



Original
Artículo inglés

The body composition in myocardial infarction males. Novel findings in both the association and relationship between anthropometric indicators of risk

Composición corporal en varones infartados. Hallazgos novedosos en la asociación y la relación entre indicadores antropométricos de riesgo

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Abstract

Objective: The aim of this study was to realize an anthropometric analysis including common indicators, somatotype rating and body fatness (BF) in males with myocardial infarction (MI)

Methods: Cross-sectional study of 116 males aged 30-75 years. **Results:** Weight (81.6±13.2 kg); height (169.4±7.1 cm); waist circumference (WC) (98.3±18.5 cm); umbilical circumference (102.4 ±21.8); hip circumference (99.3±13.6 cm); body mass index (BMI) (28.4±4 kg/m²); waist-hip ratio (WHR) (0.99±0.1, CI: 0.97-1)); waist-height ratio (WHtR) (0.58±0.1, CI: 0.56-0.60); BF (27.4%±4.5); endomorphy (4.6±1.3); mesomorphy (5.7±1.2); ectomorphy (0.8±0.8); conicity index (1.30±0.17). Correlations: BMI: BF (0.70), WC (0.70), WHR (0.48), WHtR (0.72), endomorphy (0.82), mesomorphy (0.81), ectomorphy (-0.81); WHR: BF (0.38), WC (0.69), endomorphy (0.39), mesomorphy (0.38); WHtR: BF (0.50), WC (0.96), endomorphy (0.58), mesomorphy (0.56), ectomorphy (-0.56); conicity index: WC (0.85), WHR (0.58), WHtR (0.85), endomorphy (0.45). Prevalence: WHtR (92%), WHR ≥0.95 (87%), conicity index (86.7%), WHR ≥1 (64%), BF ≥25 (69.4%), BMI ≥25-29.9 (45.6%), BMI ≥30 (37%), endomorphy ≥4.5 (47.2%), mesomorphy ≥5.6 (50%), ectomorphy ≤1.1 (71%).

Conclusions: MI males present a high-risk anthropometric profile. The somatotype rating is endomorphic-mesomorph. Waist, hip and height measurements show different involvement on the body composition. BMI-defined obesity appears to be the indicator with the more weak association and it does not discriminate between body components. WHR presents high prevalence but a weak relationship with the body composition of risk. WHtR reflects body volume distribution and the best correlations with the risk bodily components, actually being the most prevalent and accurate index to explain the biological risk associated to MI.

KEYWORDS

Obesity, myocardial infarction, somatotype, body composition, anthropometric indicator

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Resumen

Objetivo: el objetivo de este estudio era realizar un análisis antropométrico, incluyendo indicadores comunes, el somatotipo y la grasa corporal en varones con infarto de miocardio.

Método: estudio transversal en 116 varones de 30 a 75 años de edad. **Resultados:** peso ($81,6 \pm 13,2$ kg); altura ($169,4 \pm 7,1$ cm); circunferencia de cintura (CC) ($98,3 \pm 18,5$ cm); circunferencia umbilical ($102,4 \pm 21,8$); circunferencia de cadera ($99,3 \pm 13,6$ cm); índice de masa corporal (IMC) ($28,4 \pm 4$ kg/m²); índice cintura-cadera (ICCad) ($0,99 \pm 0,1$, CI: 0,97-1); índice cintura-talla (ICT) ($0,58 \pm 0,1$, CI: 0,56-0,60); grasa corporal ($27,4\% \pm 4,5$); endomorfia ($4,6 \pm 1,3$); mesomorfia ($5,7 \pm 1,2$); ectomorfia ($0,8 \pm 0,8$); índice de conicidad ($1,30 \pm 0,17$). Correlaciones: IMC: grasa corporal (0,70), cintura (0,70), ICCad (0,48), ICT (0,72), endomorfia (0,82), mesomorfia (0,81), ectomorfia (-0,81); ICCad: grasa corporal (0,38), cintura (0,69), endomorfia (0,39), mesomorfia (0,38); ICT: grasa corporal (0,50), cintura (0,96), endomorfia (0,58), mesomorfia (0,56), ectomorfia (-0,56); conicidad: cintura (0,85), ICCad (0,58), ICT (0,85), endomorfia (0,45). Prevalencia: ICT (92%), ICCad $\geq 0,95$ (87%), índice de conicidad (86,7%), ICCad ≥ 1 (64%), grasa corporal ≥ 25 (69,4%), IMC $\geq 25-29,9$ (45,6%), IMC ≥ 30 (37%), endomorfia $\geq 4,5$ (47,2%), mesomorfia $\geq 5,6$ (50%), ectomorfia $\leq 1,1$ (71%).

Conclusiones: los varones con infarto de miocardio presentan un perfil antropométrico de alto riesgo. El somatotipo es mesomorfo endomórfico. Las medidas de cintura, cadera y altura muestran diferente implicación en la composición corporal. La obesidad con criterio de índice de masa corporal es el indicador con más débil asociación, y no discrimina entre los componentes corporales. El índice cintura-cadera presenta alta prevalencia pero una débil relación con la composición corporal de riesgo. El índice cintura-talla refleja una distribución del volumen corporal y presenta las mejores correlaciones con los componentes corporales de riesgo, siendo el índice más prevalente y adecuado para explicar el riesgo biológico asociado al infarto de miocardio.

PALABRAS CLAVE

obesidad, infarto de miocardio, somatotipo, composición corporal, indicador antropométrico

Contribution to the scientific literature

The observed statistical association for waist–hip ratio in males with myocardial infarction is not consistent with our study about the body composition. Volume indices show the strongest epidemiological causal criteria.

Implications for practice and research: Weight, waist, hip and height measurements present differentiated relationships with the body composition. We recommend measures of body volume (waist and height) for the early identification of men at risk of myocardial infarction.

Introduction

Cardiovascular diseases are the leading cause of mortality worldwide ⁽¹⁾. Obesity is a global epidemic with high prevalence in adults ⁽²⁾. Coronary heart disease represents 34.6% of cardiovascular mortality in Spanish men ⁽³⁾, and prevalence of obesity reaches 22.8% of adult men ⁽⁴⁾. Body mass index (BMI) has been associated with incidence of coronary events ⁽⁵⁾, but in spite of its wide use does not provide accurate information on body composition. Thus, BMI showed a lower predictive value for myocardial infarction (MI) than indices such as waist circumference (WC) and waist-hip ratio (WHR) ^(6, 7). It is noteworthy that obesity, defined as excess fat mass actually being responsible for most of associated health risks is not always reflected by BMI ⁽⁸⁾. The somatotype is defined as the quantification of the present shape and composition of the human body ⁽⁹⁾. It has been associated with MI, although the Heath-Carter method is the most commonly used today ^(9, 10). Other obesity measures such as body fat (BF), trunk skinfolds, and waist-height ratio (WHtR) have also been evaluated in coronary events, showing different results ^(5, 10, 11).

The INTERHEART and Norwegian studies showed for WHR a stronger relation with MI than other commonly used anthropometric measures ^(6, 7). Nevertheless, the observed statistical association for WHR did not include criteria of anthropometric consistency and biologic credibility in relation to the body composition.

Few recent studies have explored the association between common indicators and the body composition by using anthropometry. Consequently, adding other variables such as BF and both central and peripheral skinfolds as well as somatotype rating we could analyze a more complete profile. We know that the contribution of anthropometric measures to predict coronary risk remains controversial, and there is not evidence of a study by using the intra-observer technical error of measurement as a way to control the precision and variability for so wide variety of variables. Indicators can be both simple measures and mathematical formulae reflecting different measurement units and risk. Therefore, some of the indicators used as proxies for adiposity assessment may present effects of confounding on the biological risk they represent. Thus, the validity, coherence and biological plausibility to link indicators and MI remains unclear. Conceptually, the risk depends on body composition rather than indicators. Every indicator would be better if shows a strong association and high causal relationship with bodily components of risk. Ultimately, only a rigorous methodology and criteria that include the magnitude of association, the consistency of anthropometric findings and biological plausibility for each variable could avoid confusing or paradoxical information between indicators. Findings should be independent on other pathophysiological mechanisms that influence atherosclerosis.

Our aim was to conduct an anthropometric analysis by adding the interrelationships with the body composition in MI males. We included common indicators as well as the somatotype components and skinfold variables representing part of body composition. We developed the analysis through variable values, their correlations, and the strength of association by estimating the prevalence.

Patients and methods

A cross-sectional study was conducted among 116 MI males included in a cardiac rehabilitation program of the Complejo Hospitalario de Cáceres, Spain. The participants, of European ethnicity, aged 30-75 years, from January 2009 to December 2010 were recruited. Data were collected in the first 10-15 days after diagnosis. The analysis was restricted to males; women were excluded from the analyses and males if they were nonage or presented any physical disability. All subjects signed an informed consent approved by the Ethical Committee of the Hospital, according to the principles of the Declaration of Helsinki (2008) and the Spanish Organic Law of Protection of Data (1999).

Anthropometric measures

Measurements were made by trained observers according to standard international protocols¹⁵. Weight was measured to the nearest 100 g, wearing light underwear. Height was read to the nearest 0.1 cm, without shoes. Skinfolds were measured (mm): Triceps, biceps, subscapular, abdominal, ileocrestal, supraspinale, anterior thigh and medial calf. Perimeters were read (cm): Relaxed upper arm girth, maximum contracted arm girth, WC, umbilical waist (UW), hip circumference (HC) and maximum calf girth. Two bone breadths were measured (cm): Biepicondylar humerus and femur. Measurements of the limbs and skinfolds were made on the right side. WC was determined at the midpoint between the lower margin of rib and the edge of the iliac crest on the midaxillary line. UW was measured at the umbilicus in a plane parallel to the ground. HC was determined at the maximum perimeter around the buttocks with the feet close together. We take duplicated or triplicated measurements, and the mean or median value for calculations was used. Technical error of measurement for each dimension, with an anthropometric tolerance for skinfolds about 5%, for perimeters and breadths 1%, and for height and weight 0.5%, was calculated.

Sum of skinfolds, BMI dividing weight by height (m^2), WHR dividing WC by HC, umbilical waist to-hip-ratio (UWHR) dividing UW by HC, WHtR dividing WC by height, and umbilical waist to-height-ratio (UWHtR) dividing UW by height were calculated. BMI ≥ 25 was defined as overweight and ≥ 30 as general obesity. Conicity index was computed in

agreement with Valdez ⁽¹³⁾: $= UW (m)/0,109 \times \sqrt{\text{weight/height (m)}}$, and cut-off point used for defining visceral obesity was ≥ 1.25 . BF percentage was estimated according to Durnin and Womersley ⁽¹⁴⁾, and cut-off point used for defining general obesity ($\geq 25\%$) was this most frequently used in the literature ⁽⁸⁾. Endomorphy, mesomorphy and ectomorphy ratings were calculated according to the well-known Heath-Carter Instruction Manual ⁽⁹⁾. Endomorphy is the relative fatness, mesomorphy is the relative musculoskeletal robustness, and ectomorphy (volume by unit of height) is the relative linearity or slenderness of the physique. Ratings on each component of 0.5 to 2.5 were considered low, 3 to 5 were moderate, and 5.5 to 7 were high. Percentiles for both BMI and ectomorphy and the 50th percentile for each somatotype rating were calculated, too.

Statistical analysis

Data were computed using SPSS® for Windows Version 19.0. A descriptive analysis with frequencies, mean values, standard deviations and confidence intervals was performed. Normal distribution was assessed using Kolmogorov Smirnov test and Student's t-test was applied as parametric test to establish differences. Bivariate analysis was used for calculating correlations of Pearson. The confidence interval was in all cases 95%. The significance level was set at 1% ($p < 0.01$).

Results

Baseline characteristics are shown (Table 1). The mean (SD) for each variable are presented (Table 2). Mean BMI was 28.4 kg/m^2 . Mean BF percentage was 27.4 % indicating obesity. Mean values for WC, WHR, WHtR and conicity denoted increased cardiovascular risk. UW, UWHR and UWHtR showed a significantly greater risk than their homonym at the level of WC.

Table 1. Baseline anthropometric characteristics of the study participants (N = 116).

Variable	Mean ± SD	95%CI	p
Age (years)	53.6 ± 10	51.7-55.5	<.001
Weight (kg)	81.6 ± 13.2	79.1-84.1	<.001
Height (cm)	169.4 ± 7.1	168-170.7	<.001
Triceps skinfold (mm)	13.9 ± 5.0	12.9 – 14.9	<.001
Biceps skinfold (mm)	5.8 ± 2.5	5.3 – 6.3	<.001
Subscapular skinfold (mm)	19.5 ± 6.4	18.2 – 20.7	<.001
Ileocrestal skinfold (mm)	20.6 ± 6.3	19.4 – 21.9	<.001
Supraspinal skinfold (mm)	13.2 ± 5.3	12.2 – 14.2	<.001
Abdominal skinfold (mm)	27.8 ± 5.8	26.6 – 28.9	<.001
Thigh skinfold (mm)	15.0 ± 2.0	14 – 16	<.001
Calf skinfold (mm)	10.7 ± 4.1	9.9 – 11.5	<.001
Biepicondylar femoral diameter (cm)	9.6 ± 0.5	9.5 – 9.7	<.001
Biepicondylar humeral diameter (cm)	7.0 ± 0.4	6.9 – 7.1	<.001
Contracted arm circumference (cm)	32.9 ± 3.1	32.3 – 33.5	<.001
Maximum calf circumference (cm)	36.5 ± 3.1	35.9 – 37.2	<.001
Waist circumference (cm)	98.3 ± 18.5	94.8 – 101.8	<.001
Umbilical waist circumference (cm)	102.4 ± 21.8	98.2 – 106.7	<.001
Maximum hip circumference (cm)	99.3 ± 13.6	96.8 – 101.9	<.001

CI: Confidence interval; p: Significance level.

Table 2. Anthropometric risk-factor variables of males with Acute Myocardial Infarction (N = 116).

Variables	Mean	SD	95%CI	p
BMI (kg/m ²)	28.4	4	27.6 - 29.2	<.001
WHR	0.99	0.1	0.97 - 1	<.001
UWHR	1.02	0.1	1 - 1.05	<.001
WHtR	0.58	0.1	0.56 - 0.60	<.001
UWHtR	0.60	0.1	0.57 - 0.62	<.001
Sum of eight skinfolds (mm)	126.1	30.8	120.1 - 132.1	<.001
Body fat percentage	27.4	4.5	26.6 - 28.3	<.001
Conicity index	1.30	0.17	1.27 - 1.34	<.001
Endomorphy	4.6	1.3	4.3-4.8	<.001
Mesomorphy	5.7	1.2	5.5-5.9	<.001
Ectomorphy	0.8	0.8	0.6-0.9	<.001

Abbreviations: BMI: Body mass index; CI: Confidence interval; p: Significance level; UWHR: Umbilical waist-to-hip ratio; UWHtR: Umbilical waist-to-height ratio; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio.

The correlation coefficients for the main variables are given (Table 3). BMI correlated with BF, WC, WHR, WHtR, endomorphy and mesomorphy (0.70, 0.70, 0.48, 0.72, 0.82, and 0.81 respectively). The correlations for WHR with BF, endomorphy and mesomorphy were 0.38, 0.39, and 0.38, in that order. The correlations for WHtR with BF, endomorphy and mesomorphy were 0.50, 0.58 and 0.56 respectively. WHtR was notably correlated with adiposity and somatotype components (all $r \geq 0.50$). WHR showed weak correlation with variables from skinfolds and somatotype (all $r \leq 0.45$). Variables from UW were more strongly correlated with all indicators of risk than those of WC (data not shown). HC showed correlations with both BF ($r = 0.34$) and mesomorphy ($r = 0.38$). Height did not correlated with any adiposity variable (all $p > .1$). Figure 1 shows the prevalence for each variable according to selected cut-off points. UWHtR showed the higher prevalence (92%). Both UWHR ≥ 0.95 and conicity index were similar frequencies (87% and 86.7% respectively). UWHR ≥ 1 showed a moderate association (64%). UW had a remarkable association (75.4%). The prevalence of BMI-defined obesity and BF ≥ 25 were 32% and 69.4% respectively. Overweight and somatotype rating in the 50th percentile presented moderate associations. Ectomorphy rating in the 70th percentile (≤ 1.1) showed remarkable association (71%).

Table 3. Correlations between anthropometric variables of males with Acute Myocardial Infarction (N = 116).

	Height	BMI	WC	HC	WHR	WHtR	BF%	Endo	Meso	Ecto
Height	1	-0.08	0.13	0.13	0.07	-0.10	-0.07	-0.12	-0.32 *	0.35 *
Weight	0.44 *	0.82 *	0.70 ()	0.54 *	0.49 *	0.56 *	0.57 *	0.64 *	0.56 *	-0.53 *
BMI	-0.08	1	0.69 *	0.55 *	0.48 *	0.72 *	0.70 *	0.82 *	0.81 *	-0.81 *
WC	0.13	0.69 *	1	0.80 *	0.69 *	0.96 *	0.46 *	0.55 *	0.50 *	-0.47 *
WHR	0.07	0.48 *	0.69 *	0.17	1	0.66 *	0.38 *	0.39 *	0.38 *	-0.45 *
WHtR	-0.10	0.72 *	0.96 *	0.78 *	0.66 *	1	0.50 *	0.58 *	0.56 *	-0.56 *
BF%	-0.07	0.70 *	0.46 *	0.34 *	0.38 *	0.50 *	1	0.90 *	0.50 *	-0.61 *
STΣ	0.02	0.78 *	0.59 *	0.48 *	0.40 *	0.60 *	0.86 *	0.94 *	0.57 *	-0.61 *
SSΣ	0.06	0.70 *	0.58 *	0.55 *	0.35 *	0.55 *	0.73 *	0.83 *	0.57 *	-0.57 *
AS	0.13	0.35 *	0.29 *	0.30 *	0.15	0.27 *	0.38 *	0.40 *	0.19 *	-0.29 *
Endo	-0.12	0.82 *	0.56 *	0.44 *	0.39 *	0.58 *	0.90 *	1	0.65 *	-0.65 *
Meso	-0.25 *	0.81 *	0.50 *	0.38 *	0.38 *	0.56 *	0.50 *	0.65 *	1	-0.76 *
Ecto	0.35 *	-0.81 *	-0.47 *	-0.32 *	-0.45 *	-0.56 *	-0.61 *	-0.65 *	-0.78 *	1
CI	0.01	0.51 *	0.85 *	0.68 *	0.58 *	0.85 *	0.35 *	0.45 *	0.36 *	-0.35 *
HC	0.13	0.55 *	0.80 *	1	0.17	0.76 *	0.34 *	0.44 *	0.38 *	-0.32 *

Data are correlation coefficients.

Abbreviations: AS: Abdominal skinfold; BF: Body fat; BMI: Body mass index; CI: conicity index; Endo: Endomorphy; Meso: Mesomorphy; Ecto: Ectomorphy; HC: Hip circumference; SSΣ: Sum of subscapular and supraspinal skinfolds; STΣ: Sum of eight skinfold thicknesses; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio;

*: Correlation is significant at the .01 level.

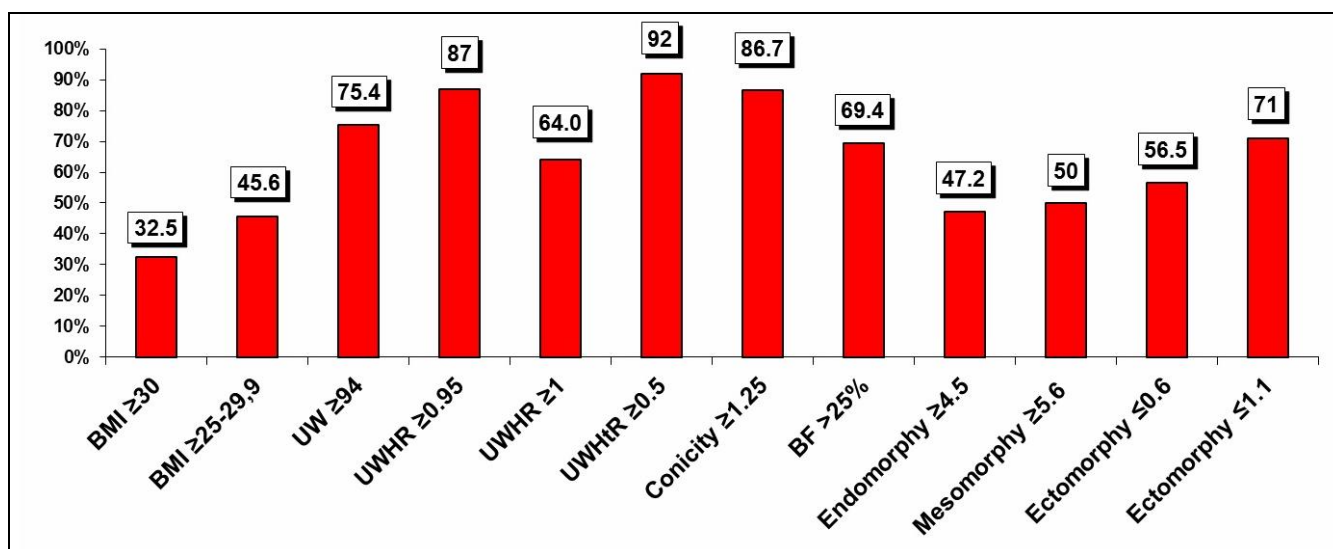


Figure 1. Prevalence of anthropometric indicators and graphic representation (weighted %) in males with acute myocardial infarction (N = 116). BF denotes body fat, BMI body mass index, CI conicity index, UW umbilical waist circumference, UWHR umbilical waist-to-hip ratio, and UWhtR umbilical waist-to-height ratio

Discussion

This study shows subjects with MI whose anthropometric characteristics denote a high-risk cardiometabolic profile only evidenced partially in previous studies^(2, 5-7, 11, 15). The somatotype (4.6-5.7-0.8) is categorized as endomorphic mesomorph where rating on each component shaped a high coronary risk. It is coincident with coronary patients from a

Spanish Thesis ⁽¹⁶⁾. The question is to ask which indicator would be the strongest in translating the more verifiable and plausible anthropometric risk. First, short-stature has been associated with a higher relative risk for MI in European males ⁽¹⁷⁾. In our data, the mean stature was found to be close to the average stature of MI European, and it was coincident with the cases from a Spanish study ⁽¹⁸⁾. On the other hand, a mean short-stature below 170.18 cm reinforces the involvement of height with the risk values of the three-number rating representing each somatotype component (high-moderate endomorphy, high mesomorphy and low ectomorphy) ⁽⁹⁾. Among other simple measurements, weight has showed low predictive ability for MI ⁽¹⁸⁾, and in our analysis does not discriminate between body components. The mean WC and UW reflect high cardiometabolic risk reinforcing previous studies in coronary events ^(5-7, 10, 15, 18). WC was found to be close to the highest quintile from the INTERHEART ⁽⁶⁾, and equivalent to those of the Swedish and PREDIMED Spanish studies ^(19, 20). Thus, prevalence and correlations of abdominal perimeter reinforces its validity as simple measurement, which may be the nuclear axis of an anthropometric profile of risk ^(5, 6, 15, 16, 18-20). The mean HC is large although no so dissonant of the healthy Spanish population ^(4, 18), and their correlations with all indicators of risk are clearly weaker than for WC. Among skinfolds, subscapular has been closely related to coronary disease, and mean subscapular was close to those of Swedish elderly population ^(10, 19). WC and WHtR were more strongly correlated with the sum of skinfolds than WHR. The skinfold of greater measurement (abdominal) was weakly correlated with WC and WHtR. This is important, since subcutaneous adipose tissue, including abdominal, is less deleterious than intraabdominal fat depots. Equally, WHtR correlated with both subscapular and supraspinal skinfolds as well as endomorphy stronger than WHR ^(10, 16).

Somatotype rating found is concordant with somatotype of risk in Framingham and European previous studies ⁽¹⁰⁾, although we have found only updated publications in Spanish studies ^(16, 18). Ectomorphy is a component that has showed inverse association with MI ^(10, 18). It is in line with our results where a low ectomorphy presents high prevalence. In the equations to calculate ectomorphy rating we used the same two measurements as to obtain BMI, but prevalence of ectomorphy was found to be clearly higher as compared to frequency of BMI ≥ 30 (both in the 70th percentile). It is clear that the balance between weight and height in both BMI and ectomorphy is not the same. BMI, unlike ectomorphy, depends very much on weight. Matter in fact, two-thirds of subjects had low ectomorphy and only one-third presented obesity in support of ectomorphy as a stronger indicator than BMI ⁽¹⁸⁾. Anyway, height affects each somatotype component, and in the shorter individuals we would find a somatotype rating of higher risk, so what the association between short stature and MI appears to be a real one ⁽¹⁶⁻¹⁸⁾.

Among composite indicators, BMI has been associated with MI, although with poor diagnostic performance ^(6, 7, 18, 19). Further, it was a worse index than BF to diagnose obesity in patients with coronary disease ⁽²¹⁾. In our findings, prevalence of BMI-defined obesity was found to be clearly lower as compared to prevalence BF $\geq 25\%$. In spite of BMI was strongly correlated with BF and skinfolds, it failed to discriminate between fat and musculoskeletal components. Weight also does not distinguish between components. In our consideration, BMI is an anthropometric confounding variable and does not provide neither a body volume index nor suitable discrimination of the biological risk. Conceptually, in anthropometry BMI is an inappropriate formula to assess the association between excess fat mass and MI. UWHtR, UWHR and conicity were the composite indicators with higher prevalence. However, WHR showed lower consistency as compared to WHtR, which correlates clearly better with all variables of adiposity and somatotype components. Conicity has shown high accuracy in visceral obesity discrimination ^(13, 22). Our data are coincident with those of Spanish studies where conicity-defined obesity was found to be as a good and similar indicator to UWHtR ^(16, 18).

To our knowledge, this study focuses in an anthropometric analysis where WC is an indisputable marker of central obesity-related health risk, and with standard cut-off points widely accepted by the scientific community ^(15, 23). Nevertheless, some composite indicators capture higher dimension of risk, although WC always actually being part of their computational formulas ^(6, 7, 18, 24). The scientific debate would focus on which other measurements, alongside WC, we should taking into account to identify with better performance individuals at risk.

WHR identified men at risk beyond that of BMI and WC^(6, 7, 18). Conversely, WHtR related better abdominal obesity with coronary events and high cardiometabolic risk^(5, 11, 25). Additionally, the recent Spanish study revealed methodological bias in the ROC analysis for WHR⁽¹⁸⁾. Biased association occurred because inverse stature, unlike HC, showed discriminatory association and height was lower than HCx2. This relationship is consonant with our data, where the inferior limit of WHtR (0.56) is higher than the superior limit of WHR $(1)/2 = 0.5$. Thus, it is possible that without keeping in mind an equivalent ratio between indices ($WHR/WHtR = 1/0.5$) (i. e., 1.12 vs. 0.56; 1 vs. 0.5; 0.95 vs. 0.475), spurious variations in WHR could be higher than in WHtR. Indeed, $UWHR \geq 0.95$ (the top tertile in the INTERHEART) have a higher prevalence because of that cut-off point implies both a lesser coronary risk and sensitivity by overestimation of HC relative to height⁽¹⁸⁾.

It is well known that HC depends on gluteal mass and gluteal-femoral fat, but does not discriminate between both components. By contrast, we know that height remains quite unchanged during adulthood, that acquired adiposity is independent on height, and that height is not dependent on muscle component. Although we recognize that height per se is not a strong predictor for MI⁽¹⁸⁾, it exhibits a cleaner relationship with body composition than HC. A systematic review found that without accounting for the protective effect of HC, the effect of obesity on cardiovascular risk might be seriously underestimated⁽²⁶⁾. However, our study implies that a greater HC is congruent with an endomorphic mesomorph somatotype of higher risk^(10, 16). In this biotype, both shorter stature and larger transversal dimensions (perimeters and bone breadths) are predominant, explaining a higher mesomorphy^(9, 10, 16, 18, 19). At time, endomorphy rating of higher risk would derive from a higher volume of fat on every body segment, independently on cellular composition and physiology of the adipocytes. By deduction, a greater HC, without discriminatory capacity of risk, determines a lower WHR that provides a spurious effect of protection if we do not keep in mind the equivalent comparison with WHtR⁽¹⁸⁾. On this basis, the association for WHR would appear biased if the selected cut-off points for both WHR and WHtR, by frequencies in the tertiles or quintiles as well as in ROC curves, were not biologically equivalents. Our findings reinforce information bias for WHR because of height and HC are not equivalent neither in measurement ($height < HCx2$) nor involvement on body composition (height, unlike HC, is independent on adiposity, and conditions both body volume and somatotype rating). Anyway, the ability of WHtR to predict cardiovascular risk and mortality in European men^(5, 11, 18, 25) also is congruent with our study, where $UWHtR$ presents high risk value as well as the higher prevalence and the best correlations with adiposity and risk bodily components. Our results support the scientific anthropometry, where a risk body composition depends very much on height^(9, 10, 16, 18). UW and height participate as physical dimensions in relation to a body volume index. The reasons for this consideration are biological and geometrical. The human body could be as a three-dimensional shape (between a cylinder and a double cone)¹³ whose area of the base depends on UW diameter, and height would determine a body volume distribution by unit of height. Besides, it has been tested that $UWHtR$ and conicity are indicators strongly associated to MI in relation to individual stature^(16, 18). Complementary, height participates on body surface area and modulates the energetic-metabolic balance process. Thereby, height would condition the storage and distribution of acquired body fat either visceral (including coronary arteries and epicardium) or peripheral. Evidence is accumulating in support of the anatomical distribution (upper-, central- and lower-body) of adipose tissue as strong indicator of coronary events and mortality^(5, 10, 15-18, 25). Further, short stature and WHtR also have been associated with the prevalence and progression of coronary artery calcium and with subclinical peripheral atherosclerosis^(27, 28). Therefore, BF disposition and atherosclerosis would be more dependent on height as an exclusive anthropometric factor. Interestingly, only a small portion of the observed association between height-associated genetic variants and coronary disease was due to association of short-stature with non-anthropometric factors of atherosclerosis (hypertension, dyslipidemia)⁽²⁹⁾. You could say that acquired body composition is dependent on diet and lifestyle, but is modulated per unit of volume and in each body segment depending on height. However, HC is modeled on the pelvic segment depending on body fatness distribution and muscle component of buttock, both genetic and acquired through adult

lifestyle. It is consistent with Framingham and recent studies where somatotype characteristics, %BF and subcutaneous fat pattern influence the coronary risk^(9, 10, 16, 18, 21, 30).

In this sense, it is clear that BMI and perimeters dependent on both fat and muscle segmental mass have a meaning well different as compared to WC. The observed association between WC and MI^(5-7, 16, 18, 19, 20) gives anthropometric consistency, possibility of verification against a gold standard of risk and biological plausibility, too. Anthropometrically, if we keep in mind a biological risk volume by unit of height, both UWHtR and conicity would appear to be the best indicators in identifying the risk of MI, at least in middle-aged adult⁽¹⁸⁾.

In epidemiology, studies should leave designed both the biological risk and equivalence between indicators. Causality for any composite indicator depends on their strength of association, but taking into account anthropometric consistency and biologic credibility as well as both the burden and spatial dimension for every measurement. Evidence supports that even using the same body measurements or non-equivalence of risk between indicators, information bias may occur⁽¹⁸⁾. The statistical association for some formulas may vary conveying the appearance of an association that presents effects of bias rather than the true putative risk may be responsible for all or much of the epidemiological causality.

Lastly, we consider that weight, HC and height present a weak strength of association depending on statistical analysis^(5-7, 13, 16-19), but do not necessarily lead us to infer a causal relationship. Nevertheless, only height, without effect of confounding, would be a modulator factor of both the body composition and MI risk^(16, 18). WC shows a strong association and epidemiological causality^(5-7, 10, 11, 15, 16, 18, 19, 23, 25). Both high rating of mesomorphy and low ectomorphy are associated^(10, 16, 18) without causation per se, but enabling a rating of endomorphy that implies higher risk and causality. BMI presents weak association^(5-7, 16, 18), and only would justify a partial causation. Excess fat mass assessed by endomorphy, BF, and skinfolds would present both moderate association and causation^(10, 16, 19, 21), although without established cut-off points. WHR shows a strong association^(6, 7, 18), but biased⁽²¹⁾ and with weak anthropometric consistency for causality. Body volume indices from UW and height measurements reflect the higher magnitude of association^(5, 11, 16, 18) and the best causal criteria.

Our study has limitations. First, the cross-sectional design does not imply causality. Second, our data cannot be generalized by the sample size and because of the lack of control group. Despite this, thousands of subjects are not necessary to analyze an anthropometric profile that coincides with those of other larger studies. The novel findings in this study extend the knowledge for the large number of infarcted people whose body composition could be very close to our values. Future studies should confirm this possibility.

Conclusion

MI males present a high-risk cardiometabolic profile. Anthropometric somatotype is endomorphic mesomorph with low ectomorphy. Waist, hip and height measurements have a differential involvement on the body composition. Differences in the anthropometric meaning and non-biologically equivalent cut-off points may systematically bias the comparison between indicators. UWHtR expresses volume distribution of a real biological risk presenting the higher prevalence and the best correlations with risk bodily components. BMI-defined obesity appears to be the indicator with the more weak association and it does not discriminate between bodily components. WHR presents high prevalence but a weak relationship with the body composition of risk. Therefore, we recommend somatotype rating and UW and height measurements, but not so much that of HC, for the early identification of men at risk of MI.

Conflict of interest

The Authors declared no conflict of interest

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