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ORIGINAL

Influence of tobacco consumption on the values of different overweight and obesity scales in 418,343 spanish people

Influencia del consumo de tabaco en los valores de diferentes escalas de sobrepeso y obesidad en 418.343 españoles

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Summary

Introduction and objectives: Both obesity and smoking can be considered pandemics due to their high prevalence worldwide. The aim of this study was to assess the effect of tobacco consumption and other sociodemographic variables such as sex, age, and social class on the prevalence of obesity assessed with different scales.
Material and methods: Descriptive, cross-sectional study carried out in 418343 Spanish workers in whom excess weight was assessed by applying different scales such as BMI, waist/height index, body fat estimators such as CUN BAE, and visceral fat estimators such as METS-VF, among others. The influence of sociodemographic variables (age, sex, and social class) and tobacco consumption on the prevalence of overweight and obesity was also assessed.
Results: Being male, being older, belonging to a more disadvantaged social class (social class III), and being a smoker increased the risk of presenting high values in the different scales that assess excess weight.
Conclusions: Both sociodemographic variables and tobacco consumption influence the prevalence of obesity determined with different scales; in the case of tobacco, this relationship is not observed if BRI and METS-VF are used.

Key words: Obesity, overweight, tobacco, sociodemographic variables.

Resumen

Introducción y objetivos: Tanto la obesidad como el tabaquismo pueden ser consideradas como pandemias debido a su alta prevalencia en todo el mundo. El objetivo de este estudio es valorar el efecto del consumo de tabaco y otras variables sociodemográficas como sexo, edad y clase social en la prevalencia de obesidad valorada con diferentes escalas.
Material y métodos: Estudio descriptivo y transversal realizado en 418.343 trabajadores españoles en el que se valora el exceso de peso aplicando diferentes escalas como IMC, índice cintura/altura, estimadores de grasa corporal como CUN BAE y estimadores de grasa visceral como METS-VF entre otros. Se valora también la influencia de variables sociodemográficas (edad, sexo y clase social) y el consumo de tabaco en la prevalencia de sobrepeso y obesidad.
Resultados: Ser varón, tener edad avanzada, pertenecer a una clase social más desfavorecida (clase social III) y ser fumador incrementan el riesgo de presentar valores altos de las diferentes escalas que valoran el exceso de peso.
Conclusiones: Tanto las variables sociodemográficas como el consumo de tabaco influyen en la prevalencia de obesidad determinada con diferentes escalas, en el caso del tabaco esta relación no se aprecia si empleamos BRI y METS-VF.

Palabras clave: Obesidad, sobrepeso, tabaco, variables sociodemográficas.

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Introduction

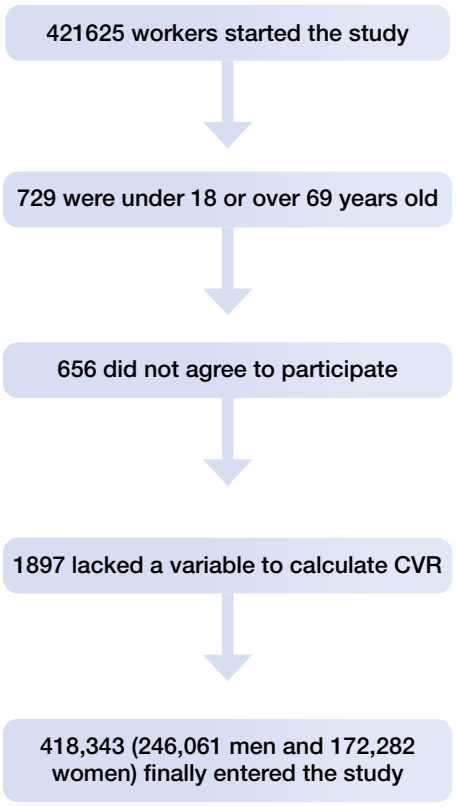
Obesity is currently considered a pandemic[1] responsible for or favoring different pathologies, whether cardiovascular[2], metabolic[3], musculoskeletal[4], gastrointestinal[5], or psychological[6].

The body mass index (BMI), which is a simple indicator of the relationship between weight and height, is frequently used to identify adults who are overweight or obese. For its calculation, a person's weight in kilograms is divided by the square of his or her height in meters (kg/m^2). However, although this indicator is the most commonly used, there are other scales for assessing excess weight, some of which are based on anthropometric parameters such as waist circumference or the waist/height index; others are based on estimates of body fat, such as the Clínica Universitaria de Navarra body fat estimator (CUN BAE)[7]; or on estimators of visceral fat, such as the Metabolic Score for Visceral Fat (METS-VF)[8].

Smoking is one of the most prevalent addictions worldwide and is responsible for a multitude of pathologies, including respiratory[9], cardiovascular[10], gastric[11], and oncologic[12], among others.

The aim of this study was to assess the effect of tobacco consumption on excess weight as determined by different scales in a Spanish working population.

Figure 1: Flowchart.



Methods

During the period from January 2017 to December 2019, a descriptive, cross-sectional study was conducted on 418,343 Spanish workers from various regions and productive sectors. The individuals were chosen from among those who underwent regular health examinations in the various participating companies.

The following were the requirements to be included in the study: being between 18 and 69 years of age, working for a company included in the study, not being temporarily incapacitated, and having signed the informed consent to participate in the study and to use their data for epidemiological purposes.

The characteristics of the population are shown in **table I**, with all anthropometric, clinical, and analytical variables showing higher or less favorable values in men. The most common age group was between 30 and 49 years. Most of the employees had only primary education and belonged to social class III. About one in three people who participated in the study smoked.

Measurement and data collection

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

A SECA 700 measuring scale was used to measure weight (in kg) and height (in cm). With the person standing, feet together, trunk erect, and abdomen relaxed, a SECA tape measure was used to measure waist circumference. At the height of the final floating rib, the tape was placed parallel to the ground.

A calibrated OMRON M3 automatic sphygmomanometer was used to measure blood pressure in a seated position after a 10-minute rest. Three determinations were made one minute apart, and the mean of each was recorded. After 12 hours of fasting, the analytical parameters were acquired. Glycemia, total cholesterol, and triglycerides were obtained using automated enzymatic methods, while HDL-c was obtained using a precipitation process with dextran sulfate-MgCl2. Friedewald's formula was used to indirectly calculate LDL-c. All analytical parameters were expressed in milligrams per deciliter.

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

The following were used as scales for overweight and obesity:

- Body mass index (BMI): weight (kg)/height^2 (cm). Obesity as from 30 kg/m^2
- Modified BMI: 1.3 x weight(kg)/height(m)$^{2.5}$

- Triponderal index: weight (kg)/height^3 (cm).
- Waist-to-height ratio: High values from 0.50.
- CUN BAE (Clínica Universitaria de Navarra body adiposity estimator)[13]
  -44.988+(0.503×age) +(10.689 ×sex) +(3.172 ×IMC) -(0.026 ×IMC2) +(0.181 ×IMC ×sex) -(0.02 ×IMC ×age) -(0.005 ×IMC2 ×sex) +(0.00021 ×IMC2 ×age), where males=0 and females=1 Obesity >25% males and >35% females.

- ECORE-BF (Equation Cordoba estimator body fat)[14]
  -97.102 + 0.123 x age + 11.9 x sex + (35.959 x Ln(BMI) where males=0 and females=1 Obesity >25% males and >35% females

- RFM (Relative Fat Mass)[15].
- RFM women= 76 - 20 x (height/waist circumference)
- RFM men = 64- 20 x (height/waist circumference) Obesity ≥ 40% women ≥ 30% men
- Deurenberg formula[16]
  (1.2 x BMI) + (0.23 x age)-(10.8 x sex)-5.4 men=0 women=1 Obesity >25% men >32% women

- Palafolls formula[17]
  men = (BMI/waist circumference) × 10) + BMI
  women = (BMI/waist circumference) × 10) + BMI + 10
  Obesity >25% men >32% women

- Metabolic score for visceral fat (METS-VF)[18]
  4.466 + 0.011*(Ln(METS-IR))3 + 3.239*(Ln(waist/height))3 + 0.319*(Sex) + 0.594*(Ln(age)). 1 = men 0 = women. High values ≥ 7,2
  METS-IR[19] = Ln (2 x glycemia + triglycerides) x BMI/Ln (HDL)

- Body Surface index (BSI)[20]
  Body Surface area (BSA) = weight^{0,425} x height^{0,725} x 0,0007184 BSI = weight/√BSA
  - normalized Weight-adjusted index (NWAI)[21]
  (weight/10) - (10 x height) + 10

- Body shape index (ABSI)[22]
  Waist/(BMI$^{2/3}$ x height$^{1/2}$)

- Body roundness index (BRI)[23]
  364.2-365.5 x √ 1-((waist/2∏)^2)/(0.5 height)^2)

- Visceral adiposity index (VAI)[24]
  Men (Waist/39.68 + (1.88 x BMI)) x (triglycerides/1.03) x (1.31/HDL)
  Women (Waist/36.58 + (1.89 x BMI)) x (triglycerides/0.81) x (1.52/HDL)

- Dysfunctional adiposity index (DAI)[25]
  Men(Waist/2.79+(2.68xBMI))x(triglycerides/1.37) x (1.19/HDL)
  Women (Waist/24.02 + (2.37 x BMI)) x (triglycerides/1.32) x (1.43/HDL)

- Conicity index[26]
  (Waist (m)/0.109) x 1/√(weight (kg)/height (m).

- Waist weight index (WWI)[27]
  waist/height$^{1/2}$

Smokers were those who had smoked at least one cigarette a day (or its equivalent in other types of consumption) in the previous 30 days or had stopped smoking less than a year before.

Three categories of social classes were created based on profession and the proposal of the social determinants group of the Spanish Society of Epidemiology[28], which established three categories: Class I includes directors and managers, sportsmen and artists, university professionals, and skilled self-employed workers. Class II includes intermediate occupations and unskilled self-employed workers. Class III includes unskilled workers.

Statistical analysis

A descriptive analysis of the categorical variables was performed, by calculating their frequency and distribution. Since the variables had a normal distribution, the mean and standard deviation were calculated for the quantitative variables.

Student's t-test for independent samples and the Chi-squared test for independent samples were used. Fisher's exact statistic was corrected when conditions required it. Multivariate analysis was carried out using multinomial logistic regression, calculating odds ratios with 95% confidence intervals. The Statistical Package for the Social Sciences (SPSS) version 28.0 for Windows was used for the statistical analysis, with an accepted statistical significance level of 0.05.

Ethical considerations

The research team undertook at all times to comply with the ethical standards for research in health sciences established nationally and internationally (Declaration of Helsinki), paying special attention to the anonymity of the participants and the confidentiality of the data collected. The Ethics and Research Committee of the Balearic Islands (CEI-IB) approved the study with indicator IB 4383/20. As participation in the study was voluntary, participants gave their consent, both oral and written, after having received sufficient information regarding the nature of the study. To achieve this, they were given an informed consent form together with an information sheet with an explanation of the study aim.

A code was used to identify the study data, and only the person in charge is able to relate these to the participants. No report of this study will reveal the identity of the participants. The investigators will avoid disseminating any information that identifies them. In any case, the research team is committed to complying with

Organic Law 3/2018, of December 5, on the protection of personal data and guarantee of digital rights, ensuring that study participants have the right to access, rectify, cancel, and oppose the data collected.

Results

The anthropometric and clinical characteristics of the 418343 workers participating in the study (246061 men, and 172282 women) are shown in **table I**. Most of the participants in the group were between 30 and 49 years old, with a mean age of 40.2 ± 11.0 years. In men, all variables showed more negative values. One out of three workers smoked, and three out of four were from social class III.

Table II shows the mean values of several scales to assess overweight and obesity. It can be observed that in the group of smokers, both men and women, all the scales analyzed show higher values. In all situations, the variations detected were statistically significant.

Table III shows the prevalence of high values in all the overweight and obesity assessment scales. Smokers of both sexes had higher values than non-smokers. In this case, the variations observed were also statistically significant.

Table I: Characteristics of the population.

	Women n=172.282 Mean (SD)	Men n=246.061 Mean (SD)	Total n=418.343 Mean (SD)	p-value
Age	39.6 (10.8)	40.6 (11.1)	40.2 (11.0)	<0.0001
Height	161.8 (6.5)	174.6 (7.0)	169.4 (9.3)	<0.0001
Weight	66.2 (14.0)	81.4 (14.7)	75.1 (16.2)	<0.0001
Waist	74.8 (10.6)	86.2 (11.1)	81.5 (12.2)	<0.0001
SBP	117.4 (15.7)	128.2 (15.5)	123.7 (16.5)	<0.0001
DBP	72.6 (10.4)	77.8 (11.0)	75.6 (11.0)	<0.0001
Cholesterol	190.6 (35.8)	192.6 (38.9)	191.8 (37.7)	<0.0001
HDL-c	56.8 (8.7)	50.3 (8.5)	53.0 (9.1)	<0.0001
LDL-c	116.1 (34.8)	118.0 (36.7)	117.2 (35.9)	<0.0001
Triglycerides	89.1 (46.2)	123.7 (86.4)	109.5 (74.6)	<0.0001
Glycemia	87.8 (15.1)	93.3 (21.3)	91.0 (19.2)	<0.0001
	%	%	%	p-value
18-29 years	20.7	18.8	19.6	<0.0001
30-39 years	29.7	27.6	28.4	
40-49 years	29.6	30.0	29.9	
50-59 years	16.8	19.7	18.5	
≥60 years	3.2	3.9	3.6	
Social class I	6.9	4.9	5.7	<0.0001
Social class II	23.4	14.9	18.4	
Social class III	69.7	80.3	75.9	
Non-smokers	67.2	66.6	66.9	<0.0001
Smokers	32.8	33.4	33.2	

Table II: Mean values of the different indicators of overweight and obesity according to tobacco consumption by sex.

	Men			Women		
	Non-smokers n=163920 Mean (SD)	Smokers n=82141 Mean (SD)	p-value	Non-smokers n=115727 Mean (SD)	Smokers n=56555 Mean (SD)	p-value
Body mass index	26.6 (4.5)	26.9 (4.5)	0.087	25.3 (5.2)	25.6 (5.1)	<0.001
Body mass index modified	26.3 (4.5)	26.5 (4.5)	<0.001	25.9 (5.4)	26.2 (5.3)	<0.001
Triponderal index	15.3 (2.7)	15.5 (2.7)	<0.001	15.7 (3.3)	15.9 (3.3)	<0.001
Waist to height ratio	0.49 (0.06)	0.49 (0.06)	0.004	0.46 (0.06)	0.46 (0.06)	0.003
CUN BAE	25.6 (6.6)	25.8 (6.6)	<0.001	35.3 (7.1)	35.7 (7.1)	<0.001
ECORE-BF	25.6 (6.3)	25.9 (6.3)	<0.001	35.2 (7.3)	35.7 (7.3)	<0.001
Relative fat mass	22.5 (5.0)	22.8 (5.0)	0.003	32.0 (5.6)	32.5 (5.5)	<0.001
Palafolls formula	29.6 (4.7)	29.9 (4.7)	<0.001	38.7 (5.5)	38.9 (5.4)	<0.001
Deurenberg formula	25.2 (6.5)	25.6 (6.5)	<0.001	34.1 (7.1)	34.5 (7.1)	<0.001
Body surface index	57.9 (7.9)	58.3 (7.9)	<0.001	50.6 (8.1)	50.9 (8.1)	<0.001
Normalized weight adjusted index	0.69 (1.37)	0.72 (1.37)	<0.001	0.45 (1.37)	0.46 (1.37)	<0.001
Body roundness index	3.3 (1.17)	3.4 (1.2)	<0.001	2.7 (1.2)	2.8 (1.2)	0.004
Body shape index	0.073 (0.006)	0.074 (0.006)	<0.001	0.069 (0.006)	0.070 (0.006)	<0.001
Visceral adiposity index	7.4 (6.4)	7.7 (6.6)	<0.001	2.7 (1.6)	2.9(1.7)	0.193
Dysfunctional adiposity index	0.90 (0.72)	0.92 (0.75)	<0.001	0.69 (0.41)	0.72 (0.41)	0.101
Conicity index	1.2 (0.1)	1.3 (0.1)	<0.001	1.1 (0.1)	1.2 (0.1)	0.022
METS-VF	6.2 (0.7)	6.4 (0.8)	<0.001	5.5 (0.8)	5.7(0.8)	<0.001
Waist triglyceride index	8.4 (0.6)	8.4 (0.6)	0.129	8.0 (0.5)	8.0 (0.5)	0.741

CUN BAE Clínica Universitaria de Navarra body adiposity estimator; ECORE-BF Equation Córdoba for estimation of body fat.

Table IV shows the results of the multivariate analysis applying the multinomial logistic regression technique, in which the odds ratios with their 95% confidence intervals were established. Age, sex, and social class increased the risk of presenting high values in all the scales that assess overweight and obesity. This risk increased with age and the lower the social class. It was also higher in men.

Tobacco consumption slightly increased this risk in all scales except BRI and METS-VF.

Table III: Prevalence of high values of the different indicators of overweight and obesity according to tobacco consumption by sex.

	Men			Women		
	Non-smokers n=163920 %	Smokers n=82141 %	p-value	Non-smokers n=115727 %	Smokers n=56555 %	p-value
BMI modified obesity	17.8	17.9	<0.001	19.3	19.6	<0.001
Waist-to-height-ratio high	41.6	41.9	0.034	20.9	21.2	0.011
BMI obesity	19.8	19.9	<0.001	16.5	17.0	<0.001
CUN BAE obesity	52.4	52.8	<0.001	48.2	48.8	<0.001
ECORE-BF obesity	52.3	52.7	<0.001	47.2	47.6	<0.001
Relative fat mass obesity	34.9	35.5	0.046	48.3	52.8	<0.001
Palafolls obesity	87.4	88.2	<0.001	73.3	74.1	<0.001
Deurenberg obesity	48.8	49.0	<0.001	69.0	69.5	<0.001
Body roundness index high	13.0	13.9	0.330	5.9	6.1	0.991
Body shape index high	15.9	16.9	<0.001	12.8	13.1	0.957
Visceral adiposity index high	86.2	86.5	0.062	30.1	30.4	0.236
Dysfunctional adiposity index high	25.3	25.7	0.012	11.5	11.7	0.149
Conicity index high	21.7	22.4	<0.001	10.3	10.5	0.813
Metabolic score for visceral fat high	8.6	8.8	0.088	1.3	1.5	0.036
Waist triglyceride index high	19.2	19.4	0.195	7.9	8.1	0.561

CUN BAE Clínica Universitaria de Navarra body adiposity estimator; ECORE-BF Equation Córdoba for estimation of body fat.

Table IV: Multinomial logistic regression.

	BMI obesity OR (95% CI)	BMI modified obesity OR (95% CI)	High WtHR OR (95% CI)	CUN BAE obesity OR (95% CI)	RFM obesity OR (95% CI)	Deurenberg obesity OR (95% CI)
18-29 years	1	1	1	1	1	1
30-39 years	1.10 (1.06-1.15)	1.19 (1.14-1.23)	1.09 (1.05-1.13)	1.91 (1.82-2.00)	1.07 (1.03-1.11)	2.97 (2.74-3.22)
40-49 years	1.41 (1.36-1.47)	1.61 (1.55-1.67)	1.28 (1.23-1.32)	4.18 (3.99-4.38)	1.28 (1.24-1.33)	10.72 (9.91-11.60)
50-59 years	1.98 (1.90-2.06)	2.32 (2.23-2.41)	1.65 (1.60-1.71)	9.07 (8.65-9.50)	1.69 (1.63-1.75)	38.56 (35.64-41.73)
60-69 years	3.1 (2.97-3.24)	3.64 (3.49-3.79)	2.33 (2.24-2.42)	19.76 (18.83-20.73)	2.27 (2.19-2.35)	118.99 (109.84-128.90)
Social class I	1	1	1	1	1	1
Social class II	1.45 (1.42-1.48)	1.55 (1.52-1.59)	1.22 (1.20-1.24)	1.36 (1.34-1.39)	1.25 (1.23-1.27)	1.30 (1.28-1.33)
Social class III	1.69 (1.63-1.76)	1.87 (1.80-1.95)	1.36 (1.32-1.40)	1.54 (1.49-1.58)	1.41 (1.37-1.45)	1.50 (1.45-1.54)
Female	1	1	1	1	1	1
Male	1.17 (1.15-1.19)	1.16 (1.15-1.18)	2.51 (2.47-2.54)	1.07 (1.06-1.09)	1.45 (1.44-1.46)	0.27 (0.26-0.27)
Smokers	1	1	1	1	1	1
Non-smokers	1.03 (1.02-1.05)	1.04 (1.02-1.06)	1.02 (1.00-1.03)	1.03 (1.02-1.05)	1.03 (1.01-1.04)	1.04 (1.03-1.06)
	Palafolls obesity OR (95% CI)	**High BRI OR (95% CI)**	**High VAI OR (95% CI)**	**High DAI OR (95% CI)**	**High METS-VF OR (95% CI)**	**High WWI OR (95% CI)**
18-29 years	1	1	1	1	1	1
30-39 years	1.24 (1.16-1.33)	1.06 (1.01-1.11)	1.12 (1.07-1.18)	1.16 (1.12-1.21)	1.45 (1.38-1.52)	1.05 (1.01-1.10)
40-49 years	1.87 (1.76-1.99)	1.23 (1.17-1.29)	1.34 (1.28-1.40)	1.60 (1.54-1.66)	2.83 (2.69-2.97)	1.32 (1.26-1.44)
50-59 years	3.22 (3.03-3.43)	1.67 (1.58-1.75)	2.79 (2.67-2.92)	2.49 (2.40-2.59)	7.57 (7.14-8.02)	1.99 (1.91-2.08)
60-69 years	6.35 (5.97-6.77)	2.17 (2.05-2.29)	2.94 (2.80-3.08)	4.77 (4.58-4.98)	31.81 (28.82-35.12)	3.98 (3.79-4.18)
Social class I	1	1	1	1	1	1
Social class II	1.20 (1.17-1.22)	1.17 (1.14-1.35-1.49)	1.10 (1.08-1.12)	1.13 (1.10-1.15)	1.16 (1.12-1.21)	1.15 (1.12-1.18)
Social class III	1.30 (1.25-1.34)	1.42 (1.35-1.49)	1.22 (1.18-1.26)	1.26 (1.22-1.31)	1.44 (1.34-1.54)	1.38 (1.32-1.44)
Female	1	1	1	1	1	1
Male	2.43 (2.39-2.47)	2.28 (2.23-2.34)	15.28 (15.04-15.53)	2.54 (2.50-2.59)	6.75 (6.46-7.06)	2.69 (2.64-2.75)
Smokers	1	1	1	1	1	1
Non-smokers	1.07 (1.05-1.08)	ns	1.03 (1.01-1.06)	1.06 (1.03-1.10)	ns	1.08 (1.05-1.11)

BMI body mass index.; WtHR waist to height ratio; CUN BAE Clínica Universitaria de Navarra body adiposity estimator; ECORE-BF Equation Córdoba for estimation of body fat; RFM relative fat mass; BRI body roundness index; VAI visceral adiposity index; DAI dysfunctional adiposity index; METS-VF metabolic score for visceral fat; WWI waist weight index.

Discussion

There is an increase in the mean values and in the prevalence of high values in the scales that determine overweight and obesity. High values are more frequent in men, with increasing age, in smokers, and in persons belonging to the most disadvantaged social levels (social class III).

A study by the Spanish food safety and nutrition agency (AESAN)[29] carried out in 2021 shows that in both sexes the prevalence of obesity increases with age, as found in our work. A study carried out in Spain by the Statista Research Department[30] expresses the same view.

In our study, male sex increases the risk of presenting high values in all the scales that assess overweight and obesity. These data coincide with those found in the aforementioned Statista study[30]. Something similar was found when we consulted the prevalence of obesity in Spain according to data from the Ministry of Health[31], revealing that the prevalence is higher among men in all the autonomous communities in Spain. This situation is not only observed in our country, as global prevalence data in adults by sex in the world also show higher figures in men[32].

According to data from the 2017 Spanish national health survey published National Institute of Statistics (INE)[33], obesity presents an important and significant social disparity. Patterns of prevalence variation with social class are particularly notable in women, ranging from 7.3% in the most favored social class (class I) to 24% in the most disadvantaged social class (class III), confirming our data. A study carried out in Colombia[34] assessed the effect of socioeconomic level on the prevalence of overweight and obesity in women, concluding that the prevalence of overweight and obesity is unequal and affects people of lower socioeconomic levels more. Another Spanish study published in *Nutrición Clínica y Dietética Hospitalaria*[35] expressed itself in similar terms.

The prevalence of overweight and obesity in our study was higher on all scales in the group of smokers.

According to research published in the British Medical Journal and funded by Cancer Research UK, an increase in body mass index, body fat percentage, and waist circumference are linked to both an increased risk of being a smoker and a higher number of cigarettes smoked daily[36]. A review conducted in Chile[37] revealed that although smoking has been associated with a low body mass index (BMI), heavy smokers are more likely to develop obesity, and 35-65% of smokers seeking smoking cessation treatment are overweight or obese.

By way of strengths, we would highlight the enormous sample size analyzed, which exceeds 418,000 workers, and the large number of scales assessing excess weight that were used.

The main limitation is that the people included in the study are aged between 18 and 69 years (working age), so the results may not be extrapolated to the general population.

Conclusions

All the sociodemographic variables analyzed –sex, age, and social class– influence the appearance of high values in the scales that assess overweight and obesity.

Tobacco consumption also had an influence, although less than the previous variables, on the appearance of high values in almost all the scales that assess overweight and obesity, except BRI and METS-VF.

Conflict of Interest

The authors declared that there is no conflict of interest.

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