Obesity and anthropometric indicators in a sample of males with Acute Coronary Syndrome in a Health Area with inclusion of inmates: case-control study

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ABSTRACT

Objectives: Obesity is a cardiovascular risk factor with a high epidemic burden on ischemic heart disease. The aim of this study was to analyze the anthropometric indicators of obesity in a sample of males who have had an Acute Coronary Syndrome (ACS) diagnosed in a prison referral hospital, and a control group.

Material and methods: Cross-sectional case-control study in a Health Area with inclusion of a penitentiary center. The participants in this study were 204 males, 102 cases and one control selected for each case (n=102). We measured weight, height waist circumference (WC), umbilical waist (UW) and hip circumference. We calculated body mass index (BMI) and other anthropometric indicators: waist to- hip-ratios (WHR and UWHR), waist to-height-ratios (WHtR and UWHtR). We obtained the areas under the receiver operating characteristic curves (AUC), the odds ratio (OR) and the correlations in the infarcted people.

Results: Obesity was more prevalent in ACS (31.4% vs. 9.1%; OR: 4.7). Other indicators show a discriminatory association. BMI (AUC: 0.699; OR: 3.9), WC (AUC: 0.750; OR: 6.3), UW (AUC: 0.777; OR: 10), inverse height (AUC: 0.619; OR: 2.1), WHR (AUC: 0.832; OR: 11.6); UWHR (AUC: 0.857; OR: 15.6), UWHtR (AUC: 0.800; OR: 8.9). In ACS the correlations for both WC and UW with waist to-height-ratios (WHtR and UWHtR) were strong (all r ≥0.90; p < 0.001).

Discussion: The anthropometric indicators of obesity are clearly associated with ACS. UW is the simple measurement with the best association. BMI is most weakly associated. UWHtR presents high discriminatory power and the best anthropometric correlation of risk that supports its use for the identification of males at risk of myocardial infarction in the general population and prison.

Keywords: Acute Coronary Syndrome; Myocardial Infarction; Obesity; Body Mass Index; Indicators; Risk Factor; Body Composition; Prisons.

26

Rev Esp Sanid Penit 2015; 17: 20-29

A Martín-Castellanos, FJ Barca, MD Cabañas, P Martín, M García, MA Muñoz, C Hoyos-Peña, P Monago
Obesity and anthropometric indicators in a sample of males with Acute Coronary Syndrome in a Health Area...

INTRODUCTION

Cardiovascular diseases are the main cause of mortality worldwide[1]. In Spain they account for 30.3% of total mortality[2] and within the imprisoned population they represent 25.3%[3] of the causes of natural death. Coronary artery disease (CAD) represents in turn 28.4% of overall cardiovascular mortality in Spain, and ischemic heart disease (IHD) or acute myocardial infarction (AMI) accounts for 48.7% of cardiovascular deaths in the imprisoned population, with a clear prevalence of male patients in both cases[2-3]. On the other hand, MI entails relevant secondary morbidity and mortality which involves Primary Care in Health Areas including correctional facilities. Therefore, the implementation of rehabilitation and secondary prevention strategies should be a priority in all control objectives, particularly in the case of obesity and body composition.

Obesity is an epidemic representing the fifth impact factor on worldwide mortality and 23% of the burden on IHD[4]. In Spain, prevalence studies have reported that obesity can affect up to 23% of the general adult population[5] and up to 18% of males[6]. As for the Spanish imprisoned population, a prevalence of 11.7% has been reported for males, although with a higher percentage of abdominal obesity (15.2%)[7], a fact that could bear direct relation with the duration of prison stay, social and educational levels, ethnic origin and a younger average age. Criteria to classify obesity according to body mass index (BMI) and its real involvement in coronary risk are still in force but other indicators reflecting abdominal obesity and cardiometabolic risk such as waist circumference (WC) or waist-hip ratio (WHR)[8-10] have been recommended. The elucidation of more useful anthropometric indicators in the assessment of coronary risk still generates lively scientific debate. BMI constitutes an easy standardized measurement, but with paradoxical effects regarding such risk and cardiovascular mortality[11] and there are many epidemiological studies which prefer indicators of abdominal obesity as discriminatory or predictive factors[12-15]. The publication of the INTERHEART study[12] revealed among other factors, the importance of abdominal obesity associated to myocardial infarction and an improved discrimination of WHR regarding the attributable population risk yet without formalizing a more global anthropometric design and without carrying out a Receiver Operating Characteristic (ROC) analysis for the chosen indicators.

In the current context where the vast majority of studies have a predictive nature to establish the risk of MI or they just assess some obesity anthropometric variables, we intend to analyze by means of anthropometry a sample of males (including prisoners) who have suffered an Acute Coronary Syndrome (ACS) and compare them to a control group, within a specific anthropometric protocol as to establish the association and correlation of different anthropometric indicators to identify those more strongly associated to acute CAD.

MATERIAL AND METHODS

A case-control study has been carried out in a sample of males who had suffered an ACS in a Health Area in Spain which included a correctional facility. The minimum sample size was 89 cases and 89 controls, calculated on the basis of an exposure frequency of 18% for obesity with a 0.95 confidence level and a 0.90 power, with a detectable odds ratio of 3. Finally, there were 102 adult male participants (10% prisoners) of Caucasian origin who were admitted to the reference hospital on the basis of a diagnosis of ACS in the first 24 hours after the onset of clinical manifestations. Individual data on the patients available from 2010 to 2011 were collected in the first 10 to 15 days of hospitalization. The 102 controls shared the same ethnic origin, were ± 5 year and decade age-matched, they were recruited during the same period from a male sample of the same health area, selected through their clinical records by means of identical anthropometric protocols carried out by the evaluators. The available facilities which were considered representative of the general male adult population included a prison (20%), a health center (40%) and a central state administration officer department (40%). As for controls, exclusion criteria were the following: age under 30 or over 65, a family or personal history of CAD, a personal record of precordial pain of suspected coronary origin, potential risk factors for MI, including the infection by HIV and except for obesity.

We measured weight (kg), height (cm), waist circumference (cm), umbilical waist circumference (cm) and hip circumference (cm) with approved anthropometric material assessed by accredited anthropometrists according to the recommendations by the International Society for Advancement of Kineanthropometri (ISAK)[16-17]. WC was established as the minimum measurement or by positioning the measure tape at the midpoint between the inferior costal margin and the mid external edge of the iliac crest and between the xiphoid process and the umbilicus, parallel to the floor, and by making every

measurement at the end of a normal expiration with the arms relaxed, extended and slightly separated from the body. On the other hand, umbilical waist circumference (UWC) was considered as the circumference which passes through the umbilicus, laterally through the superior margin of the iliac crest, therefore registering the maximal abdominal diameter, parallel to the floor. HC was measured as the largest diameter, with patients standing with their feet together and relaxed muscles by positioning the measure tape directly over the skin or over light underwear, through the pubic symphysis on the front and with the largest part of the buttocks behind, parallel to the floor. Intraobserver technical error of measurement was then established for each variable to validate the measurements by considering an acceptable range of error, with an anthropometric tolerance of 1% for perimeters and of 0.5% for weight and height.

BMI was calculated by dividing weight (kg) by height (m2), WHR by dividing WC by hip circumference, the waist to height ratio (WHtR) by dividing WC by the height, the umbilical waist to hip ratio (UWHR) by dividing UW by HC, and ectomorphism was defined according to Carter's somatotype formula[18]. They all signed written informed consent approved by the Hospital's Ethics Committee according to 1975 Helsinki Declaration, and amended by the 59th General Assembly of the World Medical Association (WMA) in 2008.

Confidentiality was granted according to the Organic Law of Personal Data Protection 15/1999 as of December 13th.

STATISTICAL ANALYSIS

A descriptive analysis of data has been carried out, according to groups, with frequencies, means, standard deviations and confidence intervals. Kolmogorov-Smirnov test was used to show the normal distribution of variables, Student's T was used for parametric contrast and square-chi for non-parametric contrast to establish the differences. Analysis of Pearson's bivariate correlations was carried out to obtain its coefficients.

Sensitivity and specificity were examined through ROC analysis and areas under the curve (AUC) were calculated, tested with non-parametric differences, to assess the strength of association of each indicator to coronary individuals. Cut-off points were defined as the points of the curve where the addition of sensitivity and specificity was higher and more optimal according to Youden's index. Furthermore, prevalence odds ratio of indicators according to different cut-off points was calculated by means of contingency tables and binary logistic regression models, with the chi-square test. 95% confidence intervals were set for statistical inference. Analysis was carried out with SPSS 19.0 for Windows XP software.

Table 1: Baseline anthropometric characteristics of the males included in the study

Variables	ACS (n:102)	95%CI	Control (n:102)	95%CI	p
Weight (kg)	81.7±13.3	79.1-84.3	77.3±12.1	74.9-79.7	<0.001
Age (years)	53.0±8	51.4-54.6	48±8.5	46.5-49.5	<0.001
Height (cm)	169.7±7.3	168.3-171.2	173.3±8.5	171.6-175.0	<0.001
BMI (kg/m2)	28.3±4.0	27.5-29.1	25.6±3	25-26.2	<0.001
WC (cm)	98.5±19.1	94.8-102.3	87.8±9	86-89.6	<0.001
UW (cm)	102.3±22.1	97.9-106.4	89.1±9.5	87.2-91	<0.001
HC(cm)	99.3±14.1	96.5-102.1	97.9±6.2	95.5-98	0.10
WHR	0.99±0.1	0.97-1	0.90±0.05	0.89-0.91	<0.001
UWHR	1.02±0.1	1-1.05	0.92±0.05	0.90-0.93	<0.001
WHtR	0.58±0.1	0.56-0.60	0.50±0.05	0.49-0.51	<0.001
UWHtR	0.60±0.1	0.57-0.62	0.50±0.05	0.50-0.52	<0.001
Ectomorphism	0.8±0.8	0.66-0.88	1.4±0.96	1.30-1.68	<0.001

WC: waist circumference; HC: hip circumference; UW: umbilical waist; WHR: waist-hip ratio; UWHR: umbilical waist hip ratio; WHtR: waist to height ratio; UWHtR: umbilical waist to height ratio; BMI: body mass index; ACS: acute coronary syndrome
*Mean values±standard deviation and confidence interval (CI); p: significance level.

A Martín-Castellanos, FJ Barca, MD Cabañas, P Martín, M García, MA Muñoz, C Hoyos-Peña, P Monago
Obesity and anthropometric indicators in a sample of males with Acute Coronary Syndrome in a Health Area...

Table 2: Correlation of obesity anthropometric indicators in Acute Coronary Syndrome (ACS) n=102

Variable	Height	BMI	WC	UW	HC	WHR	UWHR	WHtR	UWHtR	Ecto
Height	1	r=-0.08	r=0.14	r=0.09	r=0.11	r=0.07	r=0.01	r=-0.09	r=0.11	r=0.36
BMI	r=-0.08	1	r=0.70	r=0.71	r=0.58	r=0.48	r=0.51	r=0.78	r=0.73	r=-0.81
WC	r=0.14	r=0.70	1	r=0.94	r=0.78	r=0.69	r=0.67	r=0.95	r=0.90	r=-0.55
UW	r=0.09	r=0.71	r=0.94	1	r=0.74	r=0.62	r=0.79	r=0.91	r=0.97	r=-0.55
HC	r=0.11	r=0.58	r=0.78	r=0.74	1	r=0.18	r=0.19	r=0.73	r=0.68	r=-0.33
WHR	r=0.07	r=0.48	r=0.69	r=0.62	r=0.18	1	r=0.76	r=0.74	r=0.59	r=-0.57
UWHR	r=0.01	r=0.51	r=0.57	r=0.79	r=0.19	r=0.76	1	r=0.56	r=0.80	r=-0.53
WHtR	r=0.09	r=0.78	r=0.95	r=0.91	r=0.73	r=0.74	r=0.56	1	r=0.94	r=-0.66
UWHTR	r=-0.11	r=0.73	r=0.90	r=0.97	r=0.68	r=0.59	r=0.80	r=0.94	1	r=-0.63
Ecto	r=0.36	r=-0.81	r=-0.47	r=-0.46	r=0.33	r=-0.57	r=0.53	r=-0.66	r=-0.63	1

WC: waist circumference; HC: hip circumference; UW: umbilical waist; WHR: waist-hip ratio; UWHR: umbilical waist hip ratio; WHtR: waist to height ratio; UWHtR: umbilical waist to height ratio; BMI: body mass index; Ecto: ectomorphism
*significant correlation for 0.01 (bilateral)

Table 3: Association between anthropometric indicators and Acute Coronary Syndrome through ROC analysis

Variables	AUC	Typical error	p	95%CI
BMI	0.699	0.037	<0.001	0.627-0.771
WC	0.750	0.035	<0.001	0.682-0.818
UW	0.777	0.033	<0.001	0.712-0.842
WHR	0.832	0.028	<0.001	0.777-0.888
UWHR	0.857	0.027	<0.001	0.804-0.909
WHtR	0.780	0.032	<0.001	0.717-0.842
UWHtR	0.800	0.031	<0.001	0.740-0.860
Inverse ectomorphism	0.723	0.037	<0.001	0.650-0.795
Inverse height	0.619	0.039	<0.001	0.542-0.695
HC	0.550	0.041	0.222	0.470-0.629

AUC: area under the curve; WC: waist circumference; HC: hip circumference; CI: confidence interval; UW: umbilical waist; WHR: waist-hip ratio; UWHR: umbilical waist hip ratio; WHtR: waist to height ratio; UWHtR: umbilical waist to height ratio; BMI: body mass index; p: significance level.

Table 4: Cut-off points, sensitivity, specificity and odds ratio for the association between anthropometric indicators and acute coronary syndrome (ACS) n=102

Variables	Cut-off point	Sensitivity	Specificity	OR	95%CI
BMI (kg/m2)	≥26.2	0.696	0.656	3.9	2.1-7.1
	≥30	0.294	0.912	4.7	2-11
WC(cm)	≥92.2	0.706	0.725	6.3	3.4-11.6
UW(cm)	≥94.4	0.755	0.725	10	5.2-19.1
WHR	≥0.94	0.755	0.735	11.6	5.8-23
UWHR	≥0.95	0.863	0.696	15.6	7.5-32.5
WHtR	≥0.53	0.706	0.725	5.1	2.9-9.3
UWHtR	≥0.54	0.784	0.725	8.9	4.6-17.1
Height (cm)	≤169.3	0.50	0.333	2.1	1.1-3.6
Ectomorphism	≤1.15	0.706	0.63	3.7	2.0-6.6

WC: waist circumference; HC: hip circumference; CI: confidence interval UW: umbilical waist; WHR: waist-hip ratio; UWHR: umbilical waist hip ratio; WHtR: waist to height ratio; UWHtR: umbilical waist to height ratio; BMI: body mass index: OR: odds ratio

increase that UW reflects provides an added interest and sets significant differences with minimum waist measures, thus confirming its differentiating power. Ectomorphism as a component of somatotype expresses the relative linearity of the individuals and has an inverse correlation with obesity. Low values are consistent with the references of the Framingham study and of other European studies considering infarcted patients[27-28], although determined with out of date methods.

In ROC analysis, waist-to-hip ratios present larger areas, slightly bigger than waist-to-height ratios, to both waist circumferences and to the inverse of ectomorphism. BMI and height through their inverse values present smaller areas and lower quality ranges in the test. The waist-to-hip ratio is thus confirmed as a good predictor for cardiovascular events[14, 22-23] and is more strongly related to the risk of MI than BMI[12]. The wait-to-height ratios are reinforced with Ashwell's meta-analysis[15], an overview of risk prediction which suggests that WHtR (with heterogeneous waist measures) is an improved tool in the screening of cardiometabolic risk due to a better value in ROC curve, overcoming other indicators such as waist circumference and BMI. The longitudinal relation of abdominal waist measures with coronary events is evident[8, 13-14, 22-23] and is supported by our study, although its ROC curve is inferior to that of indicators expressing more than a measure, except for inverse ectomorphism and BMI. Scientific debate focuses on what indicator should be used to assess obesity as an associated risk. Our study on newly diagnosed ACS allows establishing that abdominal waist circumference as an isolated measure remains the main indicator of associated obesity, and thus has an improved yield and an enhanced ROC curve if measured at the umbilicus. Of all available indicators, those including waist and hip, or height measurements, are clearly superior to those including height and weight and excluding waist circumference (BMI and ectomorphism). The question now is to decide what accompanying anthropometric measurement we should use to establish an index or ratio with the best ROC curve and odds ratio which, keeping the waist circumference as a reference in the numerator of the index, will provide the best and more deductive scientific value as to be recommended. The waist-to-hip ratio has the larger curve with a slight difference over the UWHtR. The dilemma is whether to use the hip or the height as a correction factor over the anthropometric measure which expresses central obesity. For that matter, the hip is not a discriminatory factor and relates to butt and thigh fat and to the lean component of the buttocks, and therefore any variation in this regard would entail an alteration of the ratio and it could be interpreted as a protection or MI risk-increased factor[12]. Moreover, the hip, with lower absolute values and a wider interval, is subject to larger measurement error which entails that small variations may translate into variations of the ratios but to on the real risk. On the other hand, height is a more easily measurable discriminatory factor, with no correlation with adiposity or other indicators (except for ectomorphism) and it would this be a clear factor of individual proportionality, neater and less confusing than hip circumference. Even WHR shows more moderate correlation with waist circumference and with BMI than WHtR or UWHtR. Therefore, these connotations would explain that ROC curve and odds ratio slightly tend towards waist-to-hip ratios. However, their lower correlation with abdominal waist and the overlapping of the fat component make that scientific and anthropometric inference lead us to believe that UWHtR, with its high discriminatory power and improved correlation with waist circumference, with no overlapping of other components, can more accurately translate into individual cardiometabolic risk. In Spain, individuals from Canarias[24] and from PREDIMED study[25] reveal better curves for WHtR as a predictor of cardiovascular risk and diabetes in line with the validity of WHtR as a predictor of cardiovascular disease in international studies[15, 29-30]. Ours study is the first to confirm these findings in ACS patients, reinforcing the validity of WHtR although pending the determination of an age-optimized cut-off point and adding that the utilization of UW as the numerator is a stronger criteria that improves the power of such ratio. Finally, it is worth noting that obesity shows a weaker association and that BMI is clearly outcome by the rest of indicators. We can therefore say that a significant number of patients at risk of MI would not be included with this criterion, and we thus recommend its scientific revision and the introduction in clinical practice of other indicators. The umbilical waist-to-height ratio, more strongly associated and with an improved validity in the understanding of body composition and in the distribution of risk, allows an enhanced identification of ACS male patients and it would be recommendable to use this indicator in more effective coronary health promotion strategies among the general population, and accordingly in the imprisoned population.
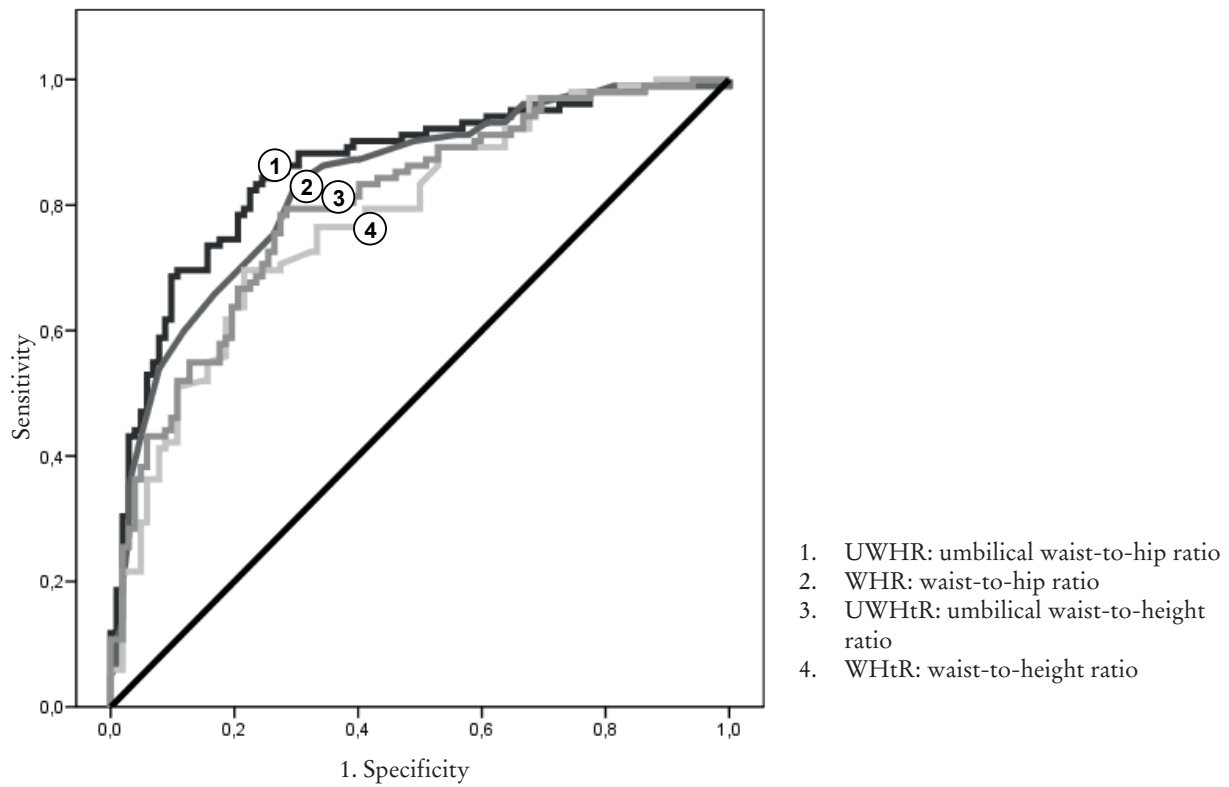
30

Rev Esp Sanid Penit 2015; 17: 20-29
A Martín-Castellanos, FJ Barca, MD Cabañas, P Martín, M García, MA Muñoz, C Hoyos-Peña, P Monago
Obesity and anthropometric indicators in a sample of males with Acute Coronary Syndrome in a Health Area...

1. UWHR: umbilical waist-to-hip ratio
2. WHR: waist-to-hip ratio
3. UWHtR: umbilical waist-to-height ratio
4. WHtR: waist-to-height ratio

Figure 1: ROC curve pattern for the four more discriminative indicators.

5. UW: umbilical waist
6. WC: waist circumference
7. Inverse ectomorphism
8. BMI: body mass index
9. Inverse height
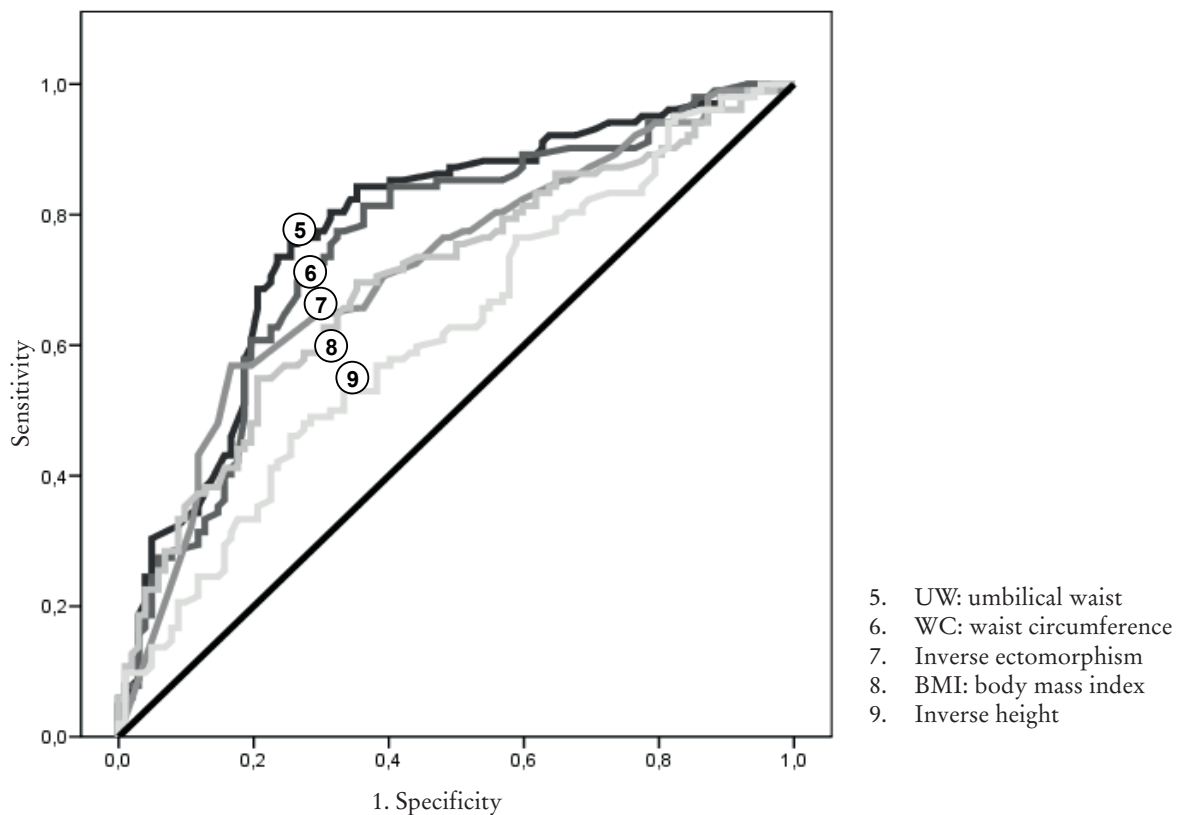
Figure 2: ROC curve pattern for the remaining indicators.

RESULTS

Table 1 shows anthropometric characteristics of the groups. There were no significant differences regarding the hip circumference, but there were so in the rest of variables including the age, where the control group presents a younger mean age within the matching interval. All the measurements with significant differences have a higher risk value in the coronary group including height and ectomorphism, with lower quantitative values inversely related with such risk.

Among anthropometric indicators in ACS, BMI≥30 kg/m2 revealed the lower prevalence (31.4% vs. 8.8%, OR: 4.7) and UWHtR ≥0.5 showed the higher frequency (91.2% vs. 63.7%; OR: 5.7).

Pearson correlation coefficients in ACS group are showed in Table 2. The correlation of BMI with WC, H, WHR, WHtR and ectomorphism were 0.70, 0.58, 0.48, 0.78 and -0.81 respectively. The correlation of WHR with WC, WHtR and ectomorphism were 0.69, 0.74 and -0.57 respectively and the correlation of WHtR with WC and ectomorphism were 0.95 and -0.66 accordingly. The correlation of UWHR and UWHtR were in line with their equivalent (WHR and WHtR) but UWHR correlates with UW (r=0.79) less than UWHtR (r=0.97). The height only revealed significant correlation with ectomorphism (r=0.36).

ROC areas under the curve for the indicators were calculated (see Table 3) to assess the degree of separation among groups according to the sensitivity and specificity at each point of the curve. It is worth noting that an area of 1 represents a perfect separation and a 0.5 area reveals the lack of discrimination between the values. This value does not need to be included in a confidence interval to be discriminatory. All areas show a discriminatory association except for the hip, with a lower limit <0.5 which shows the limit for a lack of difference with randomness. The higher values are observed for WHR and UWHR, and the lower for the inverse height yet remaining discriminatory since its lower limit is >0.5. Figures 1 and 2 show different ROC curve patterns with discriminatory power.

Cut-off points, sensitivity, specificity, odds ratio and confidence intervals for each indicator are showed in Table 4. The higher odds ratio were for UWHR, WHR, UW and UWHtR followed by WC, WHtR, BMI, ectomorphism and height. UWHR revealed the higher sensitivity and BMI≥30 the higher sensitivity.

DISCUSSION

This case control study assesses different obesity and body composition anthropometric risk indicators associated to ACS in males. Ischemic heart disease is the main cause or overall cardiovascular disease in the general and imprisoned male population[2-3] and the assessment of anthropometric measures which are more direct and useful due to their association to ACS is of paramount importance in the prevention of coronary risk that belongs to anthropometry. We have not found previous publications in acute coronary patients which assess and correlate different anthropometric variables and carry out ROC analysis. Although age, as a non-modifiable risk factor, presents some differences between both groups, it is due to an older mean in the coronary group, but in the limit of the ± 5 year interval age-matching and within the same risk decade, which could entail some variation in the coronary risk score for individuals over 50 years old, but not in the anthropometric analysis. All anthropometric variables, except for the hip, show statistically significant differences in favor of the coronary group, therefore showing more overweight and abdominal obesity in this group. The control group, alike the general or imprisoned Spanish population[5-7], reveals overweight and limit central obesity indicators[8-9,] yet waist measures do not show abdominal obesity. Short-stature has been reported to be associated in Europe to mortality and coronary risk[19] and in our study a lower height has also been associated although with lower sensitivity and less specificity. The measure of WC in our coronary group shows some parallelism with other Spanish ACS patients with regard to the extension of myocardial necrosis[20] as well as with Polish patients and adiponectin levels[21]. WHR, which has been recommended to assess abdominal obesity[8], has a value for infarcted patients, which is consistent with the Polish study[21] and with the INTERHEART study[12], where WHR has a higher attributable risk than BMI, yet with no ROC analysis or considering other indicators. Other studies on non-infarcted patients are longitudinal and use WHR as a predictive factor for cardiovascular events[14, 22-23]. WHtR is also used in the evaluation of obesity although the vast majority of available data, with cut-off points of >0.5, refer to prevention, prediction or cardiovascular risk assessment studies[15, 24-26]. In our study, WHtR emphasizes the high degree of direct association with the event. The relationship between the umbilical waist with the hip or height, are equivalent to WHR and WHtR measured at a different location, yet the

LIMITATIONS OF THE STUDY

This study has the limitations inherent to measurements, which have been minimized according to standard protocols, by assuming the technical error of measurement and accepting the aforementioned anthropometric tolerance levels which had never been considered in previous studies. The design of this study does not allow the determination of a causal effect between ACS and anthropometric indicators, and it is impossible to grant with our sample general extrapolation of some exclusive results which had never been studies before. However, in view of the consistency of the anthropometric profile and the set of classical risk indicators with the vast majority of ACS patients in other studies, the anthropometric considerations could be extrapolated to those individuals whose body composition plays a significant role on the risk for myocardial infarction.

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