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Research Article

Relationship Between Body Mass Index Values and Different Parameters and Scales Related to Cardiovascular Risk

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Abstract

Background: Excess weight is the most prevalent cardiovascular risk factor.

Aim of Study: To establish the relationship between Body Mass Index (BMI) values and different parameters and scales related to cardiovascular risk.

Methods: Descriptive and cross-sectional study of 196844 Spanish workers. Analytical parameters (lipids and glycemia), clinical (hypertension), and different scales related to cardiovascular risk were determined (metabolic syndrome with the NCEP ATP III and IDF criteria, Framingham scales for Spanish population and SCORE, vascular age).

Results: All the scales and parameters studied have higher values in people with the highest BMI (overweight and obesity). These values were always higher in men.

Discussion: There is a gradual increase in the parameters related to cardiovascular risk parallel to BMI values, in both men and women.

Keywords: *Cardiovascular Risk; Body Mass Index; Metabolic Syndrome; Hypertension; Atherogenic Index; Vascular Age*

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, according to the National Health Survey of 2011 - 2012, obesity affects 17% of the adult population (18% of men and 16% of women) and if we consider also the percentage of overweight adults affected reach 53.7%.

The increase in prevalence of obesity involves an increase in the prevalence of several obesity-related comorbidities [2-4]. 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], show 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 fact 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].

In this study we intend to show how the increase in BMI correlates with an increase in the different scales related to cardiovascular risk.

Materials and Methods

Subjects and Study Protocol

A cross-sectional study with Spanish Caucasians adult workers to different productive sectors (ages, 16-70 years) was performed. Participants in the study were systematic selected during their work health periodic examination between January 2015 and December 2016. Every day 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 406256 workers, 203128 of them were invited to participate in the study. 1987 refused to participate, 4297 were eliminated by not having hip circumference measurements or analytics being the final number of participants 196844 with 82104 women (41.7%) and 114740 men (58.3%). All participants were informed of the purpose of this study before they provided written informed consent to participle. 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 the Institutional Review Board of the Mallorca Management (GESMA). After acceptance, a complete medical history, including family and personal history was recorded. The following inclusion criteria were considered: age between 16 and 70 (working age population), 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) [16]. 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). BMI is classified according to the SEEDO criteria [17]. (Underweight < 18.5, normal 18.5 - 24.9, overweight I 25 - 26.9, overweight II 27 - 29.9, obesity I 30 - 34.9, obesity II 35 - 39.9, obesity III 40 - 49.9 and obesity IV ≥ 50 kg/m^2). Abdominal waist circumference was 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 at the sides. Waist circumference (WC) was measured using a tapeline at the level midway between the lateral lower rib margin and iliac crest.

Venous blood samples were taken from the antecubital vein with suitable vacutainers without anticoagulant to obtain serum. Blood samples were taken following a 12h overnight fast. Participants were seated at rest for at least 15 minutes before blood samples were taken. Serum was obtained after centrifugation (15 min, 1,000g, 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. Blood pressure is classified according to the Seventh Report of the Joint National Committee (JNC-7 criteria) [18].

The NCEP ATP III criteria (National Cholesterol Educational Program Adult Treatment Panel III) state that there metabolic syndrome (MS) when three or more of the following factors:

WC > 88 cm in women and > 102 cm in men, triglycerides ≥ 150 mg/dl, blood pressure ≥ 130/85 mm Hg, fasting glucose ≥ 100 mg/dl, HDL cholesterol < 40 mg/dl in men and < 50 mg/dl in women.

The International Diabetes Federation (IDF) factor considered necessary the presence of central obesity defined by a WC greater than 80 cm in women and 94 cm in men and at least two of the following four factors: triglycerides ≥ 150 mg/dl, blood pressure ≥ 130/85 mm Hg, fasting glucose ≥ 100 mg/dl, HDL cholesterol < 40 mg/dl in men and < 50 mg/dl in women.

REGICOR is the Framingham model calibrated for Spanish population [19-21], to calculate age, gender, tobacco consumption, systolic and diastolic blood pressure, cholesterol, HDL cholesterol and diabetes are needed. This model can be calculated in people between 35 and 74 years. REGICOR is considered low when the values are less than 5%, moderate between 5% and 9.9%, high between 10% and 14.9% and very high from 15%.

The SCORE model predicts cardiovascular mortality in 10 years and there are specific tables to Spain for ages between 40 and 65 years [22]. Recommended cutting points are: low les or 3%, moderate between 3% and 4.9% and high from 5%.The variables used are: age, gender, tobacco consumption, systolic blood pressure, cholesterol, HDL cholesterol.

Vascular age is a tool based on the Framingham [23] and SCORE scale [24]. The vascular age of a person is equal to the age you would have a person with the same level of cardiovascular risk estimated, but with all risk factors in normal levels.

Three atherogenic indices were calculated, Cholesterol/HDL cholesterol, LDL cholesterol/HDL cholesterol and Triglycerides/HDL cholesterol. For each different cut off were established: [25]
Cholesterol/HDL cholesterol low (< 4.5% in women and < 5% in men), moderate (between 4.5 - 7% in women and 5 - 9% in men) and high (from 7% in women and 9% in men). The LDL cholesterol/HDL cholesterol is high from 3% and triglycerides/HDL cholesterol is high from 3%.

Statistical Analysis

All the 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 mean. Chi-square test was used for the difference of proportions. Statistical analysis was carried out using IBM SPSS Statistics 20.0 software (SPSS/IBM, Chicago, IL, USA). Significance was accepted at $p < 0.05$.

Results

The distribution by age and sex of the 196844 workers in our study is shown in table 1.

Age and anthropometrical, analytical and clinical characteristics of the participants in the study as a whole and categorized by gender are shown in table 2. Significant differences between men and women were found in all parameters analyzed with higher values of age, anthropometric characteristics (height, weight and waist), clinical values (systolic and diastolic blood pressure) and analytical parameters (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides) in men.

	Women		Men		All		
	n	%	n	%	n	%	p
< 20 years	622	0,8	1031	0,9	1653	0,8	< 0.0001
20 - 29 years	15935	19,4	19471	17,0	35406	18,0	< 0.0001
30 -39 years	25780	31,4	33875	29,5	59655	30,3	< 0.0001
40 - 49 years	24260	29,5	34849	30,4	59109	30,0	< 0.0001
50 - 59 years	13137	16,0	21440	18,7	34577	17,6	< 0.0001
≥ 60 years	2370	2,9	4074	3,6	6444	3,3	< 0.0001
Total	82104	100.0	114740	100.0	196844	100.0	

Table 1: *Distribution by age and sex of the workers in our study.*

	Women n = 82104	Men n = 114740	All n = 196844	
	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Age (years)	39.4 ± 9.8	40.4 ± 10.1	40.0 ± 10.0	< 0.0001
Height (cm)	161.7 ± 6.7	174.4 ± 7.1	169.1 ± 9.3	< 0.0001
Weight (kg)	65.8 ± 6.7	81.3 ± 7.7	74.8 ± 9.3	< 0.0001
Waist (cm)	75.9 ± 8.2	88.7 ± 9.0	83.4 ± 10.7	< 0.0001
Systolic BP (mmHg)	116.2 ± 15.4	126.9 ± 14.7	122.4 ± 15.5	< 0.0001
Diastolic BP (mmHg)	71.5 ± 10.3	76.7 ± 10.4	74.5 ± 10.6	< 0.0001
Cholesterol (mg/dl)	190.3 ± 35.8	192.3 ± 38.4	191.5 ± 37.6	< 0.0001
HDL-C (mg/dl)	56.1 ± 11.2	51.5 ± 10.4	53.5 ± 10.8	< 0.0001
LDL-C (mg/dl)	119.3 ± 33.3	120.7 ± 34.3	120.1 ± 34.0	< 0.0001
Triglycerides (mg/dl)	90.3 ± 52.3	127.1 ± 90.1	112.1 ± 82.3	< 0.0001
Glycaemia (mg/dl)	86.9 ± 16.7	92.2 ± 18.8	90.1 ± 18.2	< 0.0001

Table 2: *Anthropometric, clinical and analytical characteristics of participants in the study.*

Systolic BP: Systolic Blood Pressure; Diastolic BP: Diastolic Blood Pressure; HDL-C: High-Density Lipoprotein Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol.

Mean values of different parameters relationship with cardiovascular risk according BMI with SEEDO criteria by gender are shown in table 3. Significant differences between men and women were found in all parameters analyzed with higher values of REGICOR and SCORE scales, items of metabolic syndrome with ATP III criteria, years lost of vascular age with Framingham and SCORE criteria, Cholesterol/HDL-c, LDL-c/HDL-c and triglycerides/HDL-c in men. All parameters examined, in men and women, are increasing in parallel with the values of BMI.

Table 4 shows the prevalence of high values of different clinical and analytical parameters relationship with cardiovascular risk according BMI with SEEDO criteria by gender. In men and women, all of parameters analyzed were increasing parallel to the increase of BMI levels with SEEDO criteria. The prevalence of pathological values of all parameters related with cardiovascular risk was higher in men. The differences were statistically significant.

Table 5 shows the prevalence of high values of different scales relationship with cardiovascular risk according BMI with SEEDO criteria by gender. In all of workers (men and women) all of parameters analyzed were increasing parallel to the increase of BMI levels with SEEDO criteria. The prevalence of abnormal values of all parameters related with cardiovascular risk was higher in men. The differences were statistically significant.

	Age*	REGICOR*	SCORE*	MMS ATP III*	Years lost VA SCORE*	Years lost VA Framingham*	Chol/HDL-C*	LDL-C/ HDL-C*	Triglyc/ HDL-C*
Women	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**mean ± SD**
Underweight	33.1 ± 9.2	1.6 ± 1.4	0.2 ± 0.6	0.2 ± 0.5	0.3 ± 3.9	-1.0 ± 8.2	3.2 ± 0.8	1.9 ± 0.8	1.7 ± 1.0
Normal	37.7 ± 10.1	1.9 ± 1.7	0.3 ± 0.6	0.4 ± 0.6	0.4 ± 4.0	0.0 ± 9.9	3.6 ± 1.0	2.2 ± 0.9	2.0 ± 1.5
Overweight I	41.5 ± 10.5	2.6 ± 2.3	0.4 ± 0.7	0.7 ± 0.9	0.7 ± 4.1	4.1 ± 12.4	4.0 ± 1.1	2.5 ± 1.1	2.5 ± 2.1
Overweight II	42.4 ± 10.5	2.9 ± 2.4	0.4 ± 0.7	1.0 ± 1.0	1.0 ± 4.1	6.4 ± 13.2	4.2 ± 1.2	2.6 ± 1.2	3.0 ± 2.5
Obese Type I	42.4 ± 10.5	3.3 ± 2.7	0.4 ± 0.8	1.6 ± 1.1	1.2 ± 4.2	9.1 ± 13.8	4.3 ± 1.3	2.7 ± 1.3	3.5 ± 2.8
Obese Type II	41.9 ± 10.4	3.6 ± 3.1	0.5 ± 0.8	1.8 ± 1.1	1.3 ± 4.3	11.8 ± 14.5	4.4 ± 1.2	2.7 ± 1.2	3.7 ± 2.9
Obese Type III-IV	40.6 ± 9.9	3.7 ± 3.1	0.5 ± 0.8	2.1 ± 1.1	1.9 ± 4.6	15.1 ± 14.8	4.5 ± 1.3	2.8 ± 1.1	3.8 ± 3.3
Men	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Underweight	31.8 ± 10.8	2.6 ± 1.9	1.3 ± 1.7	0.4 ± 0.6	2.4 ± 5.2	3.8 ± 8.3	3.0 ± 0.7	1.7 ± 0.7	1.3 ± 0.6
Normal	37.0 ± 10.5	2.8 ± 2.0	1.4 ± 1.7	0.7 ± 0.8	2.5 ± 5.6	4.4 ± 8.3	3.4 ± 0.9	2.1 ± 0.9	1.4 ± 0.8
Overweight I	40.9 ± 10.2	3.2 ± 2.3	1.5 ± 1.8	1.0 ± 1.0	2.6 ± 5.6	6.4 ± 9.5	3.7 ± 1.0	2.4 ± 0.9	1.8 ± 1.1
Overweight II	43.0 ± 10.1	3.6 ± 2.5	1.7 ± 1.9	1.4 ± 1.1	3.1 ± 5.7	8.5 ± 10.1	3.8 ± 1.0	2.4 ± 0.9	1.9 ± 1.2
Obese Type I	44.2 ± 10.1	4.1 ± 2.7	1.8 ± 2.0	1.9 ± 1.1	3.7 ± 5.9	10.8 ± 10.6	3.9 ± 1.0	2.5 ± 1.0	2.2 ± 1.6
Obese Type II	43.6 ± 10.3	4.5 ± 2.9	2.0 ± 2.1	2.6 ± 1.2	4.4 ± 6.0	13.5 ± 11.0	3.9 ± 1.0	2.5 ± 0.9	2.3 ± 1.2
Obese Type III-IV	42.0 ± 9.5	4.5 ± 2.8	2.1 ± 2.1	2.9 ± 1.1	4.9 ± 6.1	1.5 ± 11.2	4.0± 1.4	2.5 ± 1.2	2.4 ± 1.3

***Table 3**: Values of different parameters related to cardiovascular risk according BMI with SEEDO criteria.*

(*) p-value < 0.0001 MMS ATP III. Items of metabolic syndrome with ATP III criteria.

Characteristics	Underweight	Normal	Overweight I	Overweight II	Obese Type I	Obese Type II	Obese Type III_IV
Women	**n = 2674**	**n = 44501**	**n = 11180**	**n = 11005**	**n = 8668**	**n = 2953**	**n = 1123**
Hypertension Stage 1	2.3	4.8	9.1	12.3	17.0	21.7	23.8
Hypertension Stage 2	0.3	0.9	2.3	3.2	5.0	8.0	13.2
Cholesterol 200 -239 mg/dl	16.3	24.3	30.8	31.8	32.7	33.8	35.3
Cholesterol ≥ 240 mg/dl	3.5	6.8	10.3	11.5	11.9	13.3	14.7
HDL-C <40 mg/dl	1.1	1.1	1.4	1.4	1.9	2.0	3.4
LDL-C 130 - 159 mg/dl	6.5	9.6	12.6	12.9	13.1	14.3	15.5
LDL-C ≥ 160 mg/dl	2.0	4.9	7.1	7.3	8.1	9.1	12.9
Triglycerides 150 - 199 mg/dl	2.4	2.8	5.5	7.9	9.8	11.4	13.3
Triglycerides ≥ 200 mg/dl	0.3	1.1	3.0	4.0	6.6	7.1	8.3
Glycaemia 100 - 125 mg/dl	3.3	5.4	8.7	13.0	14.9	18.1	20.2
Glycaemia ≥ 126 mg/dl	0.3	0.6	1.3	2.2	3.9	5.9	7.9
Men	**n = 938**	**n = 42620**	**n = 23492**	**n = 25432**	**n = 17080**	**n = 4020**	**n = 1158**
Hypertension Stage 1	6.4	11.9	18.1	23.8	30.7	35.5	37.6
Hypertension Stage 2	0.9	2.2	3.9	6.7	11.0	17.8	25.4
Cholesterol 200 - 239 mg/dl	10.6	22.9	30.0	32.6	34.0	36.8	39.7
Cholesterol ≥ 240 mg/dl	3.1	6.8	11.6	13.9	14.4	15.0	18.5
HDL-C < 40 mg/dl	1.6	2.2	3.2	4.6	6.5	6.9	7.5
LDL-C 130 - 159 mg/dl	3.6	9.0	12.0	12.9	13.8	14.5	19.8
LDL-C ≥ 160 mg/dl	1.7	4.2	6.6	7.4	7.4	8.1	14.6
Triglycerides 150 - 199 mg/dl	4.6	6.9	11.3	15.2	18.3	19.0	21.7
Triglycerides ≥ 200 mg/dl	2.2	5.2	10.1	15.5	20.7	23.8	24.3
Glycaemia 100 - 125 mg/dl	6.8	10.8	15.5	19.9	24.3	27.7	27.9
Glycaemia ≥ 126 mg/dl	1.3	1.7	2.4	4.2	7.7	11.4	15.5

***Table 4:** Prevalence of high values of different clinical and analytical parameters relationship with cardiovascular risk according BMI with SEEDO criteria.*

All parameters p-value < 0.0001

	Under-weight	Normal	Overweight I	Overweight II	Obese Type I	Obese Type II	Obese Type III-IV
Women	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Metabolic Syndrome ATP III criteria	0.2	0.8	4.0	7.2	17.7	24.4	34.7
Metabolic Syndrome IDF criteria	0.0	0.1	1.1	2.2	17.2	27.1	38.8
(*) REGICOR moderated	1.6	4.1	10.5	14.0	16.8	18.3	18.8
REGICOR high	0.1	0.3	1.2	1.9	2.6	4.1	4.6
REGICOR very high	0.0	0.0	0.1	0.1	0.1	0.3	0.4
(**) SCORE medium	0.04	0.2	0.2	0.3	0.3	0.4	0.5
SCORE high	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Cholesterol/HDL-C moderated	3.5	11.0	17.7	20.2	23.3	23.3	23.7
Cholesterol/HDL-C high	0.0	0.4	0.6	0.7	0.9	0.9	0.9
LDL-C/HDL-C high	4.6	14.6	21.8	23.4	25.5	25.6	25.7
Triglycerides/HDL-C >3	1.8	3.6	8.6	12.1	17.7	22.1	22.6
Men	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Metabolic Syndrome ATP III criteria	1.1	2.8	7.9	15.9	31.1	53.5	64.9
Metabolic Syndrome IDF criteria	0.1	0.6	9.7	22.3	50.9	65.8	71.7
(*) REGICOR moderated	5.4	7.3	13.1	19.2	25.4	27.8	27.9
REGICOR high	0.2	0.6	1.2	1.8	2.4	3.3	3.3
REGICOR very high	0.0	0.1	0.2	0.3	0.5	0.8	0.9
(**) SCORE medium	1.7	1.7	2.6	3.6	4.6	4.7	4.8
SCORE high	0.9	1.4	2.0	2.9	3.5	4.3	4.7
Cholesterol/HDL-C moderated	3.4	7.9	13.8	18.5	23.2	24.7	25.1
Cholesterol/HDL-C high	0.0	0.1	0.2	0.3	0.5	0.8	0.9
LDL-C/HDL-C high	4.8	8.3	15.8	18.5	22.2	22.3	22.9
Triglycerides/HDL-C >3	7.3	13.0	22.8	32.3	42.0	46.8	46.9

Table 5: *Prevalence of high values of different scales relationship with cardiovascular risk according BMI with SEEDO criteria.*

*All parameters p-value < 0.0001 *REGICOR can only be calculated in people between 35 and 74 years (in our study 53308 women and 78728men). **SCORE can only be calculated in people between 40 and 65 years (in our study 39683 women and 60168 men).*

Discussion

The prevalence of elevated values of the different parameters and scales related to cardiovascular risk in our sample is low, which may be due to the fact that the average age of the population is also low, around 40 years.

The values of all parameters related to cardiovascular risk analyzed in this study are more unfavorable in the group with obesity using the SEEDO criteria. In all cases the values are worse in men.

We have not found studies that assess cardiovascular risk in people with normal and underweight since the research is focused on those people with overweight and obesity, therefore the comparison of our results we must do with those people who are overweight and obese.

Our workers show an increase in the values of the different lipid parameters and atherogenic indexes parallel to the increase in BMI, these data are in agreement with those found in a study carried out in a teenage population in the city of Durango, Mexico [26].

The prevalence of hypertension in our study is much higher among overweight people and especially among obese people, these data are similar to those found by other authors [27] and in the NHANES III registry [28], in which among the subjects with BMI ≥ 30 had 2 times more percentage of hypertensive than among non-obese.

The prevalence of metabolic syndrome in our study is also increasing parallel to the BMI; this was also observed in a study carried out in Mexican university students [29].

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Volume 1 Issue 2 August 2017