mass index (kg/m²)	26.67 (4.46)	25.29 (5.15)	26.10 (4.81)	<0.0001
Body mass index modified (kg/m²)	26.26 (4.47)	25.88 (5.36)	26.10 (4.86)	<0.0001
Waist to height ratio	0.49 (0.06)	0.46 (0.06)	0.48 (0.06)	<0.0001
Body surface area	1.96 (0.18)	1.70 (0.17)	1.85 (0.22)	<0.0001
Body surface index	57.84 (7.87)	50.52 (8.08)	54.82 (8.73)	<0.0001
Normalized weight-adjusted index	0.67 (1.37)	0.44 (1.37)	0.58 (1.37)	<0.0001
Body roundness index	3.31 (1.17)	2.76 (1.20)	3.08 (1.21)	<0.0001
Body shape index ($m^{7/6}/kg^{2/3}$)	0.074 (0.006)	0.069 (0.006)	0.072 (0.006)	<0.0001
Visceral adiposity index	7.39 (6.48)	2.71 (1.65)	5.46 (5.58)	<0.0001
Dysfunctional adipasity index	0.91 (0.73)	0.69 (0.41)	0.82 (0.63)	<0.0001
Conicity index ($m^{2/3}/kg^{1/2}$)	1.16 (0.09)	1.08 (0.09)	1.13 (0.10)	<0.0001
CUN BAE (%)	25.48 (6.62)	35.17 (7.14)	29.50 (8.34)	<0.0001
ECORE-BF (%)	25.48 (6.30)	35.15 (7.27)	29.46 (8.23)	<0.0001
Relative fat mass (%)	22.87 (4.99)	31.98 (5.55)	26.62 (6.89)	<0.0001
Deurenberg formula (%)	25.13 (6.49)	34.06 (7.11)	28.81 (8.05)	<0.0001
Palafolls formula (%)	29.76 (4.68)	38.67 (5.46)	33.43 (6.66)	<0.0001

Table II: Comparison of anthropometric indices in hypertensive and non-hypertensive population.

	Men			Women		
	n=175224	n=70837		n=148962	n=23320	
	Non-Hypertension	Hypertension	p-value	Non-Hypertension	Hypertension	p-value
Age (years)	38.50 (10.58)	45.70 (10.53)	<0.0001	38.31 (10.36)	47.66 (9.88)	<0.0001
Waist circumference (cm)	84.63 (10.47)	89.94 (11.64)	<0.0001	73.98 (9.97)	79.86 (12.58)	<0.0001
Body mass index (kg/m²)	25.80 (3.99)	28.79 (4.84)	<0.0001	24.76 (4.79)	28.72 (6.00)	<0.0001
Body mass index modified (kg/m²)	25.39 (4.00)	28.39 (4.83)	<0.0001	25.31 (4.98)	29.49 (6.22)	<0.0001
Waist to height ratio	0.48 (0.06)	0.52 (0.06)	<0.0001	0.46 (0.06)	0.50 (0.08)	<0.0001
Body surface area	1.94 (0.17)	2.02 (0.19)	<0.0001	1.69 (0.16)	1.77 (0.19)	<0.0001
Body surface index	56.47 (7.18)	61.23 (8.46)	<0.0001	49.77 (7.60)	55.33 (9.35)	<0.0001
Normalized weight-adjusted index	0.41 (1.23)	1.33 (1.48)	<0.0001	0.30 (0.28)	1.36 (1.57)	<0.0001
Body roundness index	3.13 (1.07)	3.75 (1.28)	<0.0001	2.65 (1.10)	3.42 (1.51)	<0.0001
Body shape index ($m^{7/6}/kg^{2/3}$)	0.074 (0.006)	0.073 (0.006)	<0.0001	0.068 (0.006)	0.069 (0.006)	<0.0001
Visceral adiposity index	6.51 (5.42)	9.59 (8.15)	<0.0001	2.58 (1.51)	3.53 (2.20)	<0.0001
Dysfunctional adiposity index	0.83 (0.63)	1.12 (0.90)	<0.0001	0.66 (0.38)	0.88 (0.54)	<0.0001
Conicity index ($m^{2/3}/kg^{1/2}$)	1.16 (0.09)	1.17 (0.09)	<0.0001	1.07 (0.09)	1.08 (0.09)	<0.0001
CUN BAE (%)	24.05 (6.19)	28.99 (6.32)	<0.0001	34.34 (6.82)	40.53 (6.78)	<0.0001
ECORE-BF (%)	24.11 (5.85)	28.87 (6.09)	<0.0001	34.29 (6.87)	40.66 (7.31)	<0.0001
Relative fat mass (%)	22.12 (4.86)	24.71 (4.81)	<0.0001	31.52 (5.35)	34.91 (5.89)	<0.0001
Deurenberg formula (%)	23.62 (5.86)	28.86 (6.47)	<0.0001	33.12 (6.58)	40.03 (7.45)	<0.0001
Palafolls formula (%)	28.86 (4.20)	32.00 (5.06)	<0.0001	38.10 (5.08)	42.31 (6.28)	<0.0001

Table III: Pearson correlation of individual anthropometric indices with blood pressure stratified by sex.

	Men n=246061				Women n=172282			
	SBP		DBP		SBP		DBP	
	Pearson	p-value	Pearson	p-value	Pearson	p-value	Pearson	p-value
Waist circumference (cm)	0.222	<0.0001	0.231	<0.0001	0.248	<0.0001	0.229	<0.0001
Body mass index (kg/m²)	0.327	<0.0001	0.354	<0.0001	0.341	<0.0001	0.318	<0.0001
Body mass index modified (kg/m²)	0.325	<0.0001	0.354	<0.0001	0.341	<0.0001	0.317	<0.0001
Waist to height ratio	0.240	<0.0001	0.256	<0.0001	0.269	<0.0001	0.247	<0.0001
Body surface area	0.234	<0.0001	0.244	<0.0001	0.257	<0.0001	0.242	<0.0001
Body surface index	0.304	<0.0001	0.326	<0.0001	0.321	<0.0001	0.302	<0.0001
Normalized weight-adjusted index	0.325	<0.0001	0.355	<0.0001	0.339	<0.0001	0.317	<0.0001
Body roundness index	0.242	<0.0001	0.256	<0.0001	0.269	<0.0001	0.249	<0.0001
Body shape index ($m^{7/6}/kg^{2/3}$)	-0.088	<0.0001	-0.109	<0.0001	-0.117	<0.0001	-0.115	<0.0001
Visceral adiposity index	0.213	<0.0001	0.250	<0.0001	0.213	<0.0001	0.204	<0.0001
Dysfunctional adiposity index	0.177	<0.0001	0.216	<0.0001	0.199	<0.0001	0.191	<0.0001
Conicity index ($m^{2/3}/kg^{1/2}$)	0.022	<0.0001	0.011	<0.0001	0.015	<0.0001	0.007	<0.0001
CUN BAE (%)	0.356	<0.0001	0.409	<0.0001	0.385	<0.0001	0.357	<0.0001
ECORE-BF (%)	0.360	<0.0001	0.411	<0.0001	0.385	<0.0001	0.356	<0.0001
Relative fat mass (%)	0.231	<0.0001	0.249	<0.0001	0.260	<0.0001	0.236	<0.0001
Deurenberg formula (%)	0.377	<0.0001	0.440	<0.0001	0.411	<0.0001	0.379	<0.0001
Palafolls formula (%)	0.328	<0.0001	0.357	<0.0001	0.342	<0.0001	0.320	<0.0001

Area under the ROC curves (AUC) of the anthropometric indices to predict hypertension. The area under the ROC curve (AUC) for each anthropometric index and hypertension is shown in the **table IV**.

The figure shows the gender-specific ROC curves of the anthropometric indices for predicting hypertension.
The AUCs of all anthropometric indices were greater than 0.5 (p <0.001) suggesting predictive significance except for Body Shape Index.

In general, the Deurenberg formula and CUN-BAE showed the highest AUC of over 0.7 for systolic hypertension in both sexes and also for diastolic hypertension in women, whereas diastolic hypertension values in men had a higher AUC for Body Mass Index (0.716).

In both sexes and in both systolic and diastolic hypertension, the values with the lowest AUC were those of the ABSI with a mean of 0.400.

The derived gender specific optimal cut-off points of each anthropometric index that best balanced sensitivity and specificity for systolic and diastolic hypertension are shown in **table V**.

In males, NWAI and Deurenberg formula had the highest sensitivities of 67.3% and 67.7% each for systolic hypertension, while the Deurenberg formula was the most sensitive (72.5%) for diastolic hypertension. As can be seen in the table, the Youden index also presented higher values for the Deurenberg formula (33.0).

In women, CUN-BAE and the Deurenberg formula were more sensitive in systolic and diastolic hypertension and also the ECORE-BF.

ABSI was the least sensitive but most specific for systolic and diastolic hypertension in both sexes but with a low Youden index, which indicates that it would not be the best parameter for interpretation in terms of specificity and sensitivity.

Table IV: AUCs of anthropometric indices for diagnosing hypertension.

	Men						Women					
	Systolic hypertension			Diastolic hypertension			Systolic hypertension			Diastolic hypertension		
	AUC	95% CI	p-value	AUC	95% CI	p-value	AUC	95% CI	p-value	AUC	95% CI	p-value
Waist circumference (cm)	0.617	0.614-0.620	<0.0001	0.675	0.672-0.678	<0.0001	0.635	0.630-0.641	<0.0001	0.646	0.639-0.653	<0.0001
Body mass index (kg/m²)	0.681	0.678-0.684	<0.0001	0.716	0.713-0.718	<0.0001	0.712	0.707-0.717	<0.0001	0.710	0.704-0.716	<0.0001
Body mass index modified (kg/m²)	0.682	0.679-0.685	<0.0001	0.707	0.705-0.710	<0.0001	0.716	0.711-0.720	<0.0001	0.711	0.705-0.716	<0.0001
Waist to height ratio	0.632	0.629-0.635	<0.0001	0.674	0.671-0.677	<0.0001	0.660	0.655-0.665	<0.0001	0.662	0.656-0.669	<0.0001
Body surface area	0.616	0.613-0.619	<0.0001	0.680	0.677-0.683	<0.0001	0.632	0.627-0.637	<0.0001	0.650	0.643-0.656	<0.0001
Body surface index	0.661	0.658-0.664	<0.0001	0.713	0.710-0.716	<0.0001	0.686	0.681-0.691	<0.0001	0.693	0.687-0.700	<0.0001
Normalized weight-adjusted index	0.682	0.679-0.684	<0.0001	0.712	0.710-0.715	<0.0001	0.715	0.710-0.720	<0.0001	0.710	0.704-0.716	<0.0001
Body roundness index	0.632	0.629-0.635	<0.0001	0.675	0.672-0.678	<0.0001	0.660	0.655-0.666	<0.0001	0.663	0.656-0.669	<0.0001
Body shape index $m^{7/6}/kg^{2/3}$	0.451	0.448-0.454	<0.0001	0.491	0.488-0.494	<0.0001	0.418	0.413-0.424	<0.0001	0.433	0.427-0.440	<0.0001
Visceral adiposity index	0.649	0.646-0.651	<0.0001	0.708	0.705-0.711	<0.0001	0.663	0.658-0.668	<0.0001	0.663	0.656-0.669	<0.0001
Dysfunctional adiposity index	0.625	0.622-0.628	<0.0001	0.668	0.665-0.671	<0.0001	0.653	0.648-0.658	<0.0001	0.654	0.647-0.660	<0.0001
Conicity index ($m^{2/3}/kg^{1/2}$)	0.513	0.510-0.516	<0.0001	0.565	0.561-0.568	<0.0001	0.503	0.498-0.509	0.210	0.519	0.512-0.526	<0.0001
CUN BAE (%)	0.704	0.702-0.707	<0.0001	0.620	0.617-0.623	<0.0001	0.749	0.745-0.754	<0.0001	0.734	0.729-0.740	<0.0001
ECORE-BF (%)	0.706	0.703-0.708	<0.0001	0.620	0.617-0.623	<0.0001	0.747	0.743-0.751	<0.0001	0.733	0.727-0.739	<0.0001
Relative fat mass (%)	0.632	0.629-0.635	<0.0001	0.532	0.529-0.535	<0.0001	0.660	0.655-0.666	<0.0001	0.663	0.656-0.669	<0.0001
Palafolls formula (%)	0.682	0.680-0.685	<0.0001	0.573	0.570-0.577	<0.0001	0.714	0.709-0.719	<0.0001	0.711	0.705-0.717	<0.0001
Deurenberg formula (%)	0.720	0.717-0.723	<0.0001	0.644	0.641-0.647	<0.0001	0.774	0.770-0.778	<0.0001	0.750	0.745-0.756	<0.0001

Table V: ROC determined cut-off, sensitivity, and specificity of each anthropometric index for predicting hypertension.

	Systolic hypertension				Diastolic hypertension			
Men	Cut-off	Sensitivity (%)	Specificity (%)	Youden index	Cut-off	Sensitivity (%)	Specificity (%)	Youden index
Waist circumference (cm)	86.00	61.1	55.5	16.6	86.00	63.5	54.7	18.2
Body mass index (kg/m^2)	27.00	63.4	63.1	26.5	27.30	65.4	64.6	30.0
Body mass index modified (kg/m^2)	26.50	64.3	62.5	26.8	26.9	65.4	64.8	30.2
Waist to height ratio	0.50	60.9	58.1	19.0	0.50	61.3	59.8	21.1
Body surface area	1.97	58.9	57.6	16.5	1.97	61.9	56.9	18.8
Body surface index	58.00	63.7	59.4	23.1	58.50	63.3	61.1	24.4
Normalized weight-adjusted index	0.70	67.3	62.0	29.3	0.85	66.2	64.0	30.2
Body roundness index	3.30	60.8	58.2	19.0	3.35	62.1	58.9	21.0
Body shape index $m^{7/6}/kg^{2/3}$	0.0722	51.3	41.9	-6.8	0.0724	48.0	45.9	-6.1
Visceral adiposity index	6.00	63.5	58.5	22.0	6.00	68.0	57.6	25.6
Dysfunctional adiposity index	0.76	60.5	58.6	19.1	0.80	61.2	60.3	21.5
Conicity index ($m^{2/3}/kg^{1/2}$)	1.15	54.5	47.4	1.9	1.16	51.0	50.6	1.6
CUN BAE (%)	26.90	65.3	65.0	30.3	26.90	70.5	63.6	34.1
ECORE-BF (%)	26.86	65.3	65.2	30.5	27.0	69.7	64.6	34.3
Relative fat mass (%)	23.75	60.8	58.2	19.0	23.75	63.6	57.2	20.8
Deurenberg formula (%)	26.30	67.7	65.3	33.0	26.40	72.5	64.5	37.0
Palafolls formula (%)	30.00	64.5	62.2	26.7	30.00	69.2	60.9	30.1
Women	Cut-off	Sensitivity (%)	Specificity (%)	Youden index	Cut-off	Sensitivity (%)	Specificity (%)	Youden index
Waist circumference (cm)	74.00	64	55.1	19.1	74.00	65.8	54.7	20,5
Body mass index (kg/m^2)	25.7	67.7	63.6	31.3	26.00	66.2	65	31,2
Body mass index modified (kg/m^2)	26.60	66.1	65.9	32	26.60	66.4	65.1	31,5
Waist to height ratio	0.47	63	61.1	24.1	0.47	63.7	60.5	24,2
Body surface area	1.71	60.3	59	19.3	1.72	61	60.8	21,8
Body surface index	51.00	65.7	61.7	27.4	51.70	64.3	64.3	28,6
Normalized weight-adjusted index	0.62	66.4	65.5	31.9	0.62	66.7	64.7	31,4
Body roundness index	2.74	62.7	61.4	24.1	2.74	63.5	60.8	24,3
Body shape index $m^{7/6}/kg^{2/3}$	0.0677	45.2	42.9	-11.9	0.0677	53.6	46.9	0,5
Visceral adiposity index	2.55	63.6	60	23.6	2.55	64.3	59.4	23,7
Dysfunctional adiposity index	0.66	61.6	60.6	22.2	0.66	62.5	60.1	22,6
Conicity index ($m^{2/3}/kg^{1/2}$)	1.07	50.6	49.9	0.5	1.07	55.1	47.2	2,3
CUN BAE (%)	37.70	68.5	68.1	36.6	37.70	67.5	67.1	34,6
ECORE-BF (%)	37.60	68.2	68.2	36.4	37.60	67.5	67.1	34,6
Relative fat mass (%)	33.10	62.5	61.7	24.2	33.2	62.6	62.1	24,7
Deurenberg formula (%)	36.40	70.9	69.9	40.8	36.30	68.5	68.4	36,9
Palafolls formula (%)	39.40	66.2	65.4	31.6	39.40	66.9	64.4	31,3

Table VI: Logistic regression for independent determinants of hypertension (≥ 140/90 mmHg).

	Systolic Hypertension		Diastolic Hypertension		Hypertension	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Gender	3.006 (2.927-3.088)	<0.0001	3.002 (2.911-3.096)	<0.0001	2.956 (2.890-3.020)	<0.0001
Age	2.729 (2.671-2.788)	<0.0001	1.951 (1.902-2.001)	<0.0001	2.787 (2.737-2.838)	<0.0001
Waist circumference (cm)	1.564 (1.514-1.617)	<0.0001	1.558 (1.501-1.617)	<0.0001	1.419 (1.378-1.462)	<0.0001
Body mass index (kg/m^2)	1.646 (1.598-1.695)	<0.0001	1.622 (1.574-1.672)	<0.0001	1.624 (1.583-1.667)	<0.0001
Waist to height ratio		ns		ns	1.055 (1.025-1.086)	<0.0001
Body roundness index		ns		ns		ns
Body shape index $m^{7/6}/kg^{2/3}$	0.860 (0.837-0.883)	<0.0001	0.807 (0.784-0.831)	<0.0001	0.944 (0.916-0.973)	<0.0001
Conicity index ($m^{2/3}/kg^{1/2}$)		ns		ns	0.968 (0.938-0.999)	<0.0001
CUN BAE (%)	1.538 (1.480-1.598)	<0.0001		ns	1.202 (1.092-1.324)	<0.0001
ECORE-BF (%)		ns	1.531 (1.462-1.603)	<0.0001	1.266 (1.151-1.392)	<0.0001
Relative fat mass (%)	1.051 (1.021-1.081)	0.001		ns	1.140 (1.109-1.172)	<0.0001
Deurenberg formula (%)	1.385 (1.331-1.441)	<0.0001	2.04 (1.942-2.146)	<0.0001	1.499 (1.454-1.545)	<0.0001
Palafolls formula (%)	1.459 (1.395-1.525)	<0.0001	1.345 (1.267-1.428)	<0.0001	1.444 (1.397-1.491)	<0.0001

In both sexes, the Deurenberg formula is the one with the highest Youden index, indicating greater specificity and sensitivity, followed by the CUN BAE and ECORE-BF formulas.

The logistic regression model included as covariates: men, aged from 50 years, high waist and obesity indices and formulas. The systolic and diastolic blood pressure cut-off levels and the presence or absence of hypertension were analyzed to see their relationship with overweight and obesity. It was possible to objectify that the independent variables age and gender are those that are related to a greater probability of presenting altered values in both systolic and diastolic blood pressure figures separately, as well as to the presence of hypertension.

Overweight and obesity indices and formulas also have a positive association with blood pressure values, except for the Body Shape Index, which has a low probability of altering blood pressure levels, with an OR <1.

The variables waist to height ratio, Body Roundness Index, chronicity index, and ECORE-BF did not influence the values of systolic or diastolic pressure, but they did influence the presence of hypertension, except for the Body Roundness Index, which had no relationship with categorical variables. (See **table VI**).

Discussion

The obesity pandemic is a global problem. It is a cardiovascular risk factor that predisposes to the development of multiple pathologies that deteriorate the quality of life of every patient.

It directly contributes to the development of hypertension as demonstrated in the systematic review by Garcia Casilimas *et al*.[14]

The results in our study show higher values in the indicators of overweight and obesity in the group of patients with hypertension compared to the group of non-hypertensive patients for both sexes. The values of the anthropometric measurements, and clinical parameters, as well as the different scales of overweight and obesity, have more unfavorable results in the group of men.

There are non-modifiable variables (age, gender, personal history) that influence the appearance of high blood pressure values, so changes in lifestyle and reduction in overweight and obesity rates are very important so as to avoid future complications.

Hypertension is related to higher morbidity and mortality, so if its values are controlled, as well as other modifiable variables (alcohol consumption, obesity, sedentary lifestyle, tobacco...), cardiovascular risk and therefore morbidity and mortality from cardiovascular diseases could be reduced[2].

Over 60% of hypertensive patients are overweight or obese and if these variables as well as lifestyle are not modified, it will be difficult to achieve optimal blood pressure levels and a reduction in cardiovascular risk[4,7].

Several studies compare overweight and obesity rates in patients with diabetes mellitus, but there are few studies in the literature that compare obesity and overweight with high blood pressure[22,24,25], so this would be one of the strengths of our study, as well as its large sample size with 421.625 patients.

With the results obtained in this study, it is observed that most of the overweight and obesity parameters, as well as their scales, have worse results in the group of men, favoring the appearance of arterial hypertension, while patients with normal weight tend to have better blood pressure levels.

It has also been seen that the older the age, the greater the risk of presenting altered blood pressure rates in both sexes. Parameters such as body fat are more altered in the group of women.

It is important to note that not all excess fat is related to obesity, so its body distribution must be taken into account. For this reason, the Deurenberg formula has a high specificity and sensitivity with a greater degree of correlation and also the CUN-BAE formula. Scales such as ABSI are imprecise for estimating body fat at the individual level[28] and do not take into account the variables of age and gender, which are directly related to the presence of hypertension. All the results obtained are statistically significant.

The limitations found in this study are that it was carried out in a specific geographic area, with a Caucasian working population, which could limit the generalization of the results to other areas; hence the findings would not be applicable to other populations.

To conclude, the study shows in a statistically significant way that overweight and obese patients have a greater risk of presenting arterial hypertension in both sexes, with an increased risk at an older age, so it is vitally important to influence lifestyle modifications, in order to reduce morbidity and mortality due to different pathologies derived from overweight, obesity, and hypertension.

Conflict of interest

None

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