

ORIGINAL

Equation Córdoba body fat values according to sociodemographic variables and healthy habits in 386924 Spanish workers

Valores de ecuación Córdoba grasa corporal según variables sociodemográficas y hábitos saludables en 386.924 trabajadores españoles

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Abstract

Introduction and objective: Excess body fat is an important risk factor for multiple pathologies, especially cardiometabolic ones, and its genesis is multifactorial. There are many ways of determining excess body fat, either directly or indirectly by means of estimation scales, among which one very easy to calculate is the Córdoba fat estimator equation (ECORE-BF). The objective is to evaluate the effect on the ECORE-BF values of various sociodemographic variables and healthy habits.

Methodology: Descriptive and cross-sectional study in 386924 Spanish workers to determine the association between sociodemographic variables such as age, gender, social class and level of education and healthy habits such as physical activity, Mediterranean diet and tobacco consumption with ECORE-BF values.

Results: Higher mean values and higher prevalence of high ECORE-BF values were observed with increasing age, lower socioeconomic level, lower level of physical activity and lower adherence to the Mediterranean diet, and in smokers.

Conclusion: All the variables studied seem to influence the ECORE-BF values, being the profile of a male of advanced age, low socioeconomic level, sedentary, with low adherence to the Mediterranean diet and smoker.

Key words: Body fat, obesity, ECORE-BF, sociodemographic variables, physical activity, Mediterranean diet, smoking.

Resumen

Introducción y objetivo: El exceso de grasa corporal es un importante factor de riesgo para múltiples patologías, especialmente las cardiometabólicas y su génesis es multifactorial. Existen muchas formas de determinar el exceso de grasa corporal, ya sean directas o indirectas mediante escalas de estimación, dentro de ellas una de muy fácil cálculo es la ecuación Córdoba estimador de grasa (ECORE-BF). El objetivo es valorar el efecto sobre los valores de ECORE-BF de diversas variables sociodemográficas y hábitos saludables.

Metodología: Estudio descriptivo y transversal en 386924 trabajadores españoles en los que se determina la asociación que existe entre variables sociodemográficas como edad, género, clase social y nivel de estudios y hábitos saludables como actividad física, dieta mediterránea y consumo de tabaco con los valores de ECORE-BF.

Resultados: Se observan mayores valores medios y mayor prevalencia de valores altos de ECORE-BF a medida que aumenta la edad, cuando el nivel socioeconómico es más bajo, cuanto menor es el nivel de actividad física y menor es la adherencia a la dieta mediterránea y en los fumadores.

Conclusión: Todas las variables estudiadas parecen influir en los valores de ECORE-BF, siendo el perfil de mayor riesgo el de un varón de edad avanzada, nivel socioeconómico bajo, sedentario, con baja adherencia a la dieta mediterránea y fumador.

Palabras clave: Grasa corporal, obesidad, ECORE-BF, variables sociodemográficas, actividad física, dieta mediterránea, tabaco.

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Introduction

Body fat percentage is an important indicator for assessing the health and physical condition of the individual¹⁻⁴.

Calculation of the amount of body fat can be performed in various ways. Some methods do it directly and objectively, such as bone densitometry (DEXA)^{5,6} which is considered the reference standard. This technique uses very low levels of radiation to assess body composition divided into three compartments: fat mass, bone mass and lean mass. Other objective techniques such as bioimpedancemetry⁷⁻⁹ and plethysmography^{10,11} are also available.

Indirect methods or estimators of body fat include the tape measure that measures the perimeters of the abdominal waist^{12,13}, hip¹⁴, neck¹⁵⁻¹⁷, or wrist¹⁸, and other procedures that use formulas for their evaluation (Clínica Universitaria de Navarra Body adiposity estimator CUN BAE^{19,20}, Deuremberg²¹ or relative fat mass RFM²²). The latter group includes a recently described indicator, the Cordoba Body fat equation (ECORE-BF)²³, which is calculated on the basis of age, gender and body mass index (BMI).

Among the different factors that can affect body fat values, the most relevant are:

1. Genetics²⁴ and Hereditary Factors²⁵: Genetic predisposition can influence the amount of fat a person stores. A family history of obesity²⁶ facilitates a greater tendency to accumulate fat.
2. Gender: The percentage of body fat varies between men and women²⁷. Women tend to have a higher fat percentage due to hormonal differences^{28,29} and the biological need to store fat for reproduction³⁰. Whereas men, under the same conditions, have a higher proportion of muscle mass³¹.
3. Age: As we age, it is common for our body fat percentage to increase³². This is a consequence of changes in metabolism, decreased physical activity, and, very importantly, sarcopenia^{33,34}, which produces a decrease in metabolic expenditure and facilitates the replacement of lean tissue by fatty tissue.

4. Eating habits and lifestyle³⁵⁻³⁷: A diet high in calories and low in physical activity increases the percentage of body fat. In contrast, a healthy diet and regular physical exercise decrease body fat and increase the proportion of lean tissue.
5. Fat distribution: The location of fat in the body is also relevant. Multiple studies have shown that subcutaneous fat³⁸⁻⁴⁰ (under the skin) and visceral fat^{41,42} (around internal organs) can affect health differently. Constituting a cardiovascular risk factor.

It is important to remember that body fat percentage is not the only indicator of health. Body composition, muscle mass and other risk factors should also be assessed to obtain a complete picture of health⁴³.

In humans, both too much and too little fat can affect health and athletic performance. Excess fat has been linked to increased risk of chronic disease, while a lack of fat can affect hormone production and muscle mass⁴⁴.

The aim of this study is to assess how different sociodemographic variables (age, gender, social class and level of education) and healthy habits (Mediterranean diet, physical activity and smoking) are associated with Ecore-BF values in a group of Spanish workers.

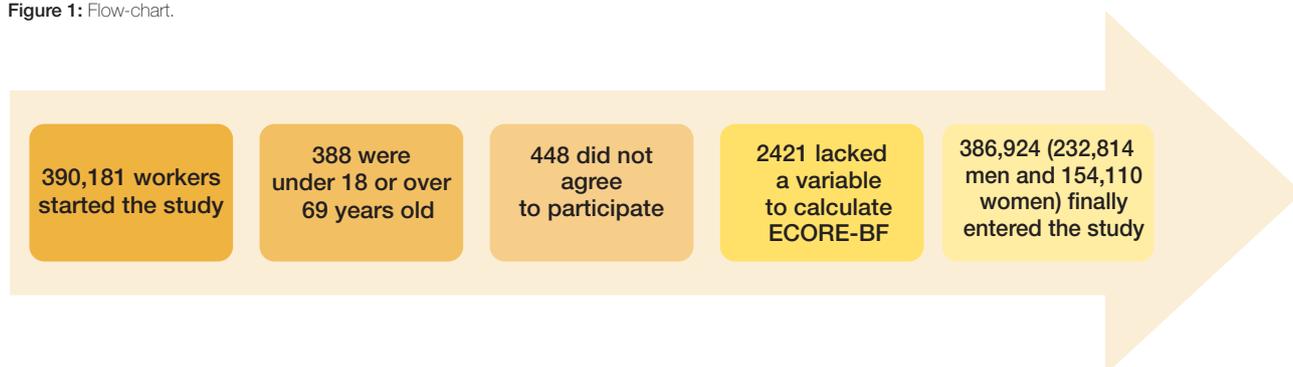
Methods

Utilising data from occupational medical tests conducted on 386,924 Spanish workers (232,814 men and 154,110 women) in the primary, secondary, and tertiary sectors between January 2019 and June 2020, a descriptive, cross-sectional analysis was conducted.

The following were the inclusion criteria:

- Aged eighteen to sixty-nine.
- Employed by one of the study's participating companies.
- Deciding to take part in the research.

Figure 1: Flow-chart.



Determination of variables

After standardising measuring techniques beforehand, the medical and nursing staff members of the study were in charge of performing clinical, analytical, and anthropometric (waist circumference, weight, and height) measures.

To calculate height and weight, a measuring scale based on the SECA 700 model was employed. An SECA model measuring tape was used to measure the subject's abdominal waist circumference when they were standing upright, with their lower limbs together, their trunk erect, and their abdomen relaxed. To obtain a precise measurement, the tape measure was placed parallel to the floor at the level of the last floating rib.

Using a calibrated automatic sphygmomanometer (OMRON M3), blood pressure was collected while the employee was seated and after at least a 10-minute rest interval.

Three measurements were made, separated by sixty seconds, and averaged. Following a minimum 12-hour fast, the different analytical values were ascertained. Total cholesterol, glycemia, and triglycerides were measured using automated enzyme techniques. Dextran sulfate-MgCl₂ precipitation techniques were used to produce high-density lipoprotein (HDL) levels.

We used the Friedewald formula to indirectly calculate low-density lipoproteins (LDL). Each of these analytical parameters has a mg/dL expression.

Friedewald's equation: LDL equals triglycerides/5 - HDL + cholesterol.

Equation Córdoba for Estimation of Body Fat, or ECORE-BF45. The cut-off points for obesity are from 25% in men and 35% in women.

ECORE-BF = 97.102+0.123 (age) +11.9 (sex) +35.959 (LnBMI).

Man = 0 Woman = 1

As evidenced by a study published in *Diabetes Care*, our group's prior investigation established a very good concordance (0.998) between ECORE-BF and the gold standard body fat estimate, the Clínica Universitaria de Navarra body adiposity estimator (CUNBAE)⁴⁶.

There are two recognised genders: male and female.

The age is calculated by subtracting the date of birth from the date of the medical examination.

The level of education that is being considered is the highest of all those that were taken. The three official educational levels are primary, secondary, and university.

For the purpose of determining social class, the 2011 national classification of occupations (CNO-11) criteria of the Spanish Society of Epidemiology were utilised⁴⁷. Three levels were established: - Social class I. This includes managers, artists, professional athletes, and professionals with university training. - Social class II. This includes intermediate-level professions and capable independent contractors. - Social class III. This holds true for unskilled workers as well.

If a person has smoked for at least one day in the preceding thirty days or if they haven't stopped for less than a year, we classify them as smokers.

The degree to which people adhere to the Mediterranean diet⁴⁸ is measured using a fourteen-item survey with a point system of 0 or 1. A nine indicates high adherence.

To ascertain an individual's degree of physical activity, the International Physical Activity Questionnaire (IPAQ)⁴⁹ is utilised. This self-administered questionnaire is intended to determine the amount of physical activity completed throughout the previous seven days.

Statistical Analysis

The Student's t-test was employed to ascertain the mean and standard deviation for quantitative data.

The chi-square test was used to find prevalences for qualitative variables. ROC curves were used to calculate the cutoff points for cardiac ages as moderate and high. Multinomial logistic regression was used to carry out the multivariate analysis. We performed the statistical analysis using SPSS 29.0. $p < 0.05$ was the recognised threshold for statistical significance.

Aspects of ethics

All other ethical principles governing research, including the 2013 Helsinki Declaration⁵⁰, have been adhered to. Anonymity and privacy for participants have always been assured. The Balearic Islands Research Ethics Committee (CEI-IB), which granted consent under IB 483/20, approved the project. The identities of the participants are only known to the principal investigator because all of the data are coded. The Organic Law 3/2018, enacted on December 5, 2018, mandates that research subjects shall always have the right to see, amend, withdraw, and object to the utilisation of the collected data. Additionally, it protects digital rights.

Results

Table I presents the anthropometric, clinical, analytical, sociodemographic, and healthy habit data for the 386924 workers in the research. The average age of the participants was somewhat higher than 39. All other variables—apart from LDL cholesterol—have lower levels in the group of women. Of the participants,

women comprised 39.8% and males 60.2%. The average age of the population is between 30 and 49 years old. Most of them just have an elementary education and come from socioeconomic class III. 41% of men and 51.4% of women eat a Mediterranean diet, and 45.5% of men and 52.2% of women regularly exercise. 37% of males and 33% of women were smokers, respectively.

Table II shows how the ECORE-BF values increase with age. This increase is also observed as we descend in social class or educational level. It is observed that both physical activity and high adherence to the Mediterranean diet or not consuming tobacco will favor the appearance of lower ECORE-BF values. The mean values are higher in women, as occurs with all the scales that assess body fat. In all cases the differences observed are statistically significant.

Table I: Characteristics of the population.

	Men n=232.814	Women n=154.110	p-value
	Mean (SD)	Mean (SD)	
Age (years)	39.8 (10.3)	39.2 (10.2)	<0.001
Height (cm)	173.9 (7.0)	161.2 (6.6)	<0.001
Weight (kg)	81.1 (13.9)	65.3 (13.2)	<0.001
Waist circumference (cm)	87.7 (9.1)	73.9 (7.9)	<0.001
Hip circumference (cm)	100.0 (8.4)	97.2 (8.9)	<0.001
Systolic blood pressure (mmHg)	124.4 (15.1)	114.4 (14.8)	<0.001
Diastolic blood pressure (mmHg)	75.4 (10.6)	69.7 (10.3)	<0.001
Total cholesterol (mg/dl)	195.9 (38.9)	193.6 (36.4)	<0.001
HDL-c (mg/dl)	51.0 (7.0)	53.7 (7.6)	<0.001
LDL-c (mg/dl)	120.5 (37.6)	122.3 (37.0)	<0.001
Triglycerides (mg/dl)	123.8 (88.0)	88.1 (46.2)	<0.001
Glycaemia (mg/dl)	88.1 (12.9)	84.1 (11.5)	<0.001
	%	%	p-value
< 30 years	17.9	19.5	<0.001
30-39 years	33.1	33.3	
40-49 years	29.7	29.4	
50-59 years	16.3	15.3	
60-69 years	3.0	2.5	
Social class I	61.2	51.8	<0.001
Social class II	34.0	40.7	
Social class III	4.8	7.5	
University	5.3	7.2	<0.001
High school	17.4	33.2	
Elementary school	77.3	59.8	
Non physical activity	54.5	47.8	<0.001
Yes physical activity	45.5	52.2	
Non Mediterranean diet	59.0	48.6	<0.001
Yes Mediterranean diet	41.0	51.4	
Smokers	62.9	67.0	<0.001
Non smokers	37.1	33.0	

HDL-c High density lipoprotein cholesterol. LDL Low density lipoprotein cholesterol

Table II: Mean values of ECORE-BF according sociodemographic variables and healthy habits by gender.

ECORE-BF	Men			Women		
	n	Mean (SD)	p-value	n	Mean (SD)	p-value
< 30 years	41742	21.3 (5.7)	<0.001	29978	31.3 (6.6)	<0.001
30-39 years	76960	24.6 (5.3)		51392	33.5 (6.6)	
40-49 years	69068	27.0 (5.2)		45296	36.4 (6.4)	
50-59 years	38028	28.9 (5.2)		23516	39.1 (6.1)	
60-69 years	7016	30.4 (4.8)		3928	41.1 (5.7)	
Social class I	12262	25.4 (5.5)	<0.001	10744	32.9 (6.2)	<0.001
Social class II	40650	25.7 (5.8)		51230	33.4 (6.4)	
Social class III	179902	26.1 (6.2)		92136	36.1 (7.2)	
University	11094	25.4 (5.4)	<0.001	11610	32.9 (6.3)	<0.001
High school	79226	25.6 (5.7)		62690	33.8 (6.6)	
Elementary school	142494	25.9 (6.1)		79810	36.2 (7.2)	
Non physical activity	126808	29.0 (5.1)	<0.001	73684	39.6 (6.5)	<0.001
Yes physical activity	106006	21.5 (3.8)		80426	30.7 (4.1)	
Non Mediterranean diet	137464	28.4 (5.4)	<0.001	74828	39.2 (6.8)	<0.001
Yes Mediterranean diet	95350	21.5 (3.9)		79282	31.0 (4.2)	
Smokers	86334	26.2 (5.7)	<0.001	50810	33.9 (6.8)	<0.001
Non smokers	146480	24.6 (6.1)		103300	35.5 (7.0)	

ECORE-BF Equation Córdoba estimator body fat. SD Standard deviation

Table III, which assesses the prevalence of obesity with the ECORE-BF scale, shows the same tendency already described for the mean values, that is, higher prevalence at older ages, in persons with a low socioeconomic level, sedentary, with low adherence to the Mediterranean diet and smokers. In this case the prevalences are higher in men. The differences observed in all cases show statistical significance.

The multinomial logistic regression analysis, shown in **Table IV**, shows that all the sociodemographic variables and healthy habits analyzed influence the appearance of obesity using the ECORE-BF scale. The most influential variables were physical activity, Mediterranean diet, gender and age. In all cases the differences observed show statistically significant differences.

Table III: Prevalence of high values of ECORE-BF according sociodemographic variables and healthy habits by gender.

ECORE-BF obesity	Men			Women		
	n	%	p-value	n	%	p-value
< 30 years	41742	22.5	<0.001	29978	24.1	<0.001
30-39 years	76960	43.5		51392	34.7	
40-49 years	69068	63.8		45296	53.1	
50-59 years	38028	78.2		23516	72.5	
60-69 years	7016	87.5		3928	86.4	
Social class I	12262	51.6	<0.001	10744	31.2	<0.001
Social class II	40650	52.6		51230	34.3	
Social class III	179902	53.0		92136	52.8	
University	11094	52.3	<0.001	11610	31.1	<0.001
High school	79226	52.9		62690	37.5	
Elementary school	142494	53.3		79810	53.0	
Non physical activity	126808	80.7	<0.001	73684	77.1	<0.001
Yes physical activity	106006	19.3		80426	15.8	
Non Mediterranean diet	137464	76.2	<0.001	74828	72.9	<0.001
Yes Mediterranean diet	95350	19.0		79282	18.9	
Smokers	86334	46.2	<0.001	50810	38.8	<0.001
Non smokers	146480	56.6		103300	48.2	

ECORE-BF Equation Córdoba estimator body fat

Table IV: Multinomial logistic regression.

ECORE-BF obesity	OR (95% CI)	p-value
Female	1	
Male	2.48 (2.22-32.74)	<0.001
< 30 years	1	
30-39 years	1.19 (1.15-1.23)	<0.001
40-49 years	1.48 (1.40-1.57)	<0.001
50-59 years	1.99 (1.80-2.19)	<0.001
60-69 years	2.70 (2.39-3.02)	<0.001
Social class I	1	
Social class II	1.18 (1.13-1.23)	0.611
Social class III	1.98 (1.70-2.27)	<0.001
University	1	
High school	1.19 (1.13-1.26)	0.001
Elementary school	2.08 (1.90-2.27)	<0.001
Non physical activity	1	
Yes physical activity	6.33 (5.75-6.92)	<0.001
Non Mediterranean diet	1	
Yes Mediterranean diet	2.87 (2.56-3.08)	<0.001
Smokers	1	
Non smokers	1.18 (1.14-1.23)	<0.001

ECORE-BF Equation Córdoba estimator body fat

Discussion

The distribution of body fat is influenced by age. Individuals tend to experience an increase in total body fat and changes in the distribution of this fat, resulting in a greater accumulation of fat in the abdomen, which is known as central obesity⁵⁰. This is due to hormonal changes, a decrease in metabolic rate and a reduction in muscle mass, which can result in a higher proportion of fat compared to lean mass.

Different studies have found that abdominal fat was related to an increased risk of type 2⁵¹ diabetes⁵², and heart disease^{53,54}, especially in older men. Therefore, controlling body fat in old age is essential to improve health and prevent chronic diseases.

The distribution of body fat is influenced by gender⁵⁵. Thus, the proportion of body fat in women is higher than

in men⁵⁶, mainly influenced by hormonal differences. Female body fat accumulates especially in the hips, thighs and breasts, while men tend to accumulate more fat in the abdomen.

Multiple studies associate this variation in body fat distribution with negative health effects. The accumulation of abdominal fat in men has been associated with an increased risk of type 2 diabetes and cardiovascular disease⁵⁷. Whereas in women, fat accumulation in the thighs and hips may be related to a lower risk of metabolic diseases⁵⁸.

Social class and educational level are also linked to weight. Epidemiological studies link people with low income and lower educational level with a higher probability of developing obesity and overweight compared to people of higher socioeconomic levels^{59,60}.

This disparity may be influenced by several factors, including limited access to healthy foods due to economic constraints, less access to physical exercise facilities, and higher levels of stress, which can lead to unhealthy eating patterns and weight gain.

Diet plays a key role in body composition. The Mediterranean diet is well known for its health benefits, including the reduction of body fat. It includes a high intake of fruits, vegetables, legumes, whole grains, fish and olive oil, along with a moderate intake of red wine and dairy products, and a low intake of red meat and processed foods.

Several studies have described that following a Mediterranean diet is associated with fewer cases of obesity, less abdominal fat and less risk of cardiovascular and metabolic diseases^{61,62}.

To maintain a healthy body composition and control body fat levels, regular physical exercise is essential. Physical activity can change the distribution of fat, especially visceral fat, which is associated with an increased risk of chronic disease, as well as help to consume calories and maintain a healthy body weight⁶³.

It has been shown that both aerobic exercise⁶³ and strength training⁶⁴ can improve overall body composition

and reduce the amount of fat in the body. Aerobic exercise, such as running, swimming or cycling, helps to consume calories and improve cardiovascular health, while strength exercise, such as weight lifting, increases muscle mass and basal metabolism, resulting in increased fat consumption by resting muscle tissue.

Body fat levels are also affected by smoking⁶⁵, although the effects vary according to the individual and other lifestyle factors. Many studies have shown that smokers tend to have a higher proportion of visceral fat⁶⁶ even at normal body weight, despite the fact that smoking can suppress appetite and lead to slight short-term weight loss due to stimulation of metabolism.

Smoking is also associated with an increased risk of cardiovascular⁶⁷ and respiratory⁶⁸ diseases, as well as several types of cancer⁶⁹, demonstrating the importance of adopting healthy lifestyle habits, such as smoking cessation, to maintain good long-term health.

We may point to the sample size's enormous size—more than 386,000 people—and the range of sociodemographic and healthy habit analyses as positives. The primary drawback is that our results cannot be applied to the broader community because the study was conducted among working adults (18-69 years old).

Conclusion

A variety of factors, such as age, gender, social class, educational level, diet, exercise, and smoking, influence body composition and fat levels. Understanding how these factors interact can help create effective methods to promote healthy body composition and prevent chronic diseases in the population. A healthy lifestyle that includes a balanced diet, regular exercise and abstaining from smoking may be crucial.

Conflict of interest

The authors declare that they have no competing interests.

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