ORIGINAL

Values of different anthropometric indices associated with obesity according to findrisc test values

Valores de diferentes índices antropométricos asociados a la obesidad según los valores del test de findrisc

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Abstract

Introduction and objective: Obesity is a metabolic disorder characterized by excessive accumulation of adipose tissue in the body and is associated with the development of abnormalities in blood glucose metabolism, either pre-diabetes or type 2 diabetes. There are different scales that assess the risk of diabetes, the most widely used being the Findrisc scale. The aim of this study is to determine the relationship of various scales of overweight and obesity with the values of the Findrisc scale.
Methods: A descriptive, cross-sectional study of 48,366 Spanish workers in which the risk of type 2 diabetes was determined using the Findrisc scale. Different scales of overweight and obesity such as BMI, waist/height, waist/hip, body adiposity index and abdominal volume index were also assessed.
Results: The prevalence of high values of all the scales analyzed in this study are much higher in those people who are at high risk of type 2 diabetes. This prevalence is higher in men.
Conclusion: There is a clear relationship between the values of the Findrisc scale and the values of all the overweight and obesity scales analyzed.

Keywords: Obesity, Findrisc score, body adiposity index, abdominal volume index, body mass index.

Resumen

Introducción y objetivo: La obesidad es un trastorno metabólico que se caracteriza por la acumulación excesiva del tejido adiposo en el cuerpo y guarda relación con la aparición de alteraciones en el metabolismo de la glucemia, ya sea prediabetes o diabetes tipo 2. Existen diferentes escalas que valoran el riesgo de diabetes, siendo la más utilizada la de Findrisc. El objetivo de este estudio es conocer la relación de varias escalas de sobrepeso y obesidad con los valores de la escala de Findrisc.
Material y métodos: Estudio descriptivo y transversal en 48.366 trabajadores españoles en los que se determina el riesgo de padecer diabetes tipo 2 mediante la escala Findrisc. También se valoran diferentes escalas de sobrepeso y obesidad como IMC, cintura/altura, cintura/cadera, índice de adiposidad corporal e índice de volumen abdominal.
Resultados: La prevalencia de valores elevados de todas las escalas analizadas en este estudio son mucho mayores en aquellas personas que presentan un alto riesgo de padecer diabetes tipo 2. Esta prevalencia es mayor en los hombres.
Conclusión: Existe una clara relación entre los valores de la escala de Findrisc y los valores de todas las escalas de sobrepeso y obesidad analizadas.

Palabras clave: Obesidad escala Findrisc, índice de adiposidad visceral, índice de volumen abdominal, índice de masa corporal.

Introduction

Obesity is a chronic and complex disease which is defined as an excess of body fat. Due to continuous increase in prevalence in adults, adolescents and children and its serious health consequences[1], obesity has become one of the most important public health problems.

According to the latest data available, worldwide more than a billion adults are overweight and 300 million of them are obese. In Spain, in 2019, overweight and obesity affects 53% of the adult population[2].

The increase in prevalence of obesity involves an increase in the prevalence of several obesity-related comorbidities[3-4]. Among others, adiposity is supposed to be the physiological characteristic of obese and overweight individuals, which puts such individuals at-risk for cardiovascular disease[5]. In fact, the relationship between overall adiposity and risk for cardiovascular disease is well documented[6-7]. Furthermore, several studies, including the Framingham heart study[8], shows the relation between the adipose tissue accumulation and the incidence of adverse metabolic events and, also, with a higher risk for developing metabolic diseases[9-11]. In Spain Framingham equation has been adjusted to allow its utilization as an effective predictor for cardiovascular risk[12-13]. Obesity also increases the risk of diabetes and certain types of cancer[14].

In addition to the consequences of their illness on the health of individual, it has been estimated that obesity and the diseases related to it, are a health cost of 2 to 7%[15].

Thus, body fat content and, mainly, the fat distribution or adiposity could be considered as important indicators of health risk. Several techniques have been developed for assessing and/or determining body fat or adiposity. Among others, these methodologies include the body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), skinfold thickness, dual-energy X-ray absorption (DXA) and hydrostatic densitometry. The BMI, an index of relative weight, is the most widely used and accepted index for classifying overweight and obesity in clinical practice, providing a simple approach to characterize obesity in individuals[16]. However, BMI presents some important and well documented limitations, such as: a different behavior in men and women, limited usefulness in children and athletes, differences between ethnic groups and especially in determining the composition and distribution of body fat, which can represent a limitation in epidemiological studies or clinical practice. Among other errors, the above indicated limitations could lead to classify individuals with high muscle mass as overweight or obese. On the other hand, subjects with BMI in the normal range may have a high percentage of fat.

In recent years they have emerged new indices to determine obesity, among them we can highlight the body adiposity index (BAI) and the abdominal volume index (AVI). The BAI was developed by Bergman et al and is determined from measurements of hip circumference and height. This index showed a high correlation with the measured body fat using DXA ($r = 0.85$; $p < 0.001$). In his study, performed only in African Americans and Mexican Americans, Bergman et al. found that this correlation was greater than that between BMI and body fat measured using DXA when together men and women were considered[5].The authors concluded that the BAI is a useful predictor of obesity and suggested that involves simple measurements, because no weight is needed. However, a recent study in Spanish Mediterranean population suggested that BAI does not exceed the limitations of BMI[17].

The AVI was developed by Guerrero-Romero et al and is determined from measurements of waist circumference and hip circumference. This index is strongly related to impaired glucose tolerance and type 2 diabetes mellitus[18].

The relationship between obesity and diabetes (DM) is so important that the term 'diabesity' has been coined. The transition from obesity to diabetes is due to a progressive defect of insulin secretion and a progressive increase in insulin resistance. Both situations appear very early in obese patients, and both worsen similarly to diabetes. A general far increase, specially visceral, specifically associated with insulin resistance[19]. Several studies have found a strong and direct association between obesity and DM[20-21].

Currently, diabetes is an uncurable disease, and its prevention has been the main focus of attention. Therefore, developing means to efficiently identify populations at high risk for DM is an important first step towards adopting preventive measures. There are many scales to predict the risk of type 2 diabetes, although the most used in our country it is the FINDRISC questionnaire. This test was initially developed for Finnish population[22] but has now been validated in many countries[23-24].

The close relationship between diabetes and obesity along with the need to advance in the prevention of DM makes us consider this study, whose primary objective is to determine what relationship exists between different indices related to obesity, such as BMI, BAI, AVI, WC, hip circumference, WHR and WtHR) and FINDRISC scale, a test that measures the risk of DM.

Materials and Methods

Subjects and Study Protocol

A cross-sectional study with Caucasians adult workers (ages, 18-69 years) was performed. All subjects were from different regions of Spain and belonged to different productive sectors. Participants in the study were selected systematically during their work health periodic examination between January and December 2019. Everyday each worker was assigned a number and half of the examined workers were randomly selected using a random number table. Thus, from a total population of 130.487 workers, 65.200 of them were invited to participate in the study. 4.402 (6.8%) refused to participate, 10.676 were eliminated by not having hip circumference measurements (16.4%) and 1.756 (2.7%) they are excluded to be diabetic and not being able to perform the FINDRISC test, being the final number of participants 48.366 (74.2%), with 19.263 women (39.8%) and 29.103 men (60.2%). Mean age of participants in the study was 39.56 years (SD±10.27). All participants were informed of the purpose of this study before they provided written informed consent to participate. Following the current legislation, members of the Health and Safety Committees were informed as well. The study protocol was in accordance with the Declaration of Helsinki and was approved by Balearic Islands Health Area Clinical Research Ethics Committee (institutional review board approval number: IB 4383/20). After acceptance, a complete medical history, including family and personal history and FINDRISC questionnaire, was recorded. The following inclusion criteria were considered: age between 18 and 69 (working age population), no diabetic, agreement to participate in the study and to be gainfully employed. Subjects who did not meet any of the inclusion criteria and those who refused to participate were excluded from the study.

Measurements and Calculations

All anthropometric measurements were made in the morning, after an overnight fast, at the same time (9 a.m.), and according to the recommendations of the International Standards for Anthropometric Assessment (ISAK)[25]. Furthermore, all measurements were performed by well trained technicians or researchers to minimize coefficients of variation. Each measurement was made three times and the average value was calculated. Weight and height were determined according to recommended techniques mentioned above. Body weight was measured to the nearest 0.1 kg using an electronic scale (Seca 700 scale, Secagmbh, Hamburg). Height was measured to the nearest 0.5 cm using a stadiometer (Seca 220 (CM) Telescopic Height Rod for Column Scales, Seca gmbh, Hamburg). BMI was calculated as weight (kg) divided by height (m) squared (kg/m^2). Criteria to define overweight were the ones of the World Health Organization (WHO)[26] which considers obesity when BMI ≥ 30 kg/m^2. Abdominal waist and hip circumferences were measured using a flexible steel tape (Lufkin Executive Thinline W 606). The plane of the tape was perpendicular to the long axis of the body and parallel to the floor. Waist circumference was measured at the level of the umbilicus and the superior iliac crest. The measurement was made at the end of a normal expiration while the subject stood upright, with feet together and arms hanging freely to the sides. Hip circumference was measured over non-restrictive underwear or light-weight shorts at the level of the maximum extension of the buttocks posteriorly in a horizontal plane, without compressing the skin. Waist circumference (WC) and hip circumference (HC) were measured using a tapeline at the level midway between the lateral lower rib margin and iliac crest as well as at the levels of trochanters. WHR was calculated as WC divided by HC. WHtR was calculated by dividing WC by height in cm.

BAI was calculated using the equation ((hip circumference)/((height)1.5)-18), which refers to Bergman et al5. Values obtained were classified in low, normal, high and very high according to criteria established by Gallagher et al for white population[27].

AVI was calculated using the equation AVI = [2 cm (waist)^2 + 0.7 cm (waist-hip)^2]/1,000

Venous blood samples were taken from the antecubital vein with suitable vacutainers without anticoagulant to obtain serum. Blood samples were taken following a 12 h overnight fast. Participants were seated at rest for at least 15 minutes before blood samples were taken. Serum was obtained after centrifugation (15 min, 1,000 g, 4°C) of blood samples. Serum was stored at -20°C and analyses were performed within 3 days. Concentrations of glucose, cholesterol and triglycerides were measured in serum by standard procedures used in clinical biochemistry laboratory using a clinical system Beckman Coulter SYNCHRON CX®9 PRO (Beckman Coulter, Brea, CA, USA).

Blood pressure was determined after a resting period of 10 minutes in the supine position using an automatic and calibrated sphygmomanometer OMRON M3 (OMRON Healthcare Europe, Spain). As indicated for the anthropometrical measures, blood pressure was measured three times with a one-minute gap between each measurement and an average value was calculated.

FINDRISC questionnaire[28] values 8 items: age, BMI, waist circumference, physical activity, dietary consumption of fruits, vegetables, and berries, Use of antihypertensive medication, previously measured high blood glucose and family history of diabetes. The maximum achievable score is 26. Less than 7 points is considered low risk, 7-11 point slightly elevated risk, 11-14 points moderate risk, and 15-26 points high or very high risk.

Statistical Analyses

All data were tested for their normal distribution (Kolmogorov–Smirnov test). Results are expressed as means and standard deviations (SD) and, when required, in percentages. Student t test for unpaired data was used to evaluate differences in anthropometric and biochemical characteristics between genders. Chi-square test was used for the difference of proportions. The existence of significant bivariate correlations between parameters such as BAI, AVI, WC, HC, WtHR, WHR and FINDRISC questionnaire was ascertained by determining Pearson or Spearman correlation coefficients. The statistical method of ROC curves (Receiver operating characteristic) curves were used to determine AVI discriminatory capacity of obesity). Cutoff values were derived mathematically from the ROC curves. Statistical analysis was carried out using IBM SPSS Statistics 27.0 software. Significance was accepted at p<0.05.

Results

Age and anthropometrical and clinical characteristics of the participants in the study as a whole and categorized by gender are shown in **table I**. Significant differences between men and women were found in all parameters analyzed with higher values of age, anthropometric characteristics (height, weight, BMI, WC, HC, WHR and WtHR), systolic and diastolic blood pressure, total cholesterol, high-density lipoprotein cholesterol and triglycerides in men and low-density lipoprotein cholesterol in women.

Mean values of anthropometrical indices according the FINDRISC test values by gender are shown in **table II**. Significant differences between men and women were found in all parameters analyzed with higher values of AVI, BMI, WC, HC, WtHR and WHR in men and higher values of BAI in women. All parameters examined, in men and women, are increasing in parallel with the values of FINDRISC test.

Table III shows the coefficients of bivariate correlations between anthropometric measures and FINDRISC test values. FINDRISC test showed the highest correlation with BMI, in men and women, and the lowest correlation with WtHR, in men and women also. In women the correlations were higher than men in BAI, HC and WHR, while the men were higher in AVI, BMI, HC and WtHR.

Figure 1 show the ROC curve in men for AVI respect to the presence of obesity determined using the BMI criteria. In men the area under the curve was 0.846 (95% CI 0.841-0.851). The best cut off point for AVI to determine obesity in men was 16.4 liters and, considering this cut off point, the sensibility was 76.3% (95% CI 75.8%-76.8%) and the specificity was 75.9% (95% CI 75.4%-76.4%)

Figure 2 show the ROC curve in women for AVI respect to the presence of obesity determined using the BMI

Table I: Anthropometric, clinical and analytical characteristics of participants in the study.

Characteristics[1]	Women (n=19.263)	Men (n=29.103)	Total (n=48.366)	p value[1]
Age (years)	39.24 ± 10.16	39.77 ± 10.33	39.56 ± 10.27	<0.0001
Weight (kg)	65.34 ± 13.21	81.10 ± 13.88	74.82 ± 15.65	<0.0001
Height (cm)	161.20 ± 6.58	173.94 ± 7.05	168.87 ± 9.28	<0.0001
BMI (kg/m²)	25.16 ± 4.93	26.79 ± 4.19	26.14 ± 4.57	<0.0001
Waist circumference (cm)	73.91 ± 7.90	87.70 ± 9.14	82.21 ± 10.99	<0.0001
Hip circumference (cm)	97.24 ± 8.95	100.05 ± 8.45	98.93 ± 8.76	<0.0001
WHR	0.76 ± 0.07	0.88 ± 0.08	0.83 ± 0.10	<0.0001
WHtR	0.46 ± 0.05	0.51 ± 0.05	0.49 ± 0.06	<0.0001
Systolic BP (mmHg)	114.38 ± 14.79	124.36 ± 15.07	120.39 ± 15.74	<0.0001
Diastolic BP (mmHg)	69.66 ± 10.28	75.39 ± 10.63	73.11 ± 10.86	<0.0001
Cholesterol (mg/dl)	193.58 ± 36.45	195.92 ± 38.87	194.99 ± 37.94	<0.0001
HDL-C (mg/dl)	53.74 ± 7.63	50.99 ± 7.03	52.09 ± 7.40	<0.0001
LDL-C (mg/dl)	122.25 ± 37.01	120.45 ± 37.59	121.17 ±37.37	<0.0001
Triglycerides (mg/dl)	88.07 ± 46.20	123.75 ± 88.03	109.54 ± 76.28	<0.0001

BMI, Body mass index. WHR, waist- to- hip ratio. WHtR, waist-to-height-ratio. Systolic BP, Systolic blood pressure. Diastolic BP, Diastolic blood pressure. HDL-C, high-density lipoprotein cholesterol. LDL-C, low-density lipoprotein cholesterol.
[1] data are expressed as means ± standard deviation.
[2] Statistical significance was estimated by independent t-test

Table II: Values of anthropometrical indices according the FINDRISC test values.

			BAI	AVI	BMI	WC	HC	WtHR	WHR
	FINDRISC	**n**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Women	**Low**	14938	28.43 ± 4.15	10.69 ± 1.52	23.42 ± 3.23	71.39 ± 5.60	94.95 ± 7.19	0.44 ± 0.04	0.75 ± 0.07
	Slightly raised	3073	33.19 ± 4.97	13.93 ± 2.65	30.60 ± 4.89	81.86 ± 7.89	104.25 ± 9.61	0.51 ± 0.04	0.79 ± 0.07
	Moderate	772	34.25 ± 5.39	14.27 ± 3.05	31.59 ± 5.15	82.75 ± 8.83	105.67 ± 9.75	0.52 ± 0.05	0.79 ± 0.07
	High-very high	480	36.68 ± 5.68	15.84 ± 3.64	34.11 ± 5.09	87.16 ± 10.22	109.83 ± 10.51	0.55 ± 0.06	0.80 ± 0.09
Men	**Low**	19920	24.57 ± 3.33	14.30 ± 1.95	25.07 ± 2.98	83.82 ± 5.97	97.71 ± 7.20	0.48 ± 0.04	0.86 ± 0.07
	Slightly raised	6759	27.63 ± 3.67	18.32 ± 3.36	29.89 ± 3.84	94.97 ± 8.89	104.47 ± 8.49	0.55 ± 0.05	0.91 ± 0.09
	Moderate	1463	29.07 ± 3.90	19.66 ± 3.51	31.85 ± 3.86	98.47 ± 9.02	106.58 ± 8.74	0.57 ± 0.05	0.93 ± 0.09
	High-very high	961	29.85 ± 4.04	20.48 ± 3.76	32.76 ± 4.26	100.48 ± 9.50	107.75 ± 9.23	0.59 ± 0.05	0.94 ± 0.09
	p-value[1]		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

BAI, body adiposity index. AVI, abdominal volume index, BMI, Body mass index. WC, waist circumference. HC, hip circumference. WHtR, waist-to-height-ratio. WHR, waist- to- hip ratio.
[1] Statistical significance was estimated by independent t-test.

Table III: Correlations between anthropometric measures and FINDRISC test values.

FINDRISC	Women	Men	Total
Body adiposity index	0.535*	0.512*	0.424*
Abdominal volumen index	0.641*	0.650*	0.586*
Body mass index	0.749*	0.768*	0.729*
Waist circumference	0.626*	0.643*	0.566*
Hip circumference	0.524*	0.456*	0.491*
Hip- to-waist ratio	0.192*	0.302*	0.275*
Waist-to-height ratio	0.577*	0.542*	0.648*

The level of significance was p*<0.01. Pearson or Spearman correlation coefficient

Figure 1: ROC curve analysis for AVI respect to obesity in men (BMI criteria).

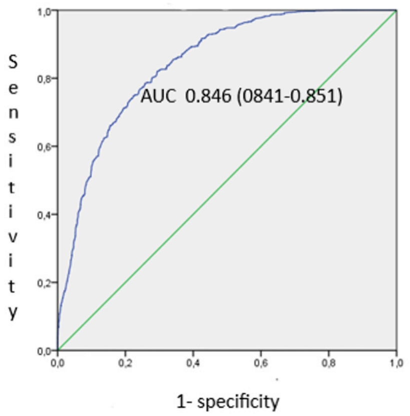
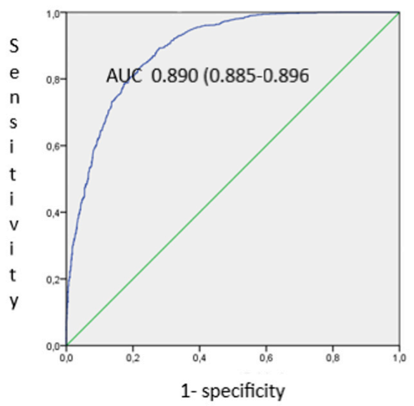


Figure 2: ROC curve analysis for AVI respect to obesity in women (BMI criteria).



criteria. In women the area under the curve was 0.890 (95% CI 0.885-0.896). The best cut off point for AVI to determine obesity in women was 12.3 liters and, considering this cut off point, the sensibility was 80.7% (95% CI 79.8%-81.6%) and the specificity was 80.7% (95% CI 79.8%-81.7%).

Table IV shows the prevalence of normal and high values of different anthropometric indices according FINDRISC test values. In men all of indices analyzed were increasing parallel to the increase of FINDRISC values. In women, BAI, AVI, BMI, WC and WtHR also increased parallel to increase of FINDRISC test values, WHR also increase with FINDRISC test but not parallelly. In general the prevalence of abnormal values of all anthropometric indices was higher in men.

Discussion

The most striking result of this study is that all the scales that assess overweight and obesity analyzed show an increase in prevalence as the values of the Findrisc questionnaire increase. This situation is observed in both sexes, although the prevalence is higher in men.

We have found several articles that agree with us on the increase in BMI values as Findrisc values increase, thus Salinero-Fort in a study carried out in primary care[29] in a population older than ours found that people with FINDRISC values of 15 and above had higher BMI and waist circumference values. Another study conducted by our group in a Spanish Mediterranean population also found this association[30]. We have not found any article that relates other scales of overweight and obesity such as BAI and AVI with the values of the FINDRISC test, so we cannot compare our results with those obtained by other authors. The strengths of the study include the large sample size, more than 48,000 people, and the

Table IV: Prevalence of normal and high values of different anthropometric indices according FINDRISC test values.

	Women					Men				
FINDRISC	Low	Slightly raised	Moderate	High -very high	p-value	Low	Slightly raised	Moderate	High -very high	p-value
BAI low weight	3.8	0.3	0.3	0.0	<0.0001	0.0	0.0	0.0	0.0	<0.0001
BAI normal weight	85.8	64.1	59.7	45.4		8.7	3.4	2.1	1.6	
BAI over weight	9.7	25.8	27.2	28.8		58.1	35.5	27.9	24.7	
BAI obese	0.6	9.8	12.8	25.8		33.3	61.1	70.1	73.8	
AVI normal	85.2	25.6	23.8	10.4	<0.0001	84.3	28.6	17.3	13.8	<0.0001
AVI high	14.8	74.4	76.2	89.6		15.7	71.4	82.7	86.2	
BMI low weight	3.2	0.2	0.1	0.0	<0.0001	0.8	0.0	0.1	0.0	<0.0001
BMI normal weight	68.3	8.1	5.4	1.7		49.4	5.5	1.6	0.8	
BMI over weight	25.1	41.2	33.4	16.0		45.0	51.0	25.1	23.4	
BMI obese	3.4	50.5	61.0	82.3		4.8	43.5	73.2	75.8	
WC normal	95.7	43.7	44.0	30.4	<0.0001	97.3	44.7	29.5	25.8	<0.0001
WC high	4.3	56.3	56.0	69.6		2.7	55.3	70.5	74.2	
WtHR normal	95.9	45.8	40.2	23.5	<0.0001	69.9	16.4	7.7	5.5	<0.0001
WtHR high	4.1	54.2	59.8	76.5		30.1	83.6	92.3	94.5	
WHR normal	92.2	81.4	83.7	74.6	<0.0001	72.9	49.4	41.1	38.8	<0.0001
WHR high	7.8	18.6	16.3	25.4		27.1	50.6	58.9	61.2	

BAI, body adiposity index. AVI, abdominal volume index, BMI, Body mass index. WC, waist circumference. WHtR, waist-to-height-ratio. WHR, waist- to- hip ratio.

variety of overweight and obesity scales analyzed. As limitations we would highlight that it has been carried out in a specific country and in a working population (ages between 18 and 69 years) which could prevent extrapolating the results to other geographical areas and to the general population.

Conclusion

All the overweight and obesity scales analyzed in this study increase in value as the values of the Findrisc scale increase

Interests conflict

The authors declare no conflict of interest.

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